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Metacognition and Knowledge Application: An Empirical Study in Product Design Education

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Abstract

The relationship between creativity and knowledge has been a debated topic in creativity and design research. Current studies have made a great effort to emphasise the significance to creativity of a specific type of knowledge, e.g. domain-specific/general, rather than interpreting their application, i.e. how they are used. That is, there is still a lack of studies to investigate the ways in which knowledge and skills within or across domains are actually used, since Christiaans and Venselaar (2005) have claimed. The lack of a performance-based measurement of creativity probably renders it difficult to ascertain whether a specific knowledge item is related to a specific creative performance. Moreover, the methodologies applied by current studies to design knowledge and creativity were based on qualitative approaches drawn from data collected from a single school in one country, ignoring the importance of the cultural context.

This thesis is supported by an investigation of a creativity-relevant construct that connects to knowledge application within the context of Product Design Education. The principal creativity-relevant construct is identified as metacognition: this identification was achieved by conducting a literature survey focusing on creativity research, which is linked to creative thinking, according to current understanding of applied knowledge, and is thought to predict creative performance. Different kinds of knowledge applied in product design students' final-year design projects (FYDPs) have been assembled and arranged into three categories. An empirical study was conducted in the form of a survey to examine the relationship between metacognition and the frequency of applying each kind of knowledge in the process of the FYDP. Cultural factors were also considered in this study based on 375 samples collected from China (228 samples) and the UK (147 samples), representing Western and Eastern cultures.

The findings identified the shared and different frequencies of applying subject-related knowledge among students with different levels of creative thinking ability. The thesis proposes five aspects of subject-related knowledge, including product-oriented, reflection-facilitating, socio-cultural environment related, conceptual-process related, and cross-disciplinary knowledge. The data indicates that product-oriented, reflection-facilitating, and socio-cultural environment related knowledge are frequently applied by students who reported higher metacognition scores. The main contribution to knowledge made through this thesis is towards design education research, where these findings may inform and extend academic support for design tutors and students to improve the FYDP process and offer further insights into China's design education.

Keywords

Design, design education, product design, creativity, creative thinking, metacognition, design knowledge, knowledge application, final-year design project

List of Abbreviations:

- FYDP: Final-year design project
- UNESCO: United Nations, Educational, Scientific and Cultural Organization
- HELPRC: The Higher Education Law of the People's Republic of China
- QAA: The Quality Assurance Agency for Higher Education
- HE: Higher education
- PjBL: Project-based learning
- PbBL: Problem-based learning
- MAI: Metacognition Awareness Inventory
- OLR: Ordinal Logistic Regression model
- FKA: Frequency of knowledge application
- DSK: Domain-specific knowledge
- DGK: Domain-general knowledge
- TK: Tacit knowledge
- KH: the frequency of knowledge application belongs to the category of relatively frequently used, i.e. ranged from ‘frequently used’ to ‘always used’.
- KL: the frequency of knowledge application belongs to the category of relatively infrequently used, i.e. ranged from ‘never used’ to ‘occasionally used’.
- MH: the male students with high MAI scores
- FH: the female students with high MAI scores
- SH: the students from southern institutions with high MAI scores
- NH: the students from northern institutions with high MAI scores

- T3H: the students with high MAI scores whose FYDP projects belong to the top three choices, i.e. there were 11 types of projects represented by participants in the survey.
- OH: the students with high MAI scores whose FYDP projects do not belong to the top three choices, i.e. there were 11 types of projects represented by participants in the survey.

Publications:

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Glossary:

A list of the key terminologies that were employed in this study is provided below.

- Creativity

The term creativity has multiple definitions as it covers a wide scope of domains. Several representative interpretations of creativity are assembled below:

> "Creativity is the interaction among aptitude, process and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context" (Plucker et al., 2004, p.90).
>
> "Over the course of the last decade, however, we seem to have reached a general agreement that creativity involves the production of novel, useful products" (Mumford, 2003, p.110).
>
> "Creativity is the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)" (Sternberg et al., 1999, p.3).
>
> "…creativity must entail the following two separate components. First, a creative idea or product must be original…However, to provide a meaningful criterion, originality must be defined with respect to a particular sociocultural group. What may be original with respect to one culture may be old news to the members of some other culture…Second, the original idea or product must prove adaptive in some sense. The exact nature of this criterion depends on the type of creativity being displayed" (Feist, 1998, p. 120).

The above interpretations reflect that the 4Ps theory (Rhodes, 1987), including people, process, product and environment (place), would form the framework for researchers to study creativity. As well, Sternberg (1999) stated that researchers may understand creativity from different views according to their different research aims and focus.

This research considered creativity in two layers. From its essence, creativity in this research was defined as a cognitive process involved in the problem-solving process, adopting one of the most common definitions based on Lubart and Sternberg (1988) and Cropley's (1999) perspectives from the view of cognition. Besides, it tried to get a comprehensive understanding of creativity from a cross-culture viewpoint (Lubart, 1990; Lan & Kaufman, 2012). According to this definition, several issues in this research regarding creativity have also been defined including creative thinking, creative ability, creative performance, creative measurement, metacognition, and creative students.

- Creative ability

As creativity refers to a large scope, creativity ability also reflects this feature. It covers a range of people's abilities such as cognitive ability. In this research, creativity ability specifically links to the creative thinking ability referred by Cropley and Cropley (2000), which is defined as the ability of "thinking that is novel and that produces ideas that are of value" (Sternberg, 2003, p. 326).

- Creativity measurement

Correspondently, creativity measurements relate to four aspects based on 4Ps theory. Creative individuals are measured from a series of abilities that are significant for creativity including "flexibility, curiosity, independence, tolerance for ambiguity, trust in one's own senses, and ability to restructure problems" (Cropley, 2000, p. 77). The creative process is measured by aspects of "divergent thinking, problem recognition and construction, ideas generation, and decision evaluation" (ibid., p. 77). The end product is used as a measurement to define the outcomes of creative activities, where common criteria includes "originality, relevance, usefulness, complexity, pleasingness" (ibid., p. 77). The environment aspect is measured with criteria like "openness, flexible, freedom, stress less" (ibid., p. 77).

In this research, creativity relevant measurement was considered from the view of the creative process, which is consistent with its definition. The studies on measuring creative process have paid most attention to measuring the divergent thinking at the early stage of creativity research. Puryear (2015) argued that the current state of creativity study and assessment generally concentrates on either the generation of ideas or the end result of creative works, which may show in more traditional measures of creativity; however, this omits the cognitive processing that occurs in the meantime and the interaction effects of these cognitive aspects.

- Creative performance

The specific meaning of creative performance is ambiguous in the literature. For example, Zhou and Oldham (2001) mentioned it as the product of creativity, while in

Choi's (2004) study, it is regarded as the representation of the creative process. This research agreed with the later one and considers creative performance as the behavioural manifestation of creativity thinking, e.g. generating novel ideas, formulating a design problem, or pushing forwards a creative process.

- Creative students

In this study, creative students were defined as those who are with a high level of creative thinking ability, which is evaluated by metacognition. Therefore, the students who get the higher score in the test regarding metacognition would be considered to be with better creative thinking ability than those who get the lower score.

- Creative thinking

When focusing on the creative process, to investigate the nature of the mental mechanisms is usually regarded as the main task, which occurs when people are engaged in creative thinking. Relevant studies usually relate to topics of creative thinking and problem-solving process from the view of cognitive function.

This research held that it is essential to understand creative thinking from a cognitive view involving interactions between divergent thinking and convergent thinking, where, “convergent thinking usually generates orthodoxy, whereas divergent thinking always generates variability” (Cropley, 2006, p. 392). To go further, both types of thinking work together “[which] allows the generation of ideas that are both original and effective” (Kozbelt, Beghetto, & Runco., 2010, p. 32).

- Design

The term design is hard to define for its broad spectrums of areas and activities. The history of modern design can be traced back to the late 18th Century since the first Industrial Revolution exploded in the UK (Margolin, 1989). Thus, it is largely stemmed from the modern industry of mechanical manifestation to satisfy the requirement of qualified machines, and at the same time absorbs elements from arts and crafts. Nowadays, design as a discipline appeared in several fields, such as architecture, interior, fashion, engineering and product design (Lawson, 2004; 2006).

Archer and Roberts (1992) perceived design to be a process of elaborating and discovering with continual appraisal and reappraisal; Warr and O'Neill (2005, p.120) defined design as doing works or tasks that involves activities such as "exploring"; Roberts (1992, p. 32) regarded design as "the capacity to conceptualise and represent ideas, aspects of present realities and future possibilities." Southee (2009, p. 184) considered design an "inclusive activity which begins by carefully observing and understanding people and sensitively shaping solutions". In China, "Design" is translated into two characters and is pronounced as "She Ji" which means conceptualising and planning (Wang, 2003). Collectively, this research defined design as a problem-solving process (e.g. appraisal and reappraisal) which involves a series of creative activities (e.g. discovering new information, generating new ideas), and this process usually ends with the creation of artificial products.

- Design education

This research perceived design education as "…the set of practices and systems for the training in the field of design; ways and methods of teaching for the acquisition of necessary knowledge and skills in order to practice the design profession." (Locker, 2008, p. 2)

- Design problem

Design begins with problems, though they are defined as different issues, such as requirements (Archer, 1979), customer needs (Svensson, 1974; Andreasen & Hein, 1987; Hales, 1993), tasks (Pahl & Beitz, 2013), or constraints (Lawson & Loke, 1997). This research perceived design problem as ill-defined or 'wicked', which is commonly accepted (Schön, 1987; Dorst, 2006). This kind of problem, as Christensen (2005, pp. 58 – 59) argued "[has] no clear path available to arrive at a correct response". Ill-structured or wicked problems can also be considered to be related to social or cultural elements and hard to solve, as Kolko (2012, p. 10) concluded the four reasons that "1) [they are] incomplete or contradictory knowledge, and continuously changing requirements; 2) the interconnected nature of these problems with other problems; 3) the large economic burden; and 4) the number of people and opinions involved". Many researchers agree with this, for example, Buchanan (2010, p. 16) pointed out that the solutions to wicked problem "cannot be true or false, only good or bad", and "there is no exhaustive list of admissible operations, in solving wicked problems" (ibid., p. 16). He further described that 'no definitive formulation, but every formulation of a "wicked problem' corresponds to the formulation of a solution" (ibid., p. 16).

It is proposed that because of this uncertainty of the solution being "ill-defined" or a "wicked" problem, the creativity may occur. As Williams, Ostwald, and Haugen (2010a, p. 14) stated, "the common definition of design problems as 'wicked' or 'ill-defined' implies the importance of creativity to design; these problems require a particular (creative) approach in order for them to be solved". Moreover, Buchanan (2010, p. 16) argued, "for every wicked problem there is always more than one possible explanation, with explanations depending" and therefore, "every wicked problem is a symptom of another and each problem is unique" (ibid., p. 16). One critical principle of wicked problem is to make sure that sufficient space is left for students to explore their own ways in order to find the solutions by providing them problems (situations) without predetermined forms of solutions, pointed by Blumenfeld et al. (1991).

- Design students

In this study, design students referred to those undergraduates who are studying product design programme in China and the UK.

- Domain knowledge

The concept of Knowledge covers a large scale and is hard to define. According to the definition of knowledge in *The Oxford Dictionary* (2010), "Knowledge can refer to a theoretical or practical understanding of a subject. It can be implicit (as with practical skill or expertise) or explicit (as with the theoretical understanding of a subject); it can be more or less formal or systematic". Another definition is the term knowledge refers to an individual's personal stock of information, skills, experiences, beliefs and memories (Alexander, Schallert, & Hare, 1991). Locate "knowledge" into this research with the design education background, domain knowledge here is considered as a range of principles, skills, and subject relevant information.

- Final year design project (FYDP)

Within the programme of product design, the FYDP examines students' subject specific knowledge and skills. The purpose is to assess whether they are ready to transition into profession. It can be seen as a bridge between students' university education and career development.

- Knowledge application

Different to the knowledge base (a series of knowledge) for design or creativity, the term knowledge application emphasises the interaction and integration between various kinds of knowledge when students engage in a design process.

- Metacognition

Metacognition "can lead you to select, evaluate, revise, and abandon cognitive tasks, goals, and strategies in light of their relationships, with one another and with your own abilities and interests with respect to that enterprise." (Flavell, 1979, p. 908). More recently, McMurray, Scott, and Pace (2004) indicated that metacognition is the individuals' awareness and comprehension of the processes that regulate their mental state, skills, memory, and behaviour; and refers to the knowledge of one's own cognitive processes, task demands, and the procedures necessary to perform a task. Collectively, the definitions describe metacognition as a complex phenomenon of human perception, which is of a large scale and involves multiple cognitive activities (Akturk & Sahin, 2011). Moreover, metacognition has also been linked to a number of other constructs, specifically and crucially creativity (Kaufman & Beghetto, 2013).

- Product design

There are three similar subjects when referring to fields of design, for example, product design, engineering design and industrial design. Generally, the scope of product design is narrower than engineering design, as the engineering design also refers to designing the chemical and physical processes. However, product design is a relatively wider concept comparing to industrial design, which, focuses more on the functions and external appearance of products (Lawson, 2006). It can be seen from current understandings of the three fields, the biggest difference between them would be their relationship between the product and end-users (Baxter, 1995; Bolling, Reid, & Ralls, 2003; Lidwell & Manacsa, 2011). Specifically, this research recognised that product design aims to create physical products after the conceptual process, which conforms with Roozenburg and Eekels' (1995) perspective.

- Project-based learning (PjBL)

PjBL is defined as a type of environment-based learning (Greeno, 1998). PjBL is established on the studies of constructivist pedagogy, which finds that students will comprehensively understand the material if they construct their understanding actively through invoking ideas and working with them. To go further, in the process of PjBL, students' engagement in a series of real, meaningful problems help them better construct their knowledge (Greeno, 1998). These problems should be important to students, and moreover, are similar to what scientists, historians, and writers do.

- Teaching and learning strategy

Teaching and learning strategy, or pedagogical strategy refers to a range of educational teaching approaches generally applied by design lecturers to achieve their specific teaching aims so as to cultivate qualified designers. Related learning strategies are identified based on correspondent teaching strategies, in order to improve students' learning processes on the specific course contents.

Chapter One: Introduction

1.1 Research motivation and background

Fostering creativity is identified as a common international goal for education (UNESCO, 1998). In China, 'creativity' has been cited frequently as a key concept in the 18th CPC report (CPC, 2012), signalling that China is keen on incorporating 'creativity' into future blueprints, which in turn are sweeping across various industries and sectors, specifically the education sector. During the past 20 years, Chinese design educators have been continuously making efforts to improve students' creativity, mainly concentrating on improving the syllabus, course settings, and teaching and learning strategies, while also absorbing experience from other cultures (Wang, 2016). This study is intended to support this ideal, through providing new insights and practical suggestions in the design education sector.

The main motivation of this study stems from the author's working experience as a design tutor in China, where the author has worked for over 5 years, and every year he teaches final year students their FYDP. The author found that most of these students are highly dependent on their lecturers, as He (2008) observed that design students enrolled in Bachelor Product Design programmes tended to remain dependent on their tutors' suggestions in the progression of these final-year projects (FYDPs). Therefore, the study focused on the final-year design project (FYDP), a commonly applied educational activity in design education at university level, where a practical problem has been identified and the students are tasked with resolving it. At the same time, the author is also working as a director of the international communication department. He realised that different cultural contexts convey different perspectives, so that a study conducted in a single cultural context may not produce a generalised finding. Therefore, China, where the research motivation stems, and the UK, where the author is currently studying, are both intended to be the target countries in this study.

There is also concern that while final-year design students should have mastered sufficient knowledge after four years of study, they still differ noticeably in creative performance within their FYDPs, in that, "the design work reflects the teacher's intentions to a large degree, because the most important decisions are often made by their teachers" (He, 2008, p. 21). The implication is that, even if the final works of the Chinese design students appear creative and innovative, the credit may largely go to the teachers rather than the students. Through a review of the product design syllabus and students' learning outcomes after engaging in different design courses, this study found that Chinese design students have been taught various types of knowledge in their undergraduate years and generally achieved satisfactory results (HELPRC, 2015)[1]. Conversely, a series of reports on Chinese students' creative abilities indicated that the performance is relatively weak (Lv, 2002; Yang, 2006). They performed well in mastering the knowledge required but lacked creativity. This contradicts the viewpoint which suggests that there is a strong relationship between knowledge and creativity, at least based on Western cases (Amabile, 1996; Christiaans, 1992). This

[1] A report on The Evaluation of Undergraduate Teaching and Learning in Higher Education (Section on Art and Design), Issued by the Higher Education Law of the People's Republic of China (2015 Amendment)

puzzle was the main motivation for this study: knowledge may not necessarily lead to creativity in the context of Chinese design education as it does in the West.

The types of knowledge considered are strongly linked to creativity in Western countries. Knowledge, as a general term, can be observed from different perspectives, such as knowledge types which are popularly used in prior studies and knowledge application which is rarely mentioned in creativity research. This study has explored the relationship between knowledge and creativity from this seemingly rarely-discussed perspective of a cross-cultural viewpoint. The incentive to find an answer to this brings up cross-cultural difference as an explanation. As part of cross-cultural studies (Cropley, 1999; Lubart, 1990), Western culture and tradition focus heavily on fostering creative thinking skills amongst students during knowledge acquisition, while Chinese culture and conventions emphasise the accumulation of knowledge as a milestone and hope creative thinking abilities develop as the knowledge accumulates (Fu, 2003). Knowledge is considered to consist of two parts: accumulation and the creative ability to critically analyse what is learnt. Western culture may value creative thinking skills more. This preliminary overview of the research background helped to frame the scope of this study, which is located within the domain of creativity and product design: more specifically, the relationship between creativity and subject-related knowledge application.

1.2 Research aim

The main research problem for this study was then introduced and outlined as follows:

- Chinese students are dependent on their lecturers;
- This dependency is related to their creative thinking abilities which determine how they link and apply the knowledge learnt appropriately.

As creative thinking abilities are not sufficiently emphasised in China's educational background (Pan, 2007), to provide constructive suggestions for effectively application of various kinds of knowledge would probably be the most direct and practical way to improve the situation in China's product design FYDP. It is assumed in this study that these suggestions of knowledge application could be formulated via an investigation of ways in which different kinds of knowledge are applied in the FYDP and how they are influenced by students' creative thinking abilities. Therefore, the primary research aims are outlined below:

- RA1. To obtain a more comprehensive understanding of subject-related knowledge applied in design process.
- RA2. To identify which knowledge items might be encouraged in order to provide practical suggestions of knowledge application in design students' FYDP process.
- RA3. To obtain a more generalised conclusion, this study intended to explore the knowledge application within at least two different cultural contexts.

1.3 Research objectives

To achieve the research aim, several objectives should be pursued:

1. To explore current studies regarding the main issues involved in this study, including creativity, knowledge application, and subject-related knowledge applied in the FYDP;
2. To construct the theoretical foundation of this study and identify the literature gaps;
3. To explore the interactions between knowledge application and creativity during product design students' FYDP via designed methodologies in two different countries;
4. To systematically analyse and discuss the result of a survey to articulate the findings of this study;
5. To explore the results of a survey whose data was collected from different countries;
6. To draw implications for design educators and students;
7. To state the limitations of this study, provide suggestions for further study, and reach conclusions for this research project.

1.4 Research questions

The main research questions were formed below to address the research objectives:

- RQ1. What kinds of knowledge are applied in relation to a creative-related construct? Are these kinds of knowledge the same ones within different cultural contexts, e.g. the Western and Eastern, the UK and China in this study?
- RQ2. Does the creative-related construct exert the same impact on the application of different kinds of knowledge?

Chapter Two: Literature Review

Part I. Research problem identification

2.1 Overview

This part of chapter two focuses on representing more details of the research background by reviewing and analysing related documents. The aim is to interpret explicitly the research problem, aims, objectives and questions. Through comprehensive investigation of related background issues (e.g. the FYDP process, pedagogical theories, and creativity), the research problem has been further identified, and rationales and the need for this research will be highlighted. Section 2.2 provides the basic information about FYDPs in China's current Bachelor's Product Design programme and in several European countries. Section 2.3 overviews the relevant pedagogical theories of FYDP, followed by Section 2.4 which discusses relevant issues related to the effectiveness of FYDP. Section 2.5 conducts a literature review of the impact of cross-culture on creativity. The part I in this chapter is concluded by a discussion to identify the research problem, aims, objectives and questions in section 2.6. The mental model of this background study is shown in Figure 1 (p. 7).

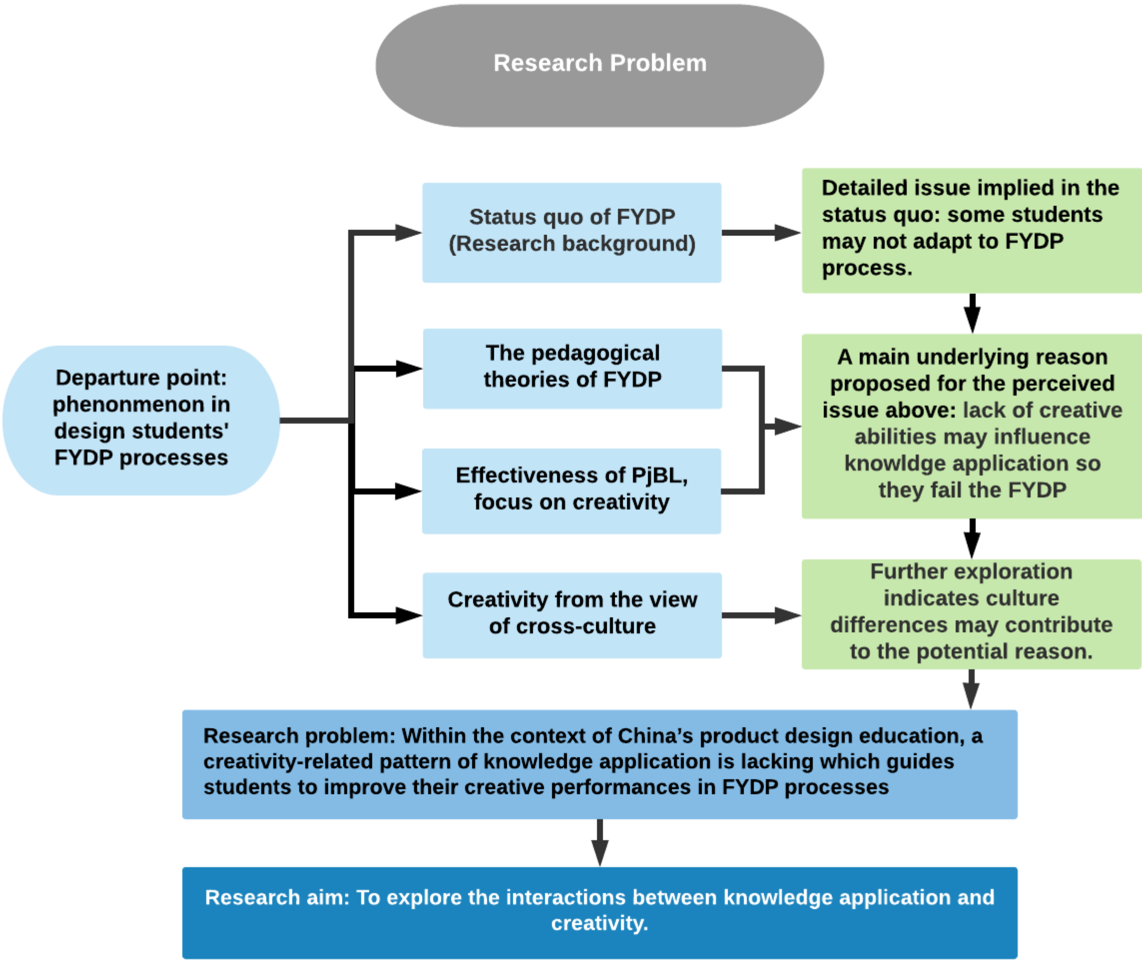

Figure 1. Mental model of research problem identification

2.2 Overview of the FYDP in Bachelor's Product Design programme

2.2.1 The FYDP in Bachelor's Product Design programme in China

This section explores how the FYDP is conducted in product design programme in China. Information to describe the research background was collected from Chinese literature based on CNKI (the most widely applied database in the China Academy), China's Universities' website and school briefs/booklets. As the top universities are taking the leading roles in design education, for the purposes of this project China's universities were based on the top 10 design colleges (CDGDC, 2013)[2] in China,

[2] The Rank is issued by China Academic Degrees and Graduate Education Development Centre (CDGDC), Jan. 29, 2013

which are listed below (as Jiangnan University and Nanjing University of the Arts are both ranked at 4^{th}, there are 11 universities in the top 10 ranking):

1. Tsinghua University (Beijing)
2. Central Academy of Fine Art (Beijing)
3. China Academy of Art (Hangzhou, Zhejiang Province)
4. Jiangnan University (Wuxi, Jiangsu Province)
5. Nanjing University of the Arts (Nanjing, Jiangsu Province)
6. Tongji University (Shanghai)
7. Donghua University (Shanghai)
8. Zhejiang University (Hangzhou, Zhejiang, Province)
9. Communication University of China (Beijing)
10. Luxun Academy of Fine Arts (Shenyang, Liaoning Province)
11. Soochow University (Suzhou, Jiangsu Province)

Within the programme of product design, the FYDP examines students' subject specific knowledge and skills. The purpose is to assess whether they are ready to transition into the profession and can be seen as a bridge between students' university education and career development. In China, FYDPs usually begin in the fourth academic year and lasts for one term (6 months). Students tend to be educated with a solid foundation of what is perceived to be relevant knowledge through a series of course modules including a range of arts history, design methods, market strategies and creative design training, as well as traditional design courses (e.g. design representation based on sketching, drawing and modelling). These courses are generally categorised into four types of courses included in most of design programmes including a) a compulsory common course (CCC); b) a compulsory subject-related course in a pre-specified term (CSCs); c) a compulsory subject-related course in an optional term (CSCo); and d) an optional course (OC). The CCC refers to those courses that every college student should take and pass; CSCs refers to those courses that every design student should take and pass in a pre-determined term; CSCo refers to those courses that every design student should take and pass in any term that he/she prefers; and the OC refers to those courses from which every design student can choose. Table 1 (p. 10) summarises course information on China's product design programme. As there is a wide range of the OCs, and most OCs are also less significant due to their relatively lower proportion in the whole programme, the information on this type of course is not included in this table.

As seen in Table 1 (p. 10), the module for the FYDP is generally in the fourth year, after students have finished a range of courses. The curricula of Bachelor product design programmes in the top 10 design colleges in China provide generic stages to complete projects, with estimated durations. There are generally 5 stages, as follows:

1. Select supervisor (usually lasts one week);
2. Determine the topic/problem (usually lasts 6 weeks);
3. Resources: collection of data including literature reviews and design surveys (usually lasts 8 weeks);
4. Detailed design including visualising ideas (usually lasts 4 weeks);
5. Implementation and evaluation (usually lasts 6 weeks).

Table 1. Summary of Product Design Syllabus, China (information is collected from official websites of China's top 10 design colleges)

Academic year	Courses	Assessment
The first year	Introduction to Chinese Art History (CCC), Art History (CSCo), Chinese Art and Craft History (CCC), World Art and Craft History (CSCo), Chinese Literacy (CCC), English Language (CCC), Political science (CCC), PE (CCC)	Exams (paper test)
	Sketch (CSCs), Forms (CSCs), Colours (CSCs), Related practice (CSCs)	Coursework
The second year	Ergonomics (CCC), Design methods (CSCs), Design principles (CSCs), Introduction to product design (CCC), Introduction to graphic design (CSCo), Sustainable design principles (CSCo)	Exams (paper test)
	Design Representation: Technical, mechanical drawing (CSCs), Computer aid design (CSCs); Material and craft; Related practice (CSC)	Coursework
The third year	Design Management (CCC), Strategy (CSCo), Product development (CSCo)	Exams (paper test)
	Exhibition Design (CSCs), Sustainable design (CSCs), Units of design project (CSCs)	Coursework Design work
The fourth year	Design project (CSCs); Final year design project (CSCs)	Design work

- *Notes: CCC: compulsory common course; CSCs: compulsory subject-related course in a pre-specified term; CSCo: compulsory subject-related course in an optional term*

A report by Liu (2012) conducted into the delivery of FYDPs from Guangxi Normal University showed that 41% of Art and Design students in that university experienced difficulty in determining the design topic. Upon investigating the situation of Art and Design students' FYDPs, Chen and Ma (2010) stated that it is common for students to continue asking questions like, 'what should I do next?', 'Can I apply this to my project?' etc. (Chen & Ma, 2010). It implies that the main difficulty that design students face when carrying out their FYDPs is the lack of independent thinking which is essential in accomplishing any design work. Without design lecturers' guidance, they cannot carry on smoothly in the progress of their FYDPs. The series of problems reflect that Chinese students are weak at making their own decisions, or setting clear goals for the project and thinking independently. In other words, their creative performances in the FYDP are not yet good enough. Schaub (2007) highlighted the crucial role of making 'quick decisions' for creativity, which, according to her, links to people's creative thinking. Therefore, as Pan (2007) has stated, Chinese students lack creative thinking abilities. These difficulties are generally applied to all the design students, including those in product design[3].

2.2.2 The FYDP module in design institutes in the world

Over the past 10 years, calls to rethink the design curriculum have become noticeably stronger. Design educators all over the world have claimed that design education should concentrate on cultivating creative design for social purposes and encourage creative works in design schools (Demirkan & Afacan, 2012; Pan, 2007). New courses and teaching strategies have been imported into the syllabus, and as the representation of the learning outcomes of a long-term study, the FYDP has been emphasised by most of the design programmes (Howard, Rasul, & Nouwens, 2013; Uziak, 2015).

Similar to the situation in China, Ghassan and Bohemia (2013) suggested that the phenomenon of design students' over dependency on their tutors is also present within

[3] According to the latest 2011 Discipline Catalogue Degree Conferring and Talent Training (DCDCTT) issued by Ministry of Education, China, the Product Design is clarified to Level II Discipline, which is embraced in the list of Level I discipline Art and Design.

design schools in the UK. They also argued that it is the tutor's pedagogical practices which make students rely on their judgments and that this can lead to tutor-led rather than student-led learning. De Graaff and Kolmos (2007) also stated that project supervision has been viewed as a challenge because of the increased 'closeness' to the students that occurs, both because the students seek help with course difficulties and also because the teachers are more intimately involved in the students' learning processes. As Osmond and Bull (2013) cited, a member of staff comments:

> "…most students are coming in from an educational system where they want to know what they need to do to pass. They are not variety or choice orientated – they want to know what is right and what is wrong. What we do is give them permission to not be asking that question – my aim is to stop them asking me what it is that they have to do next." (p. 17)

Studies further suggested that design teachers in this capacity must use heuristic approaches (coaching), first motivating students to initiate projects that require and make essential use of general knowledge, then guiding them through frustration and delay to successful completion (Waks, 2001). As Waks (2001) stated, the teachers' role of scaffolding in the learning process of FYDP is specifically emphasised.

2.2.3 Critical comments

As the FYDP examines students' subject-specific knowledge and skills, to establish whether they are ready to transition into the profession, the FYDP is generally the last stage of their professional education and may possibly reflect what is lacking in design education during their previous studies. From this point of view, the FYDP is, or could be considered to be, an ultimate assessment for testing the whole learning process.

In the existing literature, the most crucial factors that influence the FYDP process would be either teachers' instructions or the assessment approach (i.e. the Western countries pay more attention to the teachers' role in such processes and there are sufficient studies and advice to improve design teachers' guidance). It seems that the prior literature examined the problems in the FYDP either in relation to improper assessment criteria or in relation to the teachers' weakness in providing appropriate guidance for the students, rather than from the perspective that the students, as the main performers, need to take large responsibilities themselves. As de Graaff and Kolmos' (2007) research found, the project work apparently does not attempt to level out individual differences but rather provides good students with the opportunity to be even better, and conversely, does not support the weaker students appropriately.

The situation of conducting FYDPs in both China and Western countries reflects the same problem in the current research on FYDPs, which indicates that the students' engagement with them reflects more essential problems that those resulting from the whole product design programme. The question which then needs to be asked is, "what kind of students may do better in an FYDP, and who will be less able to progress well?" This, however, is ignored in general. Therefore, the problems raised by students' engagement in FYDPs need to be well-addressed. Solving this problem would help generate deep insight to improve relevant educational practices, such as providing a more practical guidance for both teachers and students in the FYDP in order to enhance their efficiency. The following two sections introduce the investigation of relevant literature from the perspective of related pedagogical theories in connection to FYDPs and their efficiency. The aim is to consolidate the theoretical base of FYDPs, and to identify the kind of students who may perform well in the FYDP process and those who may not.

2.3 Pedagogical theories related to FYDP

Mills and Treagust (2003) mentioned the key elements (keywords) of FYDPs contained in the reviewed modules, including project, long-term, problem/topic, and student conducting (also see Howard, Rasul, & Nouwens, 2013; Uziak, 2015). In general terms this aligns with teaching and learning strategies such as problem-based (PbBL) and project-based (PjBL). More recently, researchers (e.g. Frank, Lavy, & Elata, 2003; Gao, 2012) have related both concepts to a variety of theoretical notions and have generated a lot of interest. This section is mainly focused on two theories regarding PBL strategy by conducting an extensive literature review: 1) One theory refers to the general pedagogical perspective of constructivism (Piaget, Vygotsky); 2) The other one is the reflective practitioner (Schön), which is located at the higher education level particularly. After identifying the basic pedagogical theories, the teaching and learning strategies of problem-based (PbBL) and project-based learning (PjBL) have been further explored in terms of their definitions, features, and limitations, by making a comparison and analysis of their developments in design education. The main pedagogical theory in relation to the FYDP was then identified.

2.3.1 Constructivism

The root of constructivism in Education

The root of constructivism can be traced back to the concept 'experiential learning' developed by John Dewey. Several other similar perspectives could be found in the history of pedagogical development, such as 'inquiry-based learning', which is a basic component of experiential learning. Experienced teachers and pedagogues have always encouraged active and experiential learning by allowing students to find answers by themselves (de Graaff & Kolmos, 2003). For example, Socrates stressed the significance of asking students questions (de Graaff & Kolmos, 2007). The Chinese philosopher Confucius emphasised the importance of involvement with a few often quoted lines:

> "Talk to me… and I will forget
>
> Show me… and I will remember
>
> Involve me… and I will understand
>
> Step back… and I will act" (quoted in de Graaff & Kolmos, 2007, p. 11)

Dewey (1934) emphasised the interaction between environment and individual, which is related to human activities intrinsically in and around the world. In consequence, his theory refers to a process or an approach of enquiry which implies that students will develop personal potential through the material when they are engaging in real and substantial problems or tasks and thus emulating what experts do in real-world contexts (Carol, 2002). In the past three decades, researchers in teaching and learning sciences have refined and expanded on Dewey's (1934) original perception, which has led to a deeper understanding.

Main theories

One primary theory of constructivism was developed by Jean Piaget, who concentrated on the concept of the interaction between people's experiences and ideas when they are making meanings. He paid most attention to the genesis of knowledge, and therefore, considered himself to be a genetic epistemologist. His perspectives focused on the development of humans in terms of what is occurring in an individual rather than their development as influenced by others. Similarly, Kolb's (1984) reflective model, based on that of Dewey and Piaget, highlights the concept of 'experiential learning' and is centred on the transformation of information into knowledge.

Another primary theory, called social constructivism, is largely affected by Vygotsky's research, which declared that knowledge is primarily built within a social context and then learned by individuals (Bruning, Schraw, & Ronning, 1999; Eggen & Kauchak, 2004). In accordance with the viewpoint of social constructivists, Van Meter and Stevens (2000) proposed the concept of collaborative elaboration, which refers to the process of sharing individuals' views. Greeno, Collins, and Resnick (1996) further stated that collaborative elaboration contributes to learners constructing understanding together as opposed to constructing understanding alone. Other constructivist scholars give support to this, stressing that people achieve understanding via interactions with each other and with the environment in which they are engaged. Therefore, knowledge is considered to be a human product that is constructed culturally and socially (Prawat & Floden, 1994; Ernest, 2003). McMahon (1997) agreed that learning is a social process: furthermore, he pointed out that not only does it occur inside the minds of individuals, but it also emerges from individual behaviours as influenced by external elements. Thus, effective learning takes place when individuals are engaged in social activities.

Accordingly, both perspectives of constructivism emphasise people's positive activities during the learning process, which has a strong relationship with their experiences and can be seen as the key approach to forming knowledge (Cole & Wertsch, 1996). The differences are that Piaget's theory focuses on studying the internal principles of individual development, whereas Vygotsky's theory highlights the important role of social and cultural factors in individual development and states that learning cannot occur without communicating with the social environment (Cole & Wertsch, 1996). In other words, both perspectives of constructivism firmly support the constructive process of an individual's knowledge acquisition, the former is emphasising how individuals' experiences influence this process, the other focuses on what these experiences are (Blake & Pope, 2008).

To sum up, the perspective of constructivism in education believes that the knowledge forming process is related to the process of construction. The most effective learning is achieved by encouraging individuals to actively engage in an environmentally-related learning process (e.g. a real-world situation). The main theories described are all widely accepted and applied in education with a different emphasis in higher education.

Constructivism in Higher Education

Within the field of higher education (HE), de Graaff and Kolmos (2003) claimed that it has neglected pedagogy to a large extent. They further state that teaching at a university was usually the professors' job, and problems with HE teaching were paid little attention until student numbers increased enormously after the 1960s. For example, Kesidou and Roseman (2002) stated that student experience and prior knowledge is disregarded in scientific education and this is mirrored in relevant textbooks. The National Science Education Standards (National Research Council, 1996) and the AAAS report (Rutherford & Ahlgren, 1990) both advocate active learning by students themselves referring to awareness either in learning or in any other cultural and economic aspects. As a result, in many places, alternatives were suggested, such as the mass lectures attended by over a hundred of students (Van Woerden, 1991). Moreover, Frenay, Galand, Milgrom and Raucent (2007) have pointed out that traditional teaching strategies (e.g. lecturer-centred) in engineering programs are outdated and need to become more student-centred. These requirements all echo the essence of the 'constructivism' perspective and result in the need to develop a series of teaching and learning methods. Consequently, innovative teaching strategies and techniques are generated: for example, strategies similar to project-based and case-based learning, aimed at taking practical experiences into the classroom.

In the 21st Century, the new educational technologies have become the main forces that push academicians to construct alternative theories for learning (Oliver, 2002). For instance, the moves towards constructivism in higher education have been pushed by the emergence of universal connectivity through information and communication technologies (Wims & Lawler, 2007), which enables the masses to communicate globally, also providing possibilities to access world knowledge resources. Similarly, there are also a number of demands across the globe for improved design education, management education and industry relevance of the programmes. Within design education, project-based learning is gradually becoming the main teaching and learning strategy; moreover, given the access to broader sources of knowledge, collaborative projects are given increasing attention (Bell, 2010).

2.3.2 The reflective practitioner

The root of the reflective practitioner

Another notion of pedagogy that strongly connects with problem-based (PbBL) and project-based (PjBL) learning is the concept of the reflective practitioner as developed by Schön (1983), which is also built upon Dewey's theory, and seeks to rethink and reconnect his ideas (Waks, 2001). Based on reflective practitioner theories, several researchers endeavoured to enlighten the practical inquiry-based process through integrating conceptual analyses with empirical studies on expert practitioners (Waks, 2001).

Schön's theory was inspired by design education, meaning the basic ideas on the concept of design. He considered that all professional practice is design-like (Schön, 1987). Therefore, he focused on how design is taught and learned, and further pointed out the concept that the university can be seen as a collection of schools of design.

Reflective practice in higher education

In design education, Schön (1995) aspired to build an 'epistemological alternative', which revealed that professionals' actual practices are not acquired solely from science, but also from their experience and tradition. It is the professionals' actual practice which constitutes the core of professional knowledge. Schön (1983) stated that any profession's practice entails two layers of meanings, which refers to *knowledge-on-action* and *knowledge-in-action*. First of all, *reflection-on-action* involves either thinking over (reflecting on) an experience people already possess, or an action people had already committed, by conceiving what could have been done via varying approaches. The other layer of meaning, *knowledge-in-action*, means reflection on people's actions while they are engaged in carrying them out and conceiving how to achieve outstanding practice throughout the process. Another researcher, Johns (1995) echoes this perspective, stating that reflection may occur through 'looking in' on one's minds and feelings, as well as 'looking out' at the situation experienced.

As stated by Schön (1983), this kind of knowledge (on/in action) is not merely verbal, but does hold a verbal or discursive dimension, called tacit knowledge in Polanyi's (1966; 2009) terms. It is acquired not in the abstraction but in the application, where such a process is concerned with reflective practice. In addition, as Schön suggested, this kind of knowledge largely refers to forms of thinking specifically regarding professional practices and is grasped on the basis of numerous professional activities, rather than simply a few. This specific perspective developed at speed and generated different ideas about the university and its role in society. For Schön, the university can be seen as a design studio.

Based on this theory, a large number of design researchers and educators have expanded insights in this area; this includes the research of Dorst and Cross' (2001), who developed a series of theories on design processes and design problems. These studies provide a deeper insight into improving design education, e.g. setting an appropriate design task, as problem-based, project-based or workshop-based teaching and learning are largely adopted in design education (Macdonald, 2001; Prince & Felder, 2006). For example, as collected by de Graaff and Kolmos (2007), the University of Delaware and Samford University in the United States, McMaster University in Canada, the University of Maastricht in the Netherlands, Linkoping University in Sweden and the University of Newcastle in Australia have transferred their entire design curriculum to a problem-based format.

2.3.3 The relation between constructivism and reflective practitioner

Compared with constructivist pedagogical theory, the theory of the reflective practitioner would be more practical in education, especially in higher education, to cultivate professional graduates. They have areas of agreement in that they both accept the concept that knowledge is formed by construction. Basically, the reflective practitioner belongs to the family of constructivist pedagogy, but there is a slight difference: the reflective practitioner pays more attention to how the professions are cultivated. Although this is criticised in science education, when considering the principles of different disciplines, the effect that it has on design education has proven to be largely positive (Waks, 2001).

In sum, constructivism is a broad concept applied in various disciplines, including pedagogy. Its view of '*experiential learning*' is also the foundation of the theory of the reflective practitioner. There are other theories applied in pedagogy such as heuristic methods, discovery learning, and learning by doing, which reflect the nature of *experiential learning* with the perspective of constructivism. This research project considered the reflective practitioner to be the primary pedagogical theory as it is accepted and applied widely in design research and design education at the higher education level, which conforms to the research background and research field. Moreover, a comprehensive understanding of the constructivist perspective in pedagogy is the primary step in understanding the basis of relevant teaching and learning strategies, which assists in-depth thought about essential pedagogy, e.g. how people learn and how to teach.

Two pedagogical theories – constructivism and the reflective practitioner – have been reviewed and discussed in this section, which explored how individual knowledge is formed and how this process can be achieved through educational approaches. This review provided a comprehensive understanding of the nature of relevant strategies of teaching and learning generated by these theories, such as case study-based, workshop-based, discussion-based, and problem-based and project-based learning. The following section (2.3.5) explores problem-based (PbBL) and project-based (PjBL) learning, which are the most widely used strategies in the constructivist approach.

2.3.4 Problem-based (PbBL) and project-based (PjBL) strategies

This section focuses on distinguishing these two similar concepts in a pedagogical context.

i) Problem-based learning (PbBL)

After McMaster University (Canada) applied the teaching strategy of PbBL in medical education from the late 1960s, PbBL began to develop, and scholars began to pay more theoretical attention to it from the 1990s. For example, in Denmark, it is accepted that, to a certain extent, the theoretical base of PbBL was related to *experiential learning* (Savin-Baden, 2000). The following are representative theoretical learning principles from several scholars which are related to PbBL. Dolmans et al. (2002) defined PbBL "in relation to theoretical learning principles, such as learning as the construction of knowledge, meta-learning and contextual learning" (in de Graaff & Kolmos, 2003, p.657). Savin-Baden (2000) described five different models of PbBL "resting on five different views of the objective of PbBL, including the perception of knowledge, learning, problems, students, teacher roles, and assessment". Savin-Baden (2000) further referred to these five PbBL models as "attainment of knowledge, PbBL for professional work, PbBL for interdisciplinary comprehension, PbBL for cross-discipline learning and PbBL for critical competence" (ibid, p.657). Barrows from McMaster University in Canada who was involved in the early stages of PbBL development provided a definition of PbBL as "being student-centred, taking place in small groups with the teacher acting as a facilitator, and being organised around problems" (quoted in Krajcik & Blumenfeld, 2006, p. 320).

A specifically designed problem should be the core of this kind of strategy. However, there can be a number of difficulties in problem design, the most significant being that few studies pay the attention to the types of problems appropriate for application, and how they and where they might be used with reference to the level of the curriculum. Early work concerning these issues included Schmidt and Bouhuijs' (1980) study, which defined problems from the view of typology by identifying differences between the types of material presented to students. Alternatively, PbBL is used not only as an instructional strategy, but also as an approach for setting up the curriculum. For example, Savin-Baden (2000) has developed seven curriculum models centring on PbBL, which suggests that its design in educational practices would be highly flexible and would vary from college to college.

ii) Project-based learning (PjBL)

As a teaching strategy, the original idea of applying project work has been ascribed to the American author William Kilpatrick, who played a significant role in the progressive education movement in the early 20th Century (de Graaff & Kolmos, 2007).

Several pioneer universities have applied this teaching strategy since the 1970s: representative ones include Aalborg University and Roskilde University in Denmark. As one part of the constructivist pedagogy family, the use of PjBL has increased since the 1980s (Morgan, 1983; Morgan et al., 1984, cited in Gao, 2012).

Adderley (1975, p. 1) defined the PjBL by the following five aspects,

1. [Projects] involve the solution of a problem; often, though not necessarily, set by the student himself [or herself];
2. They involve initiative by the student or group of students, and necessitate a variety of educational activities;
3. They commonly result in an end product (e.g., a thesis, report, design plans, computer programme and model);
4. Work often goes on for a considerable length of time;
5. Teaching staff are involved in an advisory, rather than authoritarian, role at any or all of the stages – initiation, conduct and conclusion.

Greeno (1998) defined PjBL as a type of environment-based learning. He suggested that PjBL is established on studies of constructivist pedagogy, which means that students will comprehensively understand the material if they construct their understanding actively through invoking ideas and working with them. To take this further, in the process of PjBL, students' engagement in a series of real, meaningful problems helps them to better construct their knowledge. These problems should be important to students, and are similar to what scientists, historians, and writers do.

There are several other terms (e.g. projects, project work) conceived and used for project-based learning (Heywood, 2005). Therefore, the term *project* may be rather broad. This may be related to a task, an exercise, a programme, an activity, or a scheme; they may be conducted in groups or by individuals, and implemented in a range of places, including the library, laboratory, studio, community, or working places; they may last from weeks to a semester, with different lengths; and finally, they may conclude with different kinds of outcomes such as oral or written work (Brown, 1997). These varieties may result from conflicting objectives and assumptions about educational practices (Morgan et al., 1984). Thus, in higher education, it is usual that a large number of courses involve activities which seem like a project, but are carried out through various approaches, such as courses based on studio or workshop learning (Adderley, 1975; Morgan, 1983; Morgan, Henderson, & Natheson, 1984).

iii) A comparison between PbBL and PjBL

It can be seen from the literature reviewed that few people agree on the precise definitions of both PbBL and PjBL and how they differ from each other. In fact, the two terms are often used interchangeably (Markham, 2003). Accordingly, the elementary but usually neglected difference between the two terms is that PjBL may begin with an ill-defined problem, but typically has an end product or artefact in mind, e.g. ideas or concepts (Blumenfeld et al., 1991; Barron et al., 1998; Hanney & Savin-Baden, 2013). PbBL also begins with an ill-defined problem to solve, but often in the form of a case study, and the outcome of information gathering, organisation and analysis may not be an end product. Thus, PbBL is often considered a sub-element of successful PjBL (Blumenfeld et al., 1991). In other words, it is the problem within a project which is ordinarily activating or driving it (de Graaff & Kolmos, 2003; Thomas, 2000). From this point of view the PbBL is a broader concept than PjBL, which can be applied in either curriculum development or varied types of teaching and learning practices, whereas the PjBL has a broader scope and is more about form and strategy during teaching and learning practices. For example, the differences in type and range of problems in these two approaches are reflected in their respective scopes, as Prince and Felder (2006) noted: "a project typically has a broader scope and may encompass several problems" (p. 129). The heading of 'Problem-Orientated' and 'Project-Based Learning (POPBL)' specifically reflects this distinctive feature of the two terms but associates them by stating that "…where the project centres on a real-world problem" (Lehmann, Christensen, Du, & Thrane, 2008, p. 284).

Another featured difference between the two teaching and learning strategies is related to the knowledge being acquired. Savin-Baden (2000) found that PbBL focuses more on the *forms of knowledge*, whereas PjBL is more related to *types of activity*. Furthermore, Prince and Felder (2006) discovered that the PbBL emphasises on the *acquisition of knowledge,* underlining the fresh knowledge or skills delivered through dealing with a typically conceived problem, whereas PjBL pays more attention to the *application of knowledge*, which emphasises use and reinforcement of knowledge already acquired, rather than absorbing new knowledge.

The main similarities and differences between PbBL and PjBL are summarised in Figure 2:

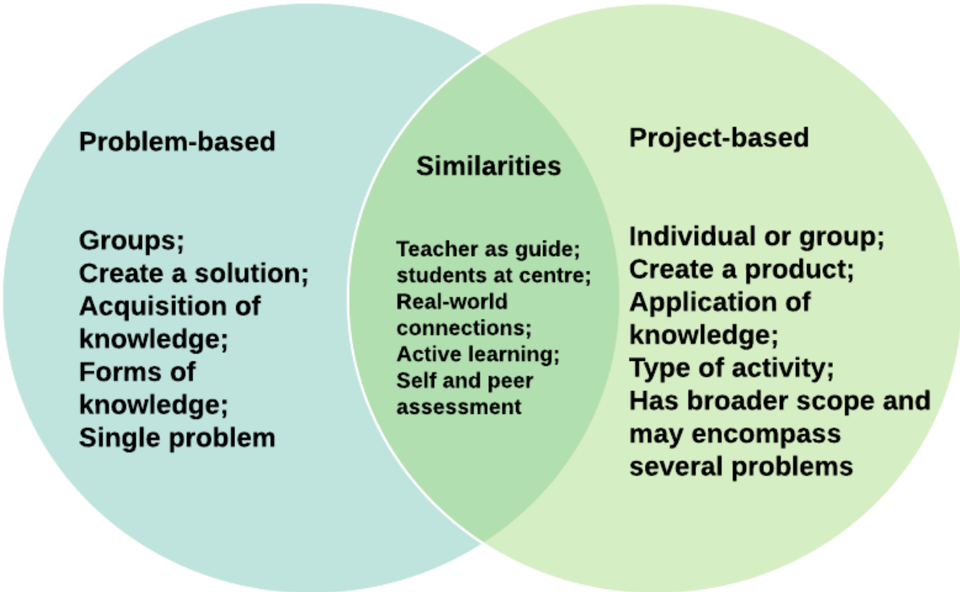

Figure 2. The main similarities and differences between PbBL and PjBL

2.3.5 Teaching and learning strategy in this research

The FYDP is largely related to PjBL, and as discussed, the main features of PbBL are also reflected by PjBL, such as *problem-driven* and *student-centred learning*. Therefore, the PjBL was identified as the main teaching and learning strategy for this research in relation to the FYDP, which belongs to the family of constructivist pedagogy and is based on the reflective practitioner.

2.4 The effectiveness of the FYDP in design education

As interpreted in the previous section (section 2.3, pp. 14–28), the FYDP follows the same principles as the PjBL. Therefore, to establish the effectiveness of FYDPs, relevant research on the effectiveness of PjBL may provide further insight. Accordingly, PjBL represents a greater paradigm shift and an overhaul of traditional methods. To improve its effectiveness, several studies have been done to address the crucial criteria to measure the effects of PjBL. For example, Luan and Bakar's (2008) study emphasised the important role of design teachers. They stated that to be effective, PjBL should be interactive between students and teachers and should involve a minimum of lectures. Teachers should serve as a facilitative source of knowledge: maintaining the role of guide and resisting the temptation to put students on the right path are an important part of the effectiveness of the methods. In addition, the teacher should establish an environment where it is acceptable to make mistakes (Mierson & Freiert, 2004). In addition, other studies discussed the effectiveness of the view of self-directed learning theory and learner engagement theory (Gao, 2012). However, only a few studies focus on PjBL's effectiveness from the viewpoint of creativity. One stated the current research over-emphasises the design project ignoring the students' creative process (Alhajri, 2013). Aligned with Alhajri's perspective, Adams (2005) argued that in addition to enhancing broad of thinking skills, PjBL may prove effective for creativity.

The teachers and students in the curriculum system are relatively stable elements and their improvement is a gradual process involving changes at the macro, structural and administrative level e.g. in the national education system and policy. Therefore, the perspective of the teachers' role in PjBL would probably not be the most practical approach in a Chinese context to improve its effectiveness. Thus, this research tended to pay more attention to Alhajri (2013) and Adams' (2005) perspective, and interpreted the relationship between creativity and PjBL from three aspects: PjBL's related theoretical base – the reflective practitioner; PjBL's driving force – an ill-structured problem; and PjBL's feature of student-centred learning, as identified in section 2.3.5 (p. 28).

2.4.1 The reflective practitioner and creativity

From the pedagogical view of PbBL and PjBL, the theory of 'the reflective practitioner' believes that students' learning process or knowledge acquisition is more related to 'doing' than 'memorising', emphasising their personal experiences in this process. For instance, Boud (1985, p. 11) argued that "reflection is an important human activity in which people recapture their experience, think about it, mull it over and evaluate it. It is this working with experience that is important in learning." Schön (1983) distinguished two types of cognitive activities when reflection occurs, which are reflection-on-action and reflecting-in-action. The former involves either thinking over (reflecting on) an experience people had already had, or an action people had already carried out, by conceiving what could have been done in varying approaches and at the same time seeking the positives from such conceptions. The latter refers to reflecting on people's actions while they are engaged in doing them and conceiving how to achieve outstanding practice throughout the process. The two types of reflection involve two types of the individual's experience, that is, their prior knowledge or experiences and what they are currently experiencing. Therefore, from this point of view, the reflective activity can be seen as experience-based.

Several studies on reflection stress its importance from the perspective of people's experience. For example, Kolb and Fry (1975, p. 39) stated that "this [reflection] takes place after a situation has occurred, and entails a practitioner reflecting on the experience, gaining a general understanding of the concepts encountered during the experience, and then testing these general understandings in a new situation. In this way, the knowledge that is formed from a situation is continuously applied and reapplied, building on a practitioner's prior experiences and knowledge." This suggests that people's different backgrounds may result in different perspectives when they are facing a similar situation, which would probably evoke the possibility/potential for creativity (Kaufman & Baer, 2005).

Alternatively, several researchers consider reflection to be connected with critical thinking, which is also seen to have a strong relation to creative thinking (Lau, 2011; Oxman-Michelli, 1992). The work of Rolheiser-Bennett, Bower, and Stevahn (2000) indicated that students would largely benefit when they are engaging in reflective practice, as it fertilises critical thinking and decision-making, which is fundamental to achieve continuous improvement and learning. Brookfield (1998), who is a specialist in adult education, may further supported this perspective in his study, suggesting that reflective practitioners keep researching their presumptions critically by considering practice from four complementary facets, including "our autobiography as a learner, our learners' eyes, our colleagues' experiences, and theoretical literature" (Brookfield, 1998, p. 202). In the design profession, Schön (1995) argued that to design is to create a framework of meaning through practical operations in an uncertain situation. This meaningful framework can be achieved by viewing those situations through a critical lens, because doubting can be seen as thinking in a specific way, through which designers question and frame situations as 'problems'. This is also where Schön considers that professional growth begins.

To conclude, it is 'human experience' that "brings action and creativity together" (Dewey, 1934; see also Glaveanu et al., 2013, p. 2). To go further, the action that achieves creativity relies on experience-based reflection. In the process of PjBL, students are experiencing an authentic designed situation, and are encouraged to apply what they have learned so far to solve the problem formulated. This largely reflects the core of experiential learning and provides sufficient conditions to stimulate students' acts of reflection. From this view, the PjBL emphasises enhancing creativity through providing a real-world situation for students to integrate what they have learnt and what they are experiencing via efficient stimulation of their reflective activities.

2.4.2 Ill-structured problem

As reviewed in section 2.3.4 (pp. 23–28), being problem-driven is one of the main features of PjBL. Within a design project, this would probably refer to the design problem. Accordingly, this is commonly considered to be an ill-defined or wicked problem, which as Christensen (2005, pp. 58–59) argued "[has] no clear path available to arrive at a correct response". Ill-structured or wicked problems can also be considered as related to social or cultural elements and are hard to solve; Kolko (2012, p. 10) concluded that there are four reasons for this:

1. [There is] incomplete or contradictory knowledge and continuously changing requirements;
2. The interconnected nature of these problems with other problems;
3. The large economic burden;
4. The number of people and opinions involved.

Buchanan (2010) agreed with this and pointed out that the solutions to wicked problems “cannot be true or false, only good or bad” (p. 16), and “there is no exhaustive list of admissible operations in solving wicked problems” (ibid., p. 16). He further commented that “no definitive formulation, but every formulation of a ‘wicked problem’ corresponds to the formulation of a solution” (ibid., p. 16).

It is suggested that due to this uncertainty of the solutions to ‘ill-defined’ or ‘wicked’ problems, creativity may occur. As Williams, Ostwald, and Haugen (2010) stated, “the common definition of design problems as *wicked* or *ill-defined* implies the importance of creativity to design; these problems require a particular (creative) approach in order for them to be solved” (p. 14). Buchanan (2010) argued that “for every wicked problem there is always more than one possible explanation, with explanations depending” (p. 16) and therefore, “every wicked problem is a symptom of another and each problem is unique” (ibid., p. 16). One critical principle of the wicked problem is to make sure that there is sufficient space for students to find their own ways to the solutions by providing them with problems (situations) without predetermined forms of solutions, as pointed out by Blumenfeld et al. (1991).

In summary, as Hanney and Savin-Baden (2013) stated, regarding the ill-structured or wicked problem as the core of a project helps to retain the open-ended and creative nature of enquiry, which may be inhibited by any relatively prescriptive project management protocols. As a result, students will gain more opportunities to design their own solutions while constructing and applying their knowledge in such a problem-solving process.

2.4.3 Student-centred learning

PjBL has a strong link with the fostering of creativity, which is also reflected in those pedagogical conceptions such as *experiential learning, learning-by-doing, discovery learning, and student-centred learning* (Gao, 2012). Amongst these constructivist perspectives, according to Prince and Felder (2006), student-centred learning would be the core of PjBL. Brown's (2007) study may support this assumption as it has summarised three specific characteristics of student-centred learning, which refers to students' responsibility for self-learning, the freedom of choice, and the condition of a supportive environment which helps to fulfil students' potential. To be more precise, Blumenfeld (1991) stated that student-centred learning enables students to enhance their abilities of decision-making and controlling the learning process, e.g. what they need to deal with and how to do this, what products to generate. He further explained that such abilities of choice and control are significant in raising students' motivation to learn as seen from the cognitive perspective. Moreover, learner control also brings more opportunity for students to apply their prior knowledge and experience: in other words, this also helps to facilitate their activity of reflection (Prince & Felder, 2006).

William Kilpatrick, an American teacher and theorist, observed that students' enthusiasm for project work is dependent on whether they can make their own choice freely (Knoll, 2012). If they are provided with more freedom to make their own choices, their enthusiasm is likely to be stimulated. This enthusiasm possibly relates to human traits like curiosity, self-determination, and the sense of mastery, which is also regarded as facilitating creative performances (Schmidt, 1983). Therefore, PjBL is believed to provide students with a 'congenial' environment for improving their creative performance, as Csikszentmihalyi (2014) has stated.

The PjBL strategy can be said to be purposeful in facilitating students' creativity from its theoretical essence (the experience-based reflection), its driving force (the ill-defined/wicked problem) and its form (student-centred). PjBL creates several conditions to stimulate activities that may lead to creativity. Therefore, PjBL can successfully involve learners' own experience in the learning process to stimulate their reflection and provide an opportunity to nurture a teaching and learning environment as an incubation space for creativity. Based on the PjBL principle, the FYDP is designed to play such a role during students' final stage of learning and to better facilitate students' creativity compared to other educational strategies. Therefore, this study argued that any discussion of the effectiveness of the FYDP should pay more attention to the perspective of creativity fostering. In addition, this study found that these conditions may be of more benefit to those students who have better skills as 'reflective practitioners', are good at generating their own ideas and think more independently, all of which are believed to contribute to their creative thinking abilities. Thus, those students who have weaker creative thinking abilities may not perform so well in such a process.

2.4.4 FYDP in China's Bachelor product design programme

In design education, design projects are widely regarded as the core activity of product design (Uziak, 2015), and have been used as vehicles to motivate and integrate learning, e.g., Georgia Tech's Learning by Design™. With respect to the research background of this study, comparing the pedagogical principles and features of PjBL with what has been investigated in China's FYDPs, several key issues regarding its effectiveness have been identified:

1. PjBL reflects the theory of the *reflective practitioner* which emphasises "a practitioner's prior experiences and knowledge" (Kolb & Fry, 1975, p. 37) and therefore, echoes its feature of *application of knowledge.* The circumstances clearly indicate that Chinese students find difficulty in applying prior knowledge efficiently to progress their project work in FYDPs.
2. Student-centeredness is generally believed to be a strength of project-based learning as well as other similar constructivist approaches, which is thought to provide an appropriate environment for encouraging students' creative performances. The status quo in China shows that a number of students lack the ability to conduct projects independently, thus teachers intervene significantly in FYDPs.

3. Being problem-driven is another feature of PjBL, which is also of concern with creativity; however, most Chinese students find difficulty in the 'defining problem' stage in FYDPs and tend to fail to achieve the learning outcomes.

The three aspects, namely, PjBL's related theoretical base – the reflective practitioner, PjBL's driving force – an ill-structured problem, and PjBL's feature of being student-centred are working together to foster creativity efficiently. Amongst them, the theoretical root is believed to be more essential to PjBL. It is a precondition that students during PjBL are able to apply or integrate their prior knowledge into this process. Otherwise, the ill-structured problem would not be properly addressed and the student-centred strategy would not work efficiently. Thus it is not surprising that Chinese design students reflect their own shortcomings in all three aspects of PjBL, indicating that its efficiency in fostering creativity may not be as good as expected.

In addition, there are several research projects that investigated Chinese students' creative abilities in relation to how they try to find solutions to a given problem. For example, Lv (2002) and Yang (2006) applied the Runco Ideation Behaviour Scale (RIBS) to measure college students' creativity from the 20 main cities in China. This instrument focuses on measuring creative ideation including items of actual behaviour description (i.e., overt actions and activities) that clearly reflect an individual's use of, appreciation of, and skill with ideas. The results of their studies indicated that over 60% of China's students are not good at producing original ideas. These perspectives echo

Wang's (2011) claim that most Chinese art and design students represent less ability in creative thinking, which is shown in their divergent thinking, e.g. imagining, abstracting, associating, but also their abilities in analysing, criticising and synthesising material, namely, the convergent thinking abilities. As PjBL is specifically designed to foster the creativity of students, it is reasonable to question that when applying PjBL in China, is there a failure to boost the creativity, the main underlying reason for the perceived issues? Further information about the creativity was needed to explore this question.

The previous section, 2.3, and this section, 2.4 (pp. 14–38), clarified the pedagogical theories regarding the FYDP by analysing the teaching and learning strategies of PbBL and PjBL, which are based on pedagogical theories of constructivism and reflective practice. The PjBL was finally considered to be the main pedagogical strategy to comprehensively understand FYDPs. The literature reviewed indicates that current investigation on PjBL strategies are focused on its efficiency in teacher instructions and roles, but less attentive to the effectiveness of students' adaptability from the perspective of creativity fostering. A specific perspective of creativity has been analysed to study the effectiveness of PjBL, and this research argued that creativity is an important aspect that relates to the effectiveness of FYDPs. With these concerns, the next section will examine the potential problems that may result from the cultivation of creativity in China's design education from a cross-cultural perspective.

2.5 A cross-cultural perspective on creativity

Creativity is a term mainly used in the Western world. Lubart (1990) and Fu (2003) argued that creativity can be understood differently by different cultures as there are indeed different perspectives on what is considered creative. Understanding the cross-cultural aspects of creativity is therefore important in understanding educational directions.

2.5.1 Creativity research in Western and Chinese culture

Creativity is “a multi-faceted phenomenon rather than a single unitary construct capable of precise definition” (Rhodes, 1987, p. 218), which refers to attributes or characteristics of a creative product, process, person/personality, and/or place, namely, the 4Ps (Kozbelt, Beghetto, & Runco., 2010; Gero, Jiang, & Williams, 2013). Therefore, it is impractical to provide a ‘one size fits all’ characterisation (Christiaans & Venselaar, 2005). Acknowledging the complexity of social context and environmental variables, creativity might be understood differently from culture to culture (Amabile, 1982), with different cultures having different perspectives on what is creative. Therefore, creativity can be considered as culture relative (Lubart, 1990). Creativity studies have been ongoing in China since the 1980s, at which time the development of creativity research was set up and based on the achievements of Western countries. Fu, one of China’s pioneer researchers on creativity, first identified and located the word creativity in the local context and pointed out that the awareness of being creative in China has a long history. He proposed that educators need to seek for its origination from philosophical perspectives rooted in Chinese culture (Fu, 2003).

Lubart (1990) also believed that religious/philosophical perspectives would be relevant and important for forming the perspectives on creativity, and how this concept is understood in the current social and political context, in order to better connect with and absorb those theories from Western cultures. The main differences between *philosophical perspectives, the social economic,* and *political context* between both cultures are given in Table 2:

Table 2. Summarised differences between Western and Chinese perspectives

	Religious/Philosophical perspectives	**Social/Economic context**	**Political context**
The Western	Christianity	Capitalist developed market economy	Individualism, Capitalism
The Chinese	Taoism, Confucius, Marxism	Developing socialist market	Collectivism, Socialism

Understanding the philosophical differences in perspectives of creativity between Western and Chinese culture is important as these differences ultimately drive educational goals. The main differences have been reviewed and summarised from the perspectives of the following three aspects.

First of all, from the aspect of philosophical basics, Lan and Kaufman's (2012) point of view is that the Chinese emphasise ‘novelty’ in creativity. This point of view has been supported by Paletz and Peng's (2008) study, which investigated evaluations of Chinese students and other students from Western countries (e.g. the U.S.) of products from the angle of ‘novelty’ and ‘appropriateness’, and they found that the Chinese were largely influenced by novelty rather than appropriateness. In contrast, Western students were more influenced by appropriateness and less by novelty. Moreover, Yue (2004) stated that to achieve creativity, the Chinese pay most attention to seeking traditional methods and skills, so they stress creativity from the social aspects, and tend to consider those products which satisfy traditions, rituals and social norms as creative (Ng, 2001; Sternberg, 1985; Westwood & Low, 2003). As a result, the Chinese would prefer to accept 'incremental' creativity (Gilson & Madjar, 2011). However, the situation is different in Western countries. They emphasised 'appropriateness' and 'groundbreaking' more when evaluating a creative product (Paletz & Peng, 2008), and therefore, they may respond to 'radical' creativity. This understanding of creativity derived from socio-culture would probably influence design students in the two countries.

As stated by Wonder and Blake (1992), the differences between East and West in terms of creativity are initially from two types of thinking, namely, the intuitive and logical. Their study indicated that Eastern thought, an essential driving force of 'novelty', is considered to be more 'intuitive' i.e. more subjective, experiential, and non-systematic. Differently, in Western thought a baseline of 'appropriateness', is regarded as more 'logical' i.e. more unemotional, structured, and individualistic. Therefore, Westerners appreciate that everything fits together following logic or according to principles, driven by their cultural emphasis on logic and appropriateness. In contrast, Easterners tend to re-arrange the pattern depending on the existent 'database' culture, rather than to push the creative process by integrating new information (Wonder & Blake, 1992). This coincides with the Chinese cultural emphasis on 'intuition' which relies mostly on the existing experience. This idea is also supported by other studies (e.g. Rudowicz, 2003).

Secondly, referring to the political context, Dineen and Collins (2004) stated that Chinese society has traditionally valued collectivity and conformity over the individual, which indicates that all people would be socially interrelated (Lau, Hui, & Ng, 2004). As Hsieh and Scammon (1993) stated, people in such cultures tend to look after others' needs and suppress their feelings to seek interpersonal harmony. Moreover, in Aaker and Schmitt's (2001) study, Chinese participants are more favorable to assimilation needs. However, Westerners emphasise the diversity of needs, and the reason would probably be, as Zha, Walczyk, Griffith-Ross, Tobacyk, and Walczyk (2006) explained, that individualism has been commonly recognised as a defining characteristic of Western culture, thus they appreciate independence and an individual is perceived as a separate entity. In addition, it seems that the creative abilities are hard to form in a collectivist society as compared to an individualist society (Lubart, 1990).

Finally, as reflected in the social/economic context, the understanding of creativity within the Chinese background is more likely to perceive it as connected to a socially-related attitude. Li (2007) suggested that creative products include those products or services which represent social and cultural meanings, as well as symbolic values; whereas in Western countries, creative products are mainly generated in the condition of intellectual property rights, which has been created in the light of demands of the individual (Li, 2007).

Although creativity reflects the cultural context of the three specific aspects, Fu (2003), Niu and Sternberg (2002) claimed that Western and Chinese cultures do share the universal core characteristics of creativity. For example, cross-cultural studies indicate that the Eastern creative process shares a similar form to the Western concept of the basic four stages for problem-solving: *preparation, incubation, insight* and *verification* (Lubart, 1990).

2.5.2 Design creativity

Clearly, design is ultimately a creative process, and thus many design researchers consider it aligned with creativity research (Williams et al., 2010b). Therefore, there is no surprise that product design as a *problem-solving* process is also a commonly accepted concept of a creative process. Thus, this study centred on the concept of *problem-solving* as the principle to define design creativity within the context of China's product design education system.

Creativity processes involve divergent thinking (Kaufman & Sternberg, 2010), which is a key factor in generalising creative ideas. Supported by this perspective, numerous tests for divergent thinking have been developed. Guilford (1957) argued that, "No creative person creates in a vacuum or with a vacuum." (p. 110) It has been observed by Hertzberger (1991) that "…essentially the more you have seen, experienced and absorbed, the more points of reference you will have to help you decide which direction to take: your frame of reference expands" (cited in Lawson, 2006, p. 156).

This means that what individuals learn and experience, the knowledge base and its diversity, plays a significant part in a successful creative process.

Recently the focus has changed from developing a stage-based model for solving the problem to exploring the interaction between each stage, especially how divergent – convergent interactions occur (Cropley, 1999; 2006), and to the development of cognitive models to describe creativity as a constant oscillation between divergent and convergent thinking.

In contrast to the process evolved in Western cultures, emotional, personal, and intrapsychic elements have more emphasis in the Eastern creative process, which echoes its notion of a self-growth process connecting with its traditional and philosophical origin (Lubart, 1990). Indeed, design and emotion as a concept is only a recent direction in Western design practice. Western and Chinese cultures do however share the universal core characteristics of creativity, such as the form of a creative process with *problem-solving* accepted by both. The development of a sound knowledge base plays a key role in cultivating talent in the Oriental culture, as to accumulate knowledge from a very young age has been emphasised in China from ancient times and is believed to provide abundant resources for the process of self-growth**.**

2.5.3 Discussion

The FYDP curricula so far reviewed involves a problem-solving process, concurrently implied within general creative and design processes and which is universally accepted by both cultures as a fundamental requirement. Although both Eastern and Western cultures accept *problem-solving* as a creative process, the emphases are different. While the Western emphasis is on the *divergent – convergent* process, the Eastern emphasis is on the *self-growth* process. The main differences in creativity cultivation from both cultures are summarised in Figure 3:

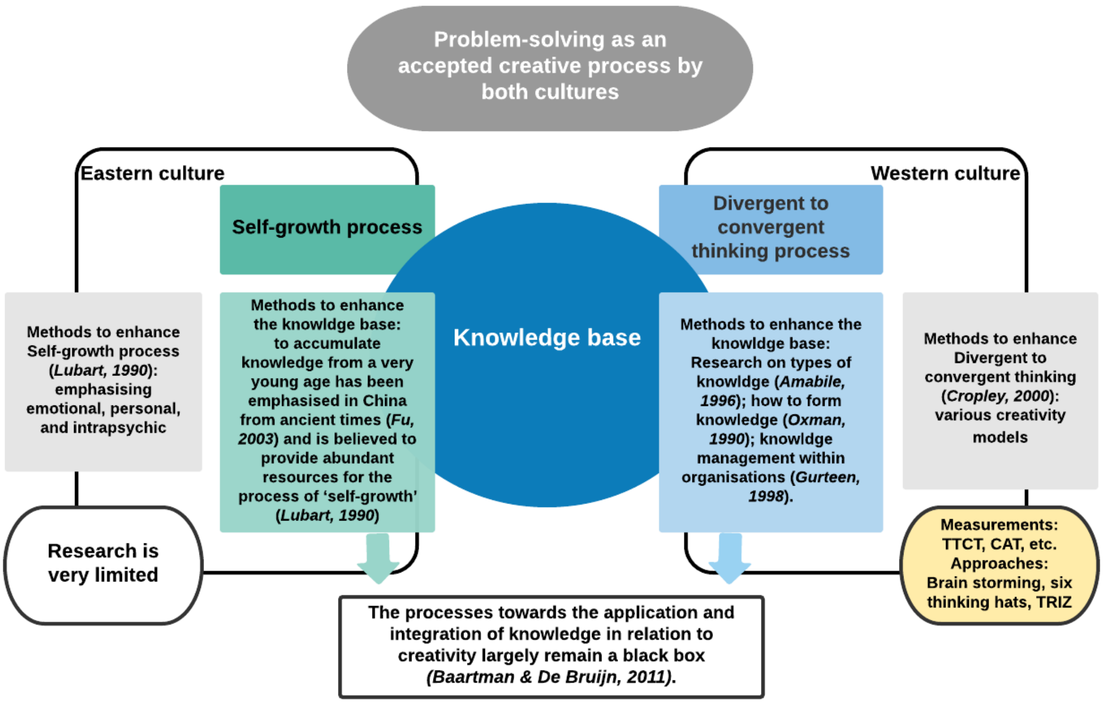

Figure 3. The main differences in creativity cultivation between Oriental and Western cultures

The current literature implies that there is little direct focus on the knowledge base as it is considered as fundamental for divergent thinking. The focus is merely on identifying how many kinds of knowledge types should be included (Osmond & Bull, 2013). Western culture has put great emphasis on the mechanics of the cognitive process via the psychological approach by developing a large number of measurements and approaches to improve creative thinking. Eastern culture pays more attention to enhancing students' abilities of cumulative knowledge and pays less attention to cultivating their relevant creative abilities; however, research on an effective approach to achieve self-growth in creativity by accumulating knowledge is very limited. The processes towards the application and integration of knowledge in relation to creativity largely remain a black box in both cultures.

China's product design students' performances in the FYDP are reflecting their abilities of flexibility, curiosity, independence, tolerance for ambiguity, trust in their own senses and restructuring problems. However, most are deemed weak, which echoes that student-centredness and the problem-driven aspects of PjBL are poorly progressed. This is explained from its theoretical base of 'reflection', which manifests as shortcomings in applying learned knowledge. But the most essential reason would be that this circumstance may result from their lack of creative abilities, which are hard to form in a collectivist society compared to an individualist society. There is the fact that Chinese students are cultivated to have a strong fundamental knowledge base, as knowledge accumulation is particularly emphasised in Chinese education; however, without an efficient approach, it is still hard to achieve creativity. Therefore, this thesis argues that lack of creative abilities results in China's students being unable to apply knowledge efficiently in the FYDP, which leads to poor creative performance.

2.6 The research problem and aims

It is proposed that the underlying issues of cultural difference may result in perceived performance issues in China's product design students' FYDPs. Due to a lack of creative abilities, students may not adapt to the process of the FYDP, even if they have strong background knowledge. It is supposed that in a well-progressed FYDP, the accumulated knowledge should be activated and applied in a certain creativity-relevant pattern, which helps to improve the creative performance. As those creativity-relevant aspects of personality are not easy to form in China's cultural background, it is necessary to provide more constructive and practical suggestions on how to apply knowledge appropriately, which would probably be the most direct and practical way to improve the situation in China's product design FYDP. These suggestions are proposed to provide relevant information about the main body of knowledge that should be used in the FYDP, and, more specifically, to articulate the role of each element of knowledge applied in the FYDP in relation to creativity. It can be applied as a guide for both product design teachers and students in the process of the FYDP, informing them of the kinds of knowledge to which they should pay more attention and which should be used more frequently to help improve the FYDP process.

As the FYDP is always set at the end of a four-year study, it is supported by the previous courses; therefore, these suggestions may also be applied as a guide to help improving the product design syllabus in order to satisfy the requirement of FYDP for both creative students and the less creative ones (effectively applying knowledge).

The research problem has been identified and interpreted below:

- Chinese students are dependent on their lecturers;
- This dependency is related to their creative thinking abilities which determine how they link and apply the knowledge learnt appropriately.

It is assumed that practice by the better-performing students, if circulated, will help their relatively weaker peers to develop and improve. With this assumption, it is interesting to observe how the more creative students apply the knowledge item learnt. It is hoped that suggestions can be drawn from the analysis of students with different levels of creative thinking abilties, which would help all students in general to improve. Furthermore, the tutors and teachers can rely on these suggestions to a certain degree to guide the students in the FYDPs. As a result, perceived suggestions of knowledge application would be creativity-related, as they are expected to be used as a guide for related educational practices (e.g. activities in the FYDP process). Therefore, exploring the interactions between knowledge application and creativity would provide a new perspective for future research, and thus formed the research focus of this project. The research aims are listed below:

- RA1. To obtain a more comprehensive understanding of subject-related knowledge applied in relation to creative thinking in the FYDP process.
- RA2. To provide practical suggestions for knowledge application to improve design students FYDP process.
- RA3. To obtain a more generalised conclusion, this study intended to explore the knowledge application within at least two different cultural contexts.

To achieve the research aim, several objectives are needed:

1. To explore current studies regarding the main issues involved in this study, including creativity, knowledge application, and subject-related knowledge applied in the FYDP;
2. To construct the theoretical foundation of this study and locate the literature gaps;
3. To explore the interactions between knowledge application and creativity during product design students' FYDP via designed methodologies in two different countries;
4. To systematically analyse and discuss the result of a survey to articulate the findings of this study;
5. To compare the results of a survey whose data was collected from different countries;
6. To draw implications for design educators and students;
7. To state the limitations of this study, provide suggestions for further study, and reach conclusions for this research project.

Part II. Theoretical foundation

2.7 Overview

This part of chapter two presents a review of the literature covering relevant issues and topics related to this research. This section aims to achieve the research objectives 1 & 2 (section 2.6, p. 47). The theoretical foundation of this research was then constructed and suggested after a critical discussion of the literature reviewed, which specifically provides a theoretical understanding of interactions between knowledge application and creative-related constructs. Based on this literature survey, the knowledge gaps have then been identified.

Apart from the present section (2.7 chapter overview), this chapter also embraces the following sections, which reflect the scope of this literature survey: 2.8) The strategy of the literature review; 2.9) A brief history of creativity research; 2.10) Definitions and measurements of creativity (the creative personality, creative process, creative product); 2.11) Creativity and metacognition; 2.12) Creativity and knowledge; 2.13) Metacognition and knowledge; 2.14) Design knowledge; 2.15) Constructing the theoretical framework; 2.16) identifying the knowledge gaps; and 2.17) stating the research purpose. The mental model of conducting this literature review is represented in the graph (Figure 4, p. 51):

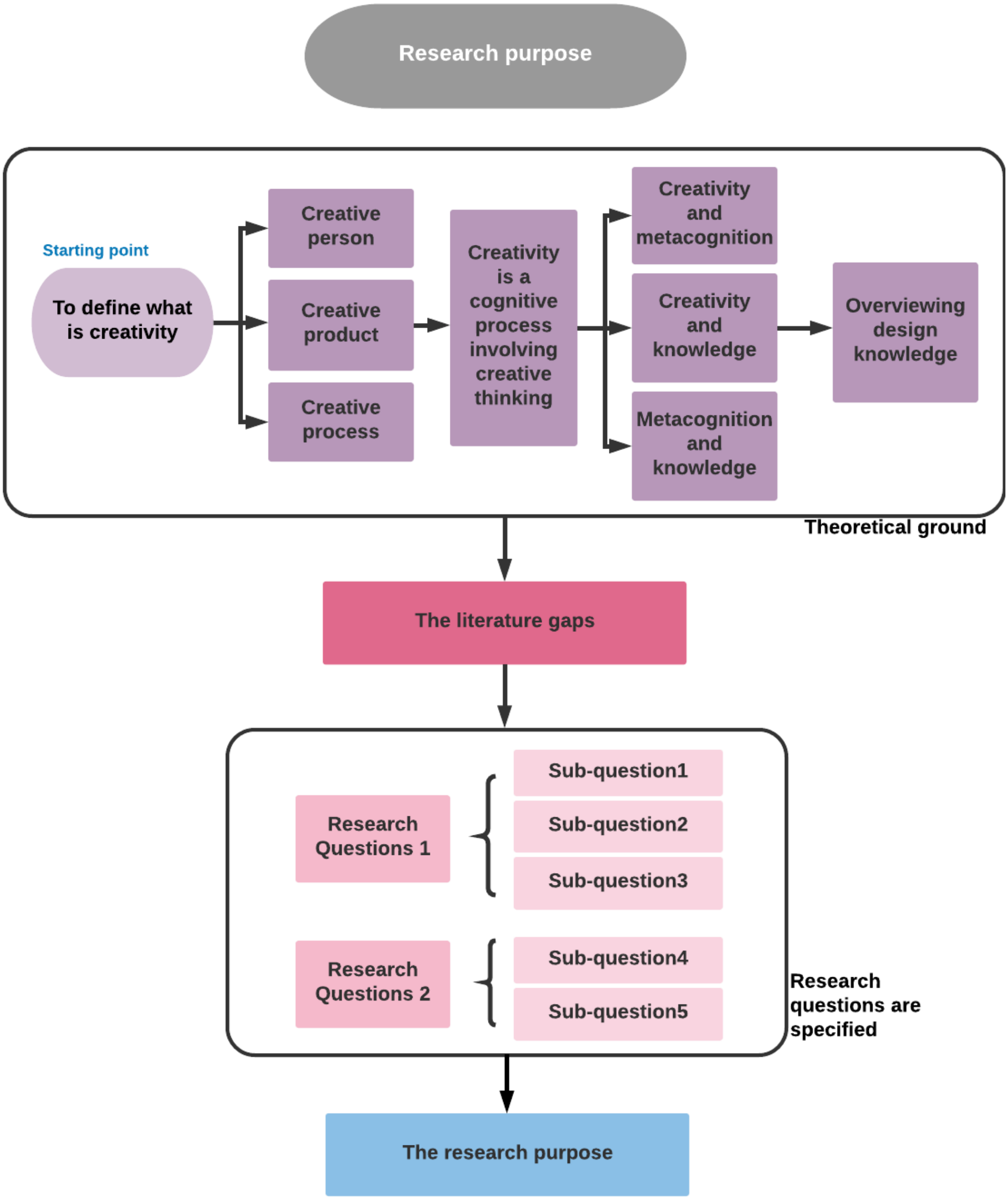

Figure 4. Mental model of the literature review

2.8 The strategy of this literature survey

A literature review is the first step in conducting any research. A good-quality literature review provides a solid foundation for a study, as it is used to clarify particular issues and areas and determine the literature gaps through critical and in-depth evaluation of previous research. Therefore, it is considered "an examination of the research that has been conducted in a particular field of study", as Ferfolja and Burnett (2002) stated. A literature survey aims to choose relevant research from existing literature and analyse both the positive and the negative elements. It also gathers data from different studies and investigates them further. An effective literature review typically utilises systematic and explicit approaches. The systematic approach often includes a stage of analysing statistically the data gathered from all relevant research, i.e. meta-analysis, to produce combined results. Alternatively, the explicit approach is progressed by examining relevant theories and models, analysing and comparing those issues considered to be similar (Obenzinger, 2005). The former approach is frequently applied in biomedical or healthcare disciplines (Obenzinger, 2005), and therefore was not suitable to apply in this study. The latter is commonly used in the domain of social science, thus the present research applied the latter approach of 'explicit', which follows Alhajri's (2013, p. 22) suggestion that "it was achieved by looking up and checking the most repeated themes and agreed consensuses reported by significant scholars" to further explore the research-related issues identified. Through this literature survey, the research hypothesis has been set up based on an established theoretical foundation which articulated the relationship between knowledge application and creative-related constructs.

To search for research-related information, a variety of both published literature and electronic resources were explored. The main online databases searched include Science Direct, APA PsycNET, Springer Link, and Taylor & Francis online. In addition, university-provided resources such as MetaLib were used to identify advanced scientific journals and databases in the most relevant research area, e.g. *Design Studies, Design Issues, International Journal of Design Creativity and Innovation, and Creativity Research Journal*. These resources all contribute towards a thorough study of the most up-to-date research in creativity, product design and design education from various views, e.g. psychological and social-cultural studies.

2.9 A brief history of creativity research in Western culture

Guilford (1950) stated that being creative is an essential part of being a person, and without it none of us would be the person we are. Creativity distinguishes human beings from animals, and it forms everywhere accompanied by the development of human civilization. However, contradictorily, it is still a phenomenon with plenty of vague areas. In Western culture, studies of creativity have been carried out for hundreds of years from ancient times to nowadays.

This began when people became aware of art creation activities, though in the ancient Greek era the traditional meaning of art was merely a *skill*. Plato made use of the word *creative,* and one could say that Aristotle was the very emulation (Williams, 2001). Creativity has since been a topic of discussion as to its origin, so that it can be defined as either an innate or acquired gift (Kaufman & Sternberg, 2010; Williams, Ostwald, & Haugen, 2010).

Research and analysis on the meaning of creativity began in the mid-twentieth century. In 1950, J.P. Guilford chose ‘creativity’ as the topic of his presidential address to the members of the American Psychological Association (APA), which can be seen as “the beginning of the era of research on creativity in psychology” (Kobnithikulwong, 2007, p. 22). Many psychologists were inspired by his presidential address. As a result, the psychological study of creativity became popular and attracted the most serious research effort in the twenty years following. The focus of the research was mainly on the cognitive processes behind creativity.

From a historical view, the development of creativity studies passed through several stages: the preliminary stage (1920–1950); the stage of developments in the basic creativity model: personal traits from the view of behaviourism (1950–1970); the stage of developments in the micro-stage stage: creative thinking from the view of cognitivism (1970–1990); and the stage of socio-cultural perspectives from the view of constructivism, where multidisciplinary and cross-cultural research are involved (1990–2010). Modern creativity studies originate within psychology, and have then been developed and applied to other domains (e.g. education and social science).

2.10 Creativity definition and measurement

Getzels (1975) argued that although creative imagination is essential to proposing new questions, leading to new scientific development, there is no common agreement on the definition of creativity. In fact, a disparate level or form of creativity can be identified in every human being, hence it would be more appropriate to regard creativity as “a multi-faceted phenomenon rather than as a single unitary construct capable of precise definition” (Rhodes, 1987, in Rhodes, 1987, p. 218). Hence, other researchers such as Christiaans and Venselaar (2005) agreed that it would be practically impossible to obtain a definition of creativity that is precise in every aspect and in every domain. Bjørner and Kofoed (2013) argued that it is vital to include both the macro level and micro level of social context in defining and using creativity in technical solutions. The influence of creativity varies greatly as well. It can be as small as merely individual level, or as large as historical creativity (Eysenck & Boden, 1994; Boden, 2004), where added information is significant to the history of a domain, or even significant to the history of humanity. From an educational perspective, according to Watts and Blessinger (2016), everyone is capable of developing their own potential creativity.

Sternberg (1999) suggested that categorising different viewpoints deduced from diverse creativity theories would reveal their interconnections and facilitate better understanding of them. The most common category, therefore, is comprised of four main aspects, named as the 4Ps, which are as follows; 1) person, 2) product, 3) process, 4) place/press (environment) (Rhodes,1987; Runco, 2003).

Cropley (2000) studied the effectiveness of using creativity tests to assess creative potential and suggested that most of the popular and effective creativity measurement tools follow the 4P construction. The Cropley’s study indicated that “flexibility, curiosity, independence, tolerance for ambiguity, trust in one’s own senses, and ability to restructure problems" (Cropley, 2000, p. 74) are examples of the most important capabilities individual persons possess in order to develop their own creativity. In particular, such capabilities would facilitate creative processes and activities including "problem recognition and construction, ideas generation, and decision evaluation" (ibid., p. 74). The outcomes of such activities, i.e. the product of creativity, are typically measured by criteria such as "originality, relevance, usefulness, complexity, pleasingness" (ibid., p. 74). Having an open, flexible, free and relaxing environment is recommended to increase motivations that contribute to creativity, e.g. "risk-taking, willingness to ask many unusual questions/to display results/to go beyond the conventional" (ibid., p. 74).

To comprehensively understand this human activity, most studies made great efforts in its definition and measurement. Considering its complexity and broad definition, these two dimensions have become very significant in studying creativity. In the following sections (section 2.10.1–2.10.4) the literature on the first three perspectives are reviewed and discussed, as "persons, processes and products" are considered the most essential components of creativity (Hasirci & Demirkan, 2007). The place (environment) perspective is not reviewed in detail here because this research is focused on the internal mechanisms e.g. the cognitive activities of knowledge application and its relationship to creativity, rather than the external mechanisms e.g. educational environment.

2.10.1 Creative person

i) Creativity research on persons

Over the past 50-plus years, many studies on personality research have explored characteristics, styles, preferences, attitudes and other various qualities that seem to differentiate highly creative individuals. Numerous studies have probed contextual qualities and stated that these influence the creative achievements of humans (Amabile, 1996; Woodman, Sawyer, & Griffin, 1993). However, Shalley, Zhou, and Oldham (2004) argued that a substantial amount of these research studies have concentrated on practices and procedures which are there to only decrease or cripple creative performance according to their evaluation criteria. One such example is Amabile's (1982) 10 personalities that contribute to creativity, based on her study of creativity for over 20 years. Guilford (1950) stated that the ability to be creative is an essential part of being human and without it none of us would be defined as the person we are. Creativity is developed everywhere, along with the evolution of human civilization, and it separates human beings from animals.

From the person's perspective, four levels of creativity were covered in Kaufman and Beghetto's (2009) 4C model of creativity. ‘Big C’ creativity means undeniable creative giants that change a domain, such as brilliant artists, whereas ‘little c’ refers to people's everyday creative ideas and actions in every part of their daily life (Richards, 2007). ‘Pro C’ represents creative activities by experts at the professional level which have influenced a field, such as applying an innovative PhD research method; and ‘mini c’ stands for creative ideas that add novelty to personal interpretation or insights (Kaufman & Beghetto, 2013), such as people's sense of humour.

Based on Kaufman and Beghetto's (2009) 'Big C' level, analysis and theories concentrated on the distinguishing qualities or characteristics of exceptionally creative people, traditionally trying to discover crucial qualities that define a creative person. For instance, different interests, attention to difficulty, high energy, great appreciation of artistic qualities, the ability to resolve antinomies, independence of discernment, and self-confidence or autonomy are identified as the common personalities that creative people tend to possess (Barron & Harrington, 1981). Persistence is another characteristic that was revealed as a main component of outstanding creators in a substantial amount of retrospective studies (e.g. Csikszentmihalyi, 1996; Gardner, 1993; Rossman, 1964; Simonton, 2004). Baer and Kaufman (2005) as well as Feist and Barron (2003) contended that having a high Intelligence Quotient (IQ) is very likely to increase the chance of having positive outcomes of creative efforts.

ii) Measurements of creative persons

The two most commonly known tools of this sort are the Alpha Biographical Inventory (ABI) developed by Taylor and Ellison (1968), and the biographical inventory proposed by Schaefer and Anastasi (1968). However, they are now outdated and do not focus only on creativity: typical academic accomplishment was given the same weight as creativity in the ABI. Cropley (2000) summarised that Anastasi's biographical inventory measured fact-based information in the following five aspects:

family background, intellectual and cultural orientation, motivation, scope of interest, and drive towards innovation and diversity. Family background includes parents' or siblings' level of education and their recognition by the public in society. Intellectual and cultural orientation are measured by several aspects, for instance, their leisure pursuits, how much classical and difficult literature they own, and how often they go to museums or art galleries. Motivation is assessed by certain facts, for example, whether they own and use any special equipment e.g. a microscope, whether they tend to forget meals in order to complete a working project, or if they are enthusiastic enough to undertake jobs in the field during holidays. The scope of interests is determined by their number of hobbies, how many favourite subjects they had at school, and other similar aspects. The drive towards innovation and diversity takes into consideration to what extent they have any unusual possessions, such as spider webs, and their level of curiosity in unconventional forms of art. The Life Experience Inventory originated from the minds of Michael and Colson (1979). Examples of the 100-item inventory include the number of times their address was changed in childhood, education, recreation, family composition and interests, to name a few, as the inventory focuses on factual information only. The Creative Activities Checklist was developed by Runco (1987), designed to be used on pupils between Grade 5 and Grade 8. The partakers of the test were required to show how often they have undertaken art, science, literature, music and drama activities recently.

The second method to study a creative being is to recognise personal traits that are believed to elevate the possibility of creativity or the appearance of creativity. It is possible to apply the Creativity Checklist (CCL) created by Johnson (1979) to rate individuals of all ages, as well as adults in work environments. Flexibility, Constructional Skills and Fluency, individual attributes e.g. Preference for Complexity, Ingenuity, Resourcefulness, Self-Referencing and Independence are assessed. The Creative Behaviour Inventory by Kirschenbaum (1989) also made use of ratings by observers.

There are assessment scales that involve self-ratings. Group Inventory for Finding Creative Talent (GIFT) and its extension the Group Inventory for Finding Interests (GIFFII and GIFFIII) developed by Rimm and Davis (1980) are examples thereof. Another example assessment that involves self-rating is the Creativity Styles Questionnaire (CSQ) proposed by Kumar, Kemmler, and Holman (1997). Participants were asked to give a self-rating ranging from 1 to 5 representing strongly disagree to strongly agree for 76 questions. The questions aim to investigate aspects including whether creativity is unconscious, the role of using other people's ideas in creativity, what contributes to the final outcome of creativity, etc. For example, participants were asked to rate their extent of agreement with the statements "Creative ideas occur to me without even thinking about them," "When I get a new idea, I get completely absorbed by it", or "I typically create new ideas by combining existing ideas" (Kumar, Kemmler & Holman, 1997, pp. 52–58). Colangelo et al. (1992) developed the Iowa Inventiveness Inventory, after studying the case data of 34 prominent inventors who held agricultural or industrial patents. The assessment tool asked participants to assess themselves against 61 statements using a similar 5-point scale. The inventory clearly separates those who are recognised as creative people from others. It also distinguishes young inventors regarded by teachers from older and well-recognised adult inventors.

As reviewed, most creativity-relevant personality tools are time-invariant, and most of these elements are natural or inherent characteristics. Therefore, although the 4P theory has been widely used in creativity research, as Cropley and Cropley (2000) and Williams et al., (2010) have argued, it would be more appropriate to regard aspects of the 'person' separately. In this research, this point of view was taken as a starting point, and a decision was made that creativity would not be measured by applying assessment regarding creative persons.

2.10.2 Creative product

i) Creativity research on product

Research focused on the creative product (including both ideas and actual products) is mainly from the perspective of the nature of creative products and their features. Barron (1955) found creative products identified as *new* or *useful* are agreed upon commonly, although different people describe them using different terms including *useful-adaptive, good, novel-original, worthwhile* (Amabile, 1996; Feist, 1998; Lubart, 1999; Matthew & Sternberg, 2009; Mumford, 2003; Ochse, 1990; Plucker, Beghetto, & Dow, 2004; Simonton, 1999). This is seen to be the most objective approach to creativity research; therefore, it can be argued that assessment techniques for the creative product would be the most suitable techniques for assessing creativity.

ii) Measurements of the creative product

In earlier stages, Taylor's (1975) Creative Product Inventory (CPI) was used for rating levels of creativity, as it measures ‘reformulation’, ‘relevancy’, ‘complexity’, ‘generation’, ‘hedonics’, ‘originality’ and ‘condensation’. In later years, the Creative Produce Semantic Scale (CPSS) was developed by Besemer and O’Quin (1987). This assessment framework measures product creativity in terms of its novelty, resolution and elaboration and synthesis. Participants' perceptions of three products along each dimension were studied. The results demonstrated the usefulness of the framework in evaluating the originality and innovative quality of a product, how logical and easy it is to use, and how elegant or well-designed it is. Besemer (1998) confirmed its ability to differentiate consistently among products. In the latest version of the framework (Besemer & O’Quin, 1999), a semantic-differential rating scale including 43 items was used in order to assess product creativity.

It appears to be reasonable to use expert opinions when rating products. The method of consensual assessment was emphasised by Hennessey (1994), who found that the judges can evaluate the creativity of process and product reliably, and there is a strong tendency that high scores in process creativity indicate high scores in product creativity, and vice versa. Another widely used instrument for measuring creative products is the Consensual Assessment Technique (CAT) proposed by Hennessey and Amabile (1999). The CAT is based on the assumption that combining independent opinions of experts who are familiar with the field is arguably the most valid and reliable way of assessing creativity. Expert judges from four different countries were requested to assess creative products of their own culture, e.g. stories and poems, and reliable results were obtained across all four cultures.

Most researchers tend to believe measuring creativity from the aspect of the product should be the most objective approach; however, there are many factors influencing the definition of which products are creative, such as the socio-cultural elements.

2.10.3 Creative process

The aim of creative process research is to understand the underlying mechanisms and cognitive procedures that happen when people are participating in creative activities or having creative thoughts. Creative process related research usually relates to topics of creative thinking and problem-solving process from the view of cognitive function. In the following paragraphs, relevant issues of both aspects including creative thinking (divergent thinking, convergent thinking, creative performance, problem-solving) and the related measurements are discussed.

i) Creative thinking

Divergent thinking

According to Mednick (1962) and Guilford (1957; 1950; 1968), divergent thinking in the creative process is the key element to generalising creative ideas. Milgram (1990) stated that divergent thinking is the cognitive ability to bring forth a variety of different original and creative thoughts to a given question, task or situation. Amabile (1996) as well as Plucker and Renzulli (1999) argued that it is been seen as having far greater power than domain-specific factors due to its significant contribution to creativity across various domains. Amabile (1996) suggested that the purpose of divergent thinking is to obtain as varied and numerous as possible reactions or resolutions to a given task or problem.

Convergent thinking

However, Cropley (2000) claimed that finding a systematic and logically sound solution to a given problem (i.e. convergent thinking) is also crucial in creative processes. Researchers such as Simonton (1990), Kaufman and Sternberg (2010), Tan (2007), and Basadur (1998) were in agreement with Cropley that convergent thinking plays no less important a role in creativity. Additionally, Bink and Marsh (2000), and Prager (2012) independently proposed cognitive models describing creativity, and demonstrated that creativity is more accurately represented as constant switching between convergent and divergent thinking.

Divergent and convergent thinking interaction

This perspective considers that the whole brain is typically engaged in creative thinking: the left hemisphere for analytic thinking or logical evolution, the right hemisphere for imaginary thinking or seeing possibilities in a situation. Jaarsveld and Van Leeuwen (2005) observed that the right hemisphere tends to play an essential role when creative thinking has just begun, facing ambiguous problems under chaotic situations. On the contrary, the left hemisphere critically analyses ideas, on the basis of whether to either reject or proceed to the planning, creating and evaluating stages, as found by Partridge and Rowe (2002), and Runco (2007). Brandoni and Anderson (2009), and Snyder, Mitchell, Bossomaier, and Pallier (2004) revealed that both hemispheres of the brain are essential to combine conscious and unconscious thinking processes for applying creativity in arts or science. Khandwalla (1993) and Runco (1994) both observed that divergent and convergent thinking interact and cooperate together for a greater outcome as opposed to working completely independently or against each other. They represent two stages required in ideation. Based on the notion of creative thinking, other thinking types are also highlighted, for example, critical thinking in the process of convergent thinking as found by Oxman-Michelli (1992) and the lateral thinking in the divergent thinking process as perceived by De Bono and Zimbalist (2010).

Creative performances

The specific meaning of creative performance is ambiguous in the literature. On one hand, several studies considered creative performance as the product of creativity. For example, in Zenasni and Lubart's (2008) study, the quantity, originality, and valence of generated ideas are defined as creative performance. Also, in Lin, Tsai, Lin, and Chen's (2014) study, an open-ended divergent thinking test and a close-ended insight problem-solving task were conducted, and the final products were recognised as creative performance.

Amabile (1996) has found that creative thinking appears to go hand in hand with creative actions or performances. From this perspective, creative performance is regarded as the representation of the creative process, including a series of activities such as generating novel ideas, formulating a design problem, or pushing forward a creative process (Amabile, 1996; Choi, 2004). Similarly, Lu (2015) listed a series of activities regarding problem identification, planning, and finding solutions as creative activities.

This research agreed with Amabile's (1996) and Choi's (2004) perspective, and considered creative performance to be the behavioural manifestation of creative thinking, because regarding creative performance as a series of creative activities during the process of a task conforms with the context of this study, where students' related performances (not only the quality of ideas/products) in the FYDPs are observed and discussed in section 2.4.4 (pp. 36–37), which indicated their weak abilities in creative thinking.

Problem-solving process

A four-step model of 'preparation', 'incubation', 'insight', and 'verification' appears to be one of the most acknowledged creative process models and has evolved into various other models based on its origin (Howard, Culley, & Dekoninck, 2008). This model suggested that the creative process is formed upon the ability to decipher problems (Wallas, 1926). The ability to decipher problems would imply that the person would first analyse the problem and then come to a conclusion, thus explaining the very first step of this model (Wallas, 1926).

Creativity is produced by continuous fluctuation between convergent and divergent thinking, so creativity is defined as various ‘cognitive models’ (Bink & Marsh, 2000; Prager, 2012). Because of this perspective, Mumford, et al. (1997) concentrated on ‘problem-solving’. They developed a series of tests regarding ‘Problem Construction, Information Encoding, Category Selection, and Category Combination and Reorganization’ to determine the way people respond when they solve problems or undertake tasks. However, as the ‘divergent – convergent interactions’ can be seen as crucial to the formation of creativity, highlighted by Eysenck (1993) and Cropley (1999), there is now a greater focus on how divergent-convergent interactions happen, rather than developing a stage-based model for problem solving. Therefore, in this study, it is argued that understanding creative thinking from the view of a problem-solving process seems outdated, which has been further interpreted in the following part of this section (*Metacognition* pp. 69–71).

ii) Measurement of creative process

Traditional ways of measuring creative process

During the 1960s, there were lots of tests produced to measure the creative process, and a number of them are still widely used. The Torrance Tests of Creative Thinking (TTCT) were originally developed in 1966 and have been reviewed and updated since its conception (Torrance, 1999). TTCT typically has two parts, ‘thinking creatively with words’ and ‘thinking creatively with pictures’, focusing on figural and verbal creative thinking respectively.

Another helpful test of creativity during this period was proposed by Wallach and Kogan (1965), who emphasised the difference between intelligence and creativity and the importance of conducting tests in a game-like relaxing way. The proposed test contained five different series of procedures. 'Instances', 'alternate uses' and 'similarities' test procedures focused on the verbal side, whereas 'pattern meanings' and 'line meanings' were tests using figural stimuli. Furthermore, in the period of the 1960s, one of the most recurrently cited tests was the Remote Associates Test (RAT), developed by Mednick (1962). The RAT test had a ground-breaking influence on creativity testing. The underlying hypothesis of the test was that there is a difference in people's capability of giving uncommon associative responses to stimulus words. Therefore, those more capable of making remote association between words are regarded as more creative.

The creativity test for children is a set of ten tests based on the model of intelligence from Guilford's (1976) Structure of Intellect (SI). The tests content is taken from the semantic or visual and figurative areas of the SI model. Meeker's (1985) the Structure of the Intellect Learning Abilities Test is another example which is based on the SI model. It uses figural, symbolic, semantic and behavioural contents to measure cognitive abilities. All activities included in the test require divergent thinking. Doolittle (1989) published the Creative Reasoning Test (CRT), which innovatively used riddles of two different levels of difficulty as the testing approach. One is suitable for primary children between Grade 3 and Grade 6, and the other is for secondary and college students. Each level consists of 20 riddles. This test is similar to RAT in its problem-solving nature and its requirement for associative and divergent thinking (Cropley, 2000).

Differently, the Test of Creative Thinking-Drawing Production (TCP-DP) (Urban & Jellen, 1996) attempted to break the limitation of rating only participants' verbal production. Instead, the score of TCP-DP is based upon what the authors call ‘image production’. The Gestalt-psychology theory on creativity and its elements were used to rate the production of the participants: they were given graphic fragments as stimuli. The drawing produced in response would be evaluated against quality aspects such as content and composition. It would also be assessed by novel criteria including introducing new elements, boundary breaking, and even emotions like humour and affectivity.

While investigating creative thinking, Mumford et al., (1997) concentrated on problem solving using a highly convergent approach. They requested participants to identify categories of given example sets of words, and created new categories by combining the identified categories, providing additional items in the new categories and highlighting the link in between.

Metacognition

In the studies on measuring the creative process, measuring divergent thinking has been given the most attention in the early stages of creativity research. As the exploration of the problem-solving process developed further, the role of convergent thinking was noted and the relevant measurements developed, such as those of Mumford’s et al., (1997). Several new perspectives have been mentioned: the most featured example discussed here is Puryear's (2015, 2016) studies. Puryear (2016) argued that the current state of creativity study and assessment generally concentrates on either the generation of ideas or the end result of creative work. This omits the cognitive processing that occurs in the meantime and the interaction effects these cognitive aspects may show with more traditional measures of creativity. She then interpreted the dimensions of metacognition to have a substantial theoretical foundation with regard to its development. To systematically prove the outcomes of people’s creative actions, the Cognitive-Creative Sifting Model (Figure 5) has been developed and is seen as a moderator (Puryear, 2016). Therefore, the process of creativity could be intensified by paying more attention to the measurement of metacognition. It is recommended that methods in this view are necessary to facilitate a holistic view that evaluates intrapersonal interpretations as well as moment-to-moment and relatively small, or foundational, sparks of creativity.

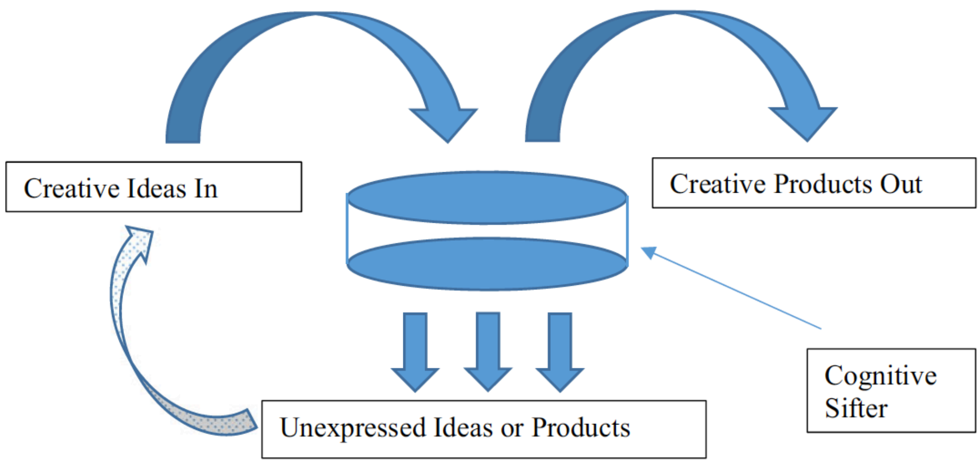

Figure 5. Cognitive-Creative Sifting Model (Puryear, 2016, p. 8)

The understanding of the problem-solving process (the model of creativity) has been updated with the development of creative thinking studies. As creative thinking research developed from simply focusing on divergent thinking to paying more attention to the interactions between divergent and convergent thinking, the model of creativity developed to reflect such a feature, and its aim was not to explicitly state the stages of the creative process, but to explore the nature of how such a process occurs. The relevant measurements of the creative process are also developing with the changing trend in creative thinking studies which moves from divergent thinking in the early research stage to the interaction between divergent and convergent thinking. Metacognition has been noted in the research, which examines creativity through the lens of development and can add richness to its study by putting creative products in their broader context, rather than making them the ultimate focus (Sawyer, 2003).

2.10.4 Critiques

This section reviewed the studies on creativity from the perspective of person, product and process. Because of the wide scale of the creativity realm, research on creativity is usually restricted to a certain aspect. A review of creativity literature in the design domain shows that the majority of studies are focused on a single facet of creativity (Gero, Jiang, & Williams, 2013). Most of the wide spread of measures used are derived from aspects of the 4Ps (Cropley, 2000), which implies a close relationship between creativity definitions and ways of measurement. That is, the instrument for measuring creativity is selected according to how researchers define creativity in a specific study.

Although the 4Ps have been adopted by most of creativity researchers, it is suggested that the aspect of the *person* is better to be considered separately (Cropley & Cropley, 2000; Williams, Ostwald, & Haugen, 2010a). In this research, this perspective was adopted and considers that this aspect of creativity may be time-invariant, and most of these elements are inherent characteristics (Mann & Araci, 2014). For educational purposes, a focus on the personal trait approach is not very interesting, since a trait by definition is a very stable disposition and therefore not easily influenced by training (Christiaans & Venselaar, 2005). Personal aspects of creativity are particularly important in the case of children given their ambiguous creative potential (Runco, 2003).

Measuring creativity from the view of the product has been considered the 'gold standard' by many researchers; however, it was not suitable for this research. As suggested in the research problem, within China's design education, the product may be affected by many factors, e.g. the lecturers' intervention or their personal judgements. Similarly, in Western countries, the evaluation and assessment of a product is subject to the lecturers' own criteria, which is likely to cause problems of transparency and equity (Sawyer, 2003).

In this research, creativity was considered to be a cognitive process, as supported by Hasirci and Demirkan's (2007) study. This implied the significant correlation between process and overall creativity. It further argued that it is essential to understand creativity from a cognitive view and define it as a process involving interactions between divergent and convergent thinking. This perspective provides new insight to measuring creativity, which can predict a person's creative performances effectively. It moves from defining those relatively fixed but context-limited criteria to exploring those elements that are directly related to an individual's creative performances, such as an individual's creative thinking, which would be more suitable for application in the education context. Therefore, creativity is taken from the view of creative process in this study, and the intention was to evaluate students' creativity via their creative thinking. According to this conclusion, metacognition has then been adopted as the key criterion for evaluating creative thinking. Because this has been identified in recent creativity research as believed to play a significant role in the interactions between divergent and convergent thinking, it will be discussed in detail in the next section (2.11).

2.11 Creativity and metacognition

2.11.1 The definition of metacognition

The understanding and study of metacognition has required a long history of effort to reach its current level. The interest in understanding our mind and knowledge perception can be dated back to as early as the time of ancient psychologists such as Plato and Aristotle (Georghiades, 2004; Sandi-Urena, 2008). The early development psychologist Jean Piaget (1950) studied how humans obtain, create and apply knowledge, and revealed the developmental stages of our intelligence, thus starting a new era of cognitive development psychology. Steinbach (2008) researched how accurately adults are able to make judgments on memory, and proved that the conscious feeling of knowing is a valid predictor that people will recognise the correct information when present (Peters, 2007). Vygotsky (1962) presented consciousness theories and argued that consciousness and consciousness control contributes highly to social development during school years (Tsai, 2001). In summary, all these research areas stimulated research in metacognition.

Flavell (1976) was the first researcher who extended metamemory to the concept of metacognition. Since then, a variety of research has been undertaken to further our understanding of it. Brown, Bransford, Ferrara, and Campione (1983) as well as Miller (1985) agreed that metacognition could be described as the conscious organisation of information obtained while learning to accomplish tasks. Alternatively, Scarr and Zanden (1984) explained metacognition as one's realisation and perception of cognitive processes that control their mind, memory, skills, learning and behaviour: or, in simpler terms, 'knowing the knowing' and 'thinking the thinking' (Steinbach, 2008). Many different words that have similar meanings to metacognition have been used to refer to the same concept. In the cognitive and effective learning strategies presented by O'Neil and Spielberger (1979), the term *self-regulation* was used to describe the constant reviewing and adaptive nature of metacognition processes. Bogdan (2003), in his book, used terminologies such as *metamentation* or *mental reflexivity* to refer to the ability to consciously think about and reflect on our thoughts. Veenman, Van Hout-Wolters, and Afflerbach (2006) provided a comprehensive list of terms that are typically associated with metacognition, including 'comprehension monitoring', 'metamemory', and 'learning strategies'. Nowadays, metacognition covers a wide range of inconsistent terminologies that are all associated with individuals' thinking of memory and regulation of cognitive processes (Leader, 2008).

Cross and Paris (1988) stated that metacognition consists of two components: the knowledge of cognition, and its monitoring and regulation. Flavell (1979) defined metacognitive knowledge as knowledge about oneself, actions, tasks and strategies, and how their interaction produces intellectual outcomes. Firstly, self-examining refers to understanding an individual's cognitive process, requirements of tasks, and any compulsory steps to accomplish the tasks. Secondly, self-regulation is to consciously reflect and control the forward planning, implementation and evaluation processes. The key to self-regulation is the continuous and dynamic monitoring of oneself and one’s performance before, during and after a cognitive activity, which feeds back and leads to the creation and solving of problems. Brown (1987) also stated that regulation contributes to the effectiveness of thought and behaviour to try and transform an incomplete situation into a more understandable but completely novel one. As well as the cultivation of metacognition, Feldhusen and Goh (1995) suggested that metacognitive skills add to the effectiveness and efficiency by which one thinks creatively. Similar to Armbruster’s (1989) perspective, they concluded that these skills can be learned with proper instruction (Feldhusen & Goh, 1995). However, Kuhn (2000) characterised the development of metacognition as the very gradual (and not always unidirectional) movement to acquire better cognitive strategies to replace inefficient ones.

According to the review of several perspectives on understanding metacognition, it is clear that it is a large-scale concept, describing complicated processes of human cognition, and concerning diverse cognitive activities. Nevertheless, the majority of such activities would be unknown without the awareness of their metacognition. As metacognition refers to ability which is highly associated with people's cognitive activities, its important function in achieving creativity has been noticed in creativity research by those researchers who consider creativity from the view of the cognitive process, namely, the problem-solving process (Davidson & Sternberg, 1998; Feldhusen & Goh, 1995; Sternberg, 1998). These researchers believed that people with high level metacognition should solve a problem more creatively. Several studies have been conducted to prove that higher level metacognitive abilities lead to more creative outcomes in art-related work (Kozbelt, 2008), as well as in engineering-related tasks (Zeng, Proctor, & Salvendy, 2011). Sanz de Acedo Lizarraga and Sanz de Acedo Baquedano's (2013) study found that people's metacognition was correlated with their divergent thinking abilities. Similar studies have been conducted via investigating its correlation with divergent thinking and have supported that metacognition would be a good indicator for creative performance (Batey, Furnham, & Safiullina, 2010; Park, Lee, & Hahn, 2002). The following paragraphs (3.5.2 – 3.5.6) in this section review the relationship between metacognition and creativity from varying aspects including the learning process, motivation, and creative thinking, followed by a brief summary and critique accordingly.

2.11.2 Metacognition and learning process

There was a great deal of effort to explore metacognition through the relationship between creativity and the learning process (Plucker et al., 2004). This point has been studied and supported to various degrees by a great number of researchers (Cropley, 1999; Feldhusen & Goh, 1995; Isaksen, Dorval, & Treffinger, 2010; Pesut, 1990; Sternberg, 1988). They believe that creative processes provide students with opportunities to show the distinction between memorisation and more in-depth perception, which facilitates new knowledge generation, so that a more effective learning process is achieved. They also claim that if creativity involves cognitive processing, then measurement of metacognition must be involved. Likewise, John-Steiner's (1997) work regarding inner speech writing, or, in other words, verbal thinking, could also be considered as relevant to metacognition. The learners or creators are always reviewing and generating fresh meanings according to a perception of their status. Significantly, according to Runco (2006), the creativity theorists usually apply similar expressions in describing creative processes to those which Flavell uses to describe metacognition. However, these interpretations take various forms in diverse research on creativity, and the roles of process and reasoning are not specified in creativity development. As Fasko (2006) mentioned, studies explicitly discussing the link of creativity to reasoning are rare, except in a few existing research studies on metacognition (e.g., Niu, Zhang, & Yang, 2007).

2.11.3 Metacognition and motivation

Metacognition has been associated with various other concepts throughout cognitive psychology research, and metamemory is one example of these. A number of researchers have accentuated the connection between metacognition and motivation (e.g. Eisenberg, 2010; Martinez, 2006; Whitebread et al., 2009). Vollmeyer, Rheinberg, and Burns' (1998) Cognitive-Motivational Process Model assumed that motivational factors affect performance via metacognition. In addition, metacognition can facilitate critical thinking, to the extent that observing one’s thoughts and the quality thereof would make it more probable that one will become involved in critical thinking. as motivation and critical thinking are strongly related to creativity, the important role of metacognition in creativity has been emphasised more and more in recent years in creativity research, such as in studies conducted by Kaufman and Beghetto (2013), Sanz de Acedo Lizarraga and Sanz de Acedo Baquedano (2013), and Feldhusen and Goh (1995).

2.11.4 Metacognition and creativity thinking

Having a clear definition of what metacognition means exactly is crucial for understanding the consequences of regarding creativity as related to metacognitive processes. Puryear (2016) applied Flavell’s (1979) consideration to further explain how metacognition relates to creativity. According to Flavell (1979), “metacognition was related to four interrelated areas: metacognitive knowledge, metacognitive experiences, goals/tasks, and actions/ strategies” (p. 906). He also stated that metacognitive knowledge can be further divided into three subcategories: "knowledge of persons (either intrapersonal or interpersonal), knowledge of task, and knowledge of strategies" (ibid., p. 906). In Puryear's (2016) model, the creativity of an idea depends on its value to the generator of the ideas and to other people. Knowledge of persons (both oneself and others) would help to decide if an idea is useful to oneself and to others, thus contributing to the generation and evaluation of creative ideas. Knowledge of a task would be useful in perceiving if an idea requires tasks that are familiar or unfamiliar, well-organised or poorly-organised, too many or not enough, which also helps to assess the value of the ideas to people. Knowledge of strategies is related to creativity of ideas in a similar way. Feldhusen and Goh (1995), Mokhtari and Reichard (2002), Pesut (1990), and Sternberg and Williams (1996) argued that metacognition is an important ingredient of creative thinking because producing creative ideas through creative thinking is metacognitive in nature.

Divergent thinking

Several recent studies have investigated closely the relationship between metacognition and divergent creative thinking. For example, De Acedo Lizarraga and de Acedo Baquedano's (2013) study demonstrated that metacognition is a factor that could predict verbal creativity reasonably well, and concluded that both metacognition skills and creativity skills are important in education. Kaufman and Beghetto (2013) argued that thinking creatively at inappropriate time or places would not be appreciated. They raised the concept of 'creative metacognition', claiming that understanding the creative weaknesses and strengths of oneself is as important as knowing where, when, why, and how they should be creative. These research studies revealed the detailed interconnection between metacognition and divergent creative thinking, especially a raised awareness in understanding and teaching creative metacognition in order to increase students' creative potential.

Convergent thinking

Other examples of research have focused on the connection between metacognition and convergent creative thinking. For instance, Armbruster (1989) systematically studied how metacognition influences the process of creativity in each stage of Wallas' (1926) four-stage model of the creativity process. In the preparation stage, it is possible for creative people to obtain knowledge of their cognitive status. During the incubation stage, unconscious cognitive processes take place. Then sparks of creative ideas occur in the illumination stage. Finally, the link between metacognition and the verification stage is described below:

> "In sum, creative individuals seem to be especially adept at the conscious metacognitive skills that are required during the verification stage. They may be unusually sensitive to both internal and external standards and particularly able to revise the creative product accordingly. Creative individuals may also be especially good at improving these abilities with experience and practice." (Ambruster, 1989, pp. 180–181)

The search for and exploration of an interrelation between metacognition and people's creative potential are still being pursued. The most influential research is likely to be Puryear's (2016) Cognitive-Creative Sifting Model (CCS). The CCS is based on previous research on cognitive development and creativity (Piaget, 1950; Vygotsky, 1962; Tsai, 2001; Steinbach, 2008). The ingenious aspect of Puryear's study is that she emphasises the moderated role of metacognition in the creative ideation process and evidences its moderate effect to predict creative ideation through an empirical approach. Puryear's model was based on the understanding that creative ideas that are not expressed would go through a continuous metacognitive process to be interpreted and transformed into final creative products. More particularly, the internal metacognitive process is one that repeatedly sifts more desirable ideas using previously accumulated knowledge and experiences. This way of evaluating, choosing and transforming incoming ideas into outcoming products is the same for creative or non-creative individuals (Beghetto & Kaufman, 2007). However, Runco (1996) declared that strategies to choose more desirable ideas are highly personal and completely the individuals' own choice. Therefore, it is crucial to be aware of such personal preferences in the metacognition process. This might also imply that teaching students how to be creative in an appropriate context would increase their abilities to be creative. Runco (2003, 2006) stated that increasing students' capabilities to use discretion where appropriate would avoid distraction from undesired incidents and facilitate their creativity in the longer term.

2.11.5 The measurement of metacognition

Metacognition is a broad term covering many aspects. There have been a wide variety of assessment methods corresponding to metacognition (Lai, 2011). However, a large number of the existing instruments for measuring it focus on only one or a few aspects, such as meta-memory (Schneider, 2008). Amongst the methods reviewed, the Metacognitive Awareness Inventory (MAI), developed by Schraw and Dennison (1994), was found efficient for evaluating metacognition comprehensively. The MAI consists of 52 items regarding how people evaluate their cognitive activities, which are based on a specific framework of the metacognition component (Table 3, p. 83). According to Schraw and Dennison (1994), metacognition consists of two components: the knowledge about cognition and the monitoring and regulation of cognition. Based on the two components, they further divided cognitive knowledge into three sub-types, including *declarative, procedural, conditional*; and also identified five sub-types within cognitive regulations, namely, *planning, information management, monitoring, debugging, and evaluating* (Schraw & Dennison, 1994).

This instrument has been tested by Schraw and Dennison (1994) themselves in a factor replication analysis to support the validity of the eight factors in their framework. Yildiz, Akpinar, Tatar, and Ergin (2009) conducted a similar study to examine the eight factors of metacognition and extracted the same results as Schraw and Dennison's study. They also applied Confirmatory Factor Analysis (CFA) to further confirm the eight factors in MAI and found that all items had significant paths underlying their specific factors. Puryear's (2015, 2016) studies analysed the impact of the eight factors of metacognition on creative thinking, and found that each factor had a great effect (at the medium and large level) on the creative thinking process (the idea generating and idea selecting process), further suggesting that metacognition should be considered to be a crucial criterion to evaluate creative thinking abilities and the MAI would be an appropriate instrument to use. The instrument also demonstrated reliability of = .95 in several studies (AL-khayat, 2012; Corebima, 2009), which is very high.

Table 3. The Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994)

	Items	Definition / *Sample item*
Overall items	52	
Cognitive Knowledge	**17**	
Declarative Knowledge	8	Knowledge about one's skills, intellectual resources, and abilities *Sample item: I understand my intellectual strength and weakness*
Procedural Knowledge	4	Knowledge about how to implement learning procedures/strategies *Sample item: I try to use strategies that have worked in the past*
Conditional Knowledge	5	Knowledge about when and why to use learning procedures *Sample item: I use different learning strategies depending on the situation*
Cognitive Regulations	**35**	
Planning	7	Planning, goal setting, and allocating resources prior to learning *Sample item: I pace myself while learning in order to have enough time*
Information Management	10	Skills and strategy sequences used on-line to process information efficiently *Sample item: I consciously focus my attention on important information*
Monitoring	7	Assessment of one's learning or strategy use *Sample item: I ask myself periodically if I am meeting my goals*
Debugging	5	Strategies used to correct comprehension and performance errors *Sample item: I ask others for help when I don't understand something*
Evaluation	6	Analysis of performance and strategy effectiveness after a learning episode *Sample item: I ask myself if I have considered all options after I solve a problem*

2.11.6 Critiques

This section summarised current literature about the nature of metacognition and its components. More specifically, in the literature the relationship between metacognition and creativity is articulated by analysing the relevant studies, which are summarised in Figure 6 (p. 84). In summary, sufficient theoretical and empirical evidence exists to affirm that the activation of creative thinking has a significant relationship to metacognition. Most of these studies accepted that the creative process involves interactions between divergent and convergent thinking, but their focus was different. Those studies from the ‘creative metacognition’ perspective concentrated more on the efficiency of divergent thinking, such as when and where the creative activities are appropriate, which can be seen as the conditions for appropriate divergent thinking; whereas those studies, for example, conducted by Armbruster (1989) and Puryear (2015), paid more attention to exploring the efficiency of convergent thinking (e.g. selection, evaluation, verification). This study on hand argued that the effect of metacognition is significant on both sides of the creative cognition process, which has been proven by Puryear's (2016) study. Because the close relationship between metacognition and creative thinking has been identified, metacognition could be seen as a good indicator for creative performances as creative thinking is always affected by related performances as discussed in section 2.10.3 (pp. 69–71). However, there is a lack of empirical studies to further investigate the link between of metacognition and creative outputs.

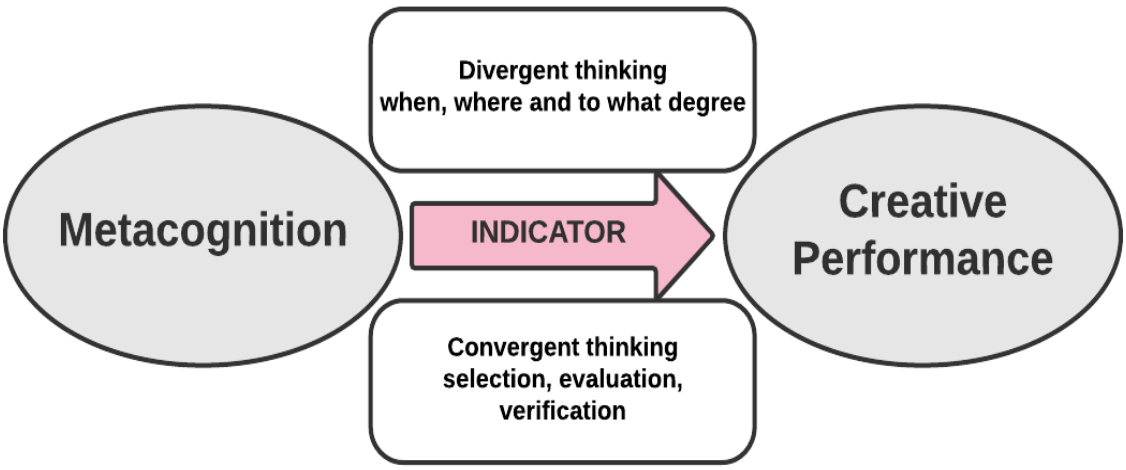

Figure 6. The relationship between metacognition and creativity

Moreover, although the literature illustrates the importance and the strong relationship between metacognition and creativity, there is no further research or empirical studies on how metacognition affects other cognitive activities which are related to creative performances. For example, how and to what degree does it affect people's critical thinking? Does it affect thinking directly or indirectly (i.e. via controlling people's memory)? How to articulate the cognitive-motivational process model which assumes that motivational factors (i.e., mastery confidence, incompetence fear, interest, and challenge) affect performance via metacognition (Vollmeyer et al., 1998)? Therefore, as Armbruster (1989) suggested, the relationship between metacognition and creativity was a potentially fruitful area of research nearly 25 years ago; however, the empirical research in this area remains relatively limited.

According to Feldhusen and Goh's (1995) argument, metacognition would be one of the key elements related to creativity. It is further claimed that metacognition has a strong relationship with an individual's creative thinking and would be used as an appropriate criterion for evaluating creative thinking ability (Puryear, 2015, 2016). Considering the gaps in current studies in metacognition, it is intended that this study will focus its investigation predominantly on the ways in which metacognition may exert impact on a specific cognitive process.

2.12 Creativity and knowledge

2.12.1 The definition of knowledge

Knowledge is an umbrella term that describes a spectrum of academic knowledge and is not as easy to properly define as it may seem. *The Oxford Dictionary* (2010) definition of 'knowledge' reads as follows "Knowledge can refer to a theoretical or practical understanding of a subject. It can be implicit (as with practical skill or expertise) or explicit (as with the theoretical understanding of a subject); it can be more or less formal or systematic". Christiaans and Venselaar (2005) suggested that knowledge means "an individual's personal stock of information, skills, experiences, beliefs and memories" (p. 219). In the context of the author's research in design education, the term 'knowledge' has been used to refer to a wide variety of theories, abilities and domain-specific information.

2.12.2 The importance of a knowledge base in creativity

From the literature, as concluded in section 2.9 (pp. 53–54) the development of creativity studies passed through a preliminary stage (1920–1950); the basic creativity model, personal traits from the view of behaviourism, developed subsequently (1950–1970); the development of the micro-stage stage, creative thinking from the view of cognitivism, followed this (1970–1990); and finally the socio-cultural perspective from the view of constructivism emerged (1990–2010). During the third stage, cognitive methods were used to investigate creativity, and various research studies concerning divergent thinking were undertaken which revealed the significant influence knowledge has on creativity. Guilford argued, "No creative person creates in a vacuum or with a vacuum" (Guilford, 1950, p. 448). This argument can be interpreted as an individual's knowledge base, accumulated from past experiences, study and the diversity of the knowledge base, which is essential to an effective creative process. Armbruster (1989, p. 177) argued that creative processes are cognitive processes by nature. Creativity requires interpreting, studying, pondering and recollecting. In other words, the creative process includes obtaining knowledge, transferring existing knowledge to new knowledge, and generating products that are suitable for sharing from new knowledge. Sawyer (2003, p. 220) similarly emphasised that the key to creativity is to have "sustained focus, hard work, well-organised knowledge, persistence in the face of failure, and a coherent presentation of the work".

More and more researchers from different disciplines have been attracted to the close correlation between the knowledge base and creativity (Kaufman & Baer, 2006; Simonton, 1990). Hertzberger (1991) declared that having an extended reservoir of knowledge through experience greatly enhances the ability to produce creative architectural design. In addition, Lawson (2006) provided a similar point of view, as well as highlighting the importance of keeping the balance between learning other people's theories yet not being so tied to others' ideas that originality is inhibited.

2.12.3 Domain-specific and domain-general debates on creativity studies

As the focus of creativity studies has developed from divergent thinking to convergent thinking, a debate on whether creativity is *domain-specific* or *domain-general* has emerged, greatly influencing the research on knowledge and creativity. The disagreement mainly lies in whether the nature of creativity is domain-specific or domain-general. Either side of the argument seems to have sufficient empirical support from literature and studies. The following sections (section i – iii) represent the review of the existing literature from domain-general, domain-specific and hybrid perspectives respectively.

i) The domain-specific perspective

Many different researchers who have apprehended the domain-specific characteristics of creativity struggled to believe that creativity can be a cross-disciplinary term. The reason for this may be because of the disciplinary norms and training or the types of people who are drawn to various disciplines (Mann & Cadman, 2014). The 'eight intelligences', namely, linguistic, naturalistic, spatial, musical, bodily kinaesthetic, logical-mathematical, interpersonal and intrapersonal, formed by Gardner (2011), appear as categories of "creative achievement" (Kaufman, 2012, p. 298). Similarly, seven absolute elements of the mind are suggested by Feist (2005) including psychology, biology, mathematics, music, physics, linguistics and art-aesthetics. Concerning the area of creative products, various characteristics, abilities or attributes can be said to be situated in various domains according to research carried out in the past (Kaufman, Pumaccahua, & Holt, 2013; Silvia, Kaufman, & Pretz, 2009). Nonetheless, with regard to the interpersonal and intrapersonal domains, it can be quite challenging to identify new, perceptible and useful products. Suitable candidates should have the skill of originality, good leadership or problem-solving (i.e. interpersonal creativity) or morality and inner peace (i.e. intrapersonal creativity). The problem is that researchers in favour of a domain-specific perspective have not yet been successful in supplying convincing proof against regarding divergent thinking as domain-general.

ii) The domain-general perspective

Researchers who have studied components of the 'domain-general perspective' agree with the opinion that creativity is not restricted to a particular discipline, but that it is a generic concept that combines originality and value (Williams et al., 2010b, p. 115). Research that focuses on the characteristics of creative giants (on the "Big-C" level), defined by Kaufman and Beghetto (2009), attempted to identify key traits that deem a person to be creative: for example, these personal traits have been identified as "high valuation of aesthetic qualities in experience, broad interests, attraction to complexity, high energy, independence of judgment, autonomy, self-confidence, or the ability to resolve antinomies" (Barron & Harrington, 1981, p. 451). It has also been revealed in many retrospective findings (e.g., Csikszentmihalyi, 1996; Gardner, 1993; Rossman, 1964; Simonton, 2010) that persistence is also a core characteristic of exceptional creators. Plucker (1999) demonstrated that the results of these creative tests (mainly measuring divergent thinking) seemed to support the statement that creativity is domain-general. There are also studies which support that having a high IQ in general can be regarded as a cognitive skill that stimulates and facilitates creative efforts (Baer & Kaufman, 2005; Feist & Barron, 2003). Due to kinaesthetic skills that play a more supportive role in some forms of creativity (e.g. creative dancing), it appears that creativity may be more required in mathematics and physics. Being able to keep perfect pitch is another element of talent that adds to creativity, predominantly in the area of music (Simonton, 2005).

Scores gained from the Torrance Tests of Creative Thinking (TTCT), used in elementary schooling grades, can give references for the differences in 'adult achievements' within various domains, providing evidence for the research done on the domain-general perspective (Plucker, 1999; Cramond, Matthews-Morgan, Bandalos, & Zuo, 2005). However, there has also been an argument pointing out the lack of close correspondence between creativity scores in diverse domains and divergent thinking (Baer, 1993; 1994; Han & Marvin, 2002).

iii) The hybrid perspective

Although most theories favour either the domain-specific perspective or the domain-general perspective, there exist other attempts at combining both perspectives. One example of such a hybrid perspective is the Componential Model of Creativity proposed by Amabile (1996) (Figure 7, p. 91). It suggests that in order to add to the specific creative performance, skills relevant to both general and domain creativity, as well as initial intrinsic task motivation need to be combined (Amabile, 1983; Conti, Coon, & Amabile, 1996).

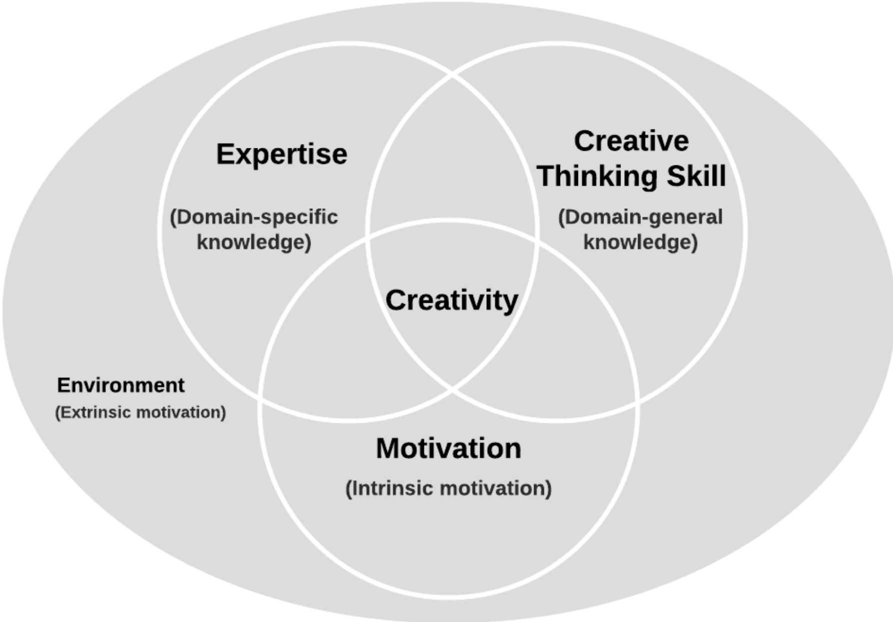

Figure 7. Componential Model of Creativity (adapted from Amabile, 1996)

Another significant study attempting to combine both of the two perspectives is Baer and Kaufman's (2005) Amusement Park Theoretical Hierarchical Model (APT theory). This model compared achieving creativity to going to an amusement park, e.g. buying a ticket is necessary to go to an amusement park; similarly, executing motivation and intelligence in a helpful environment is the initial step to achieve creativity, which can be seen as analogous to the ticket to access an amusement park, as explained by APT theory. Afterwards, a person enters a general subject domain such as science or arts, reinforced by the person's individual characteristics, expertise and comprehension. There are more limited factors within a specific domain (e.g. dance or music) that develop creativity specifically related to that domain. Lastly, in complicated domains, for instance biology, you will find that there are sub-domains within and that specific information has to be acquired in order to make creative contributions (Baer & Kaufman, 2005, 2008).

2.12.4 Knowledge and creativity from the view of domains

In Amabile's Componential Creativity Model, the term 'knowledge' has been regarded as any domain-relevant information and expertise from which a problem-solver can extract solutions. This subject is then explored in depth to reveal that the knowledge necessary for generating creative responses typically appears in two different forms. For one thing, gathering an extensive amount of experience in a specific domain is essential to form an adequate level of expertise and aid the developing of creativity. For another, it is necessary for people to think out of the box and comprehend knowledge from broader domains of interest to stimulate creativity. Thus, as Adams (2005) proposed, "the best profile for creativity is the T-shaped mind, with a breadth of understanding across multiple disciplines and one or two areas of in-depth expertise" (p. 5). Johansson (2017) also agreed that "we must strike a balance between depth and breadth of knowledge in order to maximize our creative potential" (p. 104). This is supported by the Amusement Park Theoretical Hierarchical theory (Baer & Kaufman, 2005). Similarly, various theories also state that it is helpful to recognise the difference between domain-specific knowledge and domain-general knowledge, similar to how Amabile classified "domain-relevant skills" and "creativity-relevant processes" as separate components of creativity (Christiaans & Venselaar, 2005).

As a result, it would in principle be acceptable to classify knowledge into two categories: domain-specific knowledge and domain-general knowledge. Hence, the following sections (section i – iii) focus on interpreting the relationship between creativity and both types of knowledge respectively.

i) Domain-specific knowledge and creativity

It has been commonly agreed by various researchers that domain-specific knowledge plays an important role in creativity (Feldhusen, 2005; Mayer, 2005; Weisberg, 1999). For example, Weisberg (1999) suggested that knowledge provides essential building blocks or foundations from which creative ideas can be produced. He stated that the amount of knowledge and information that an individual applies to a problem in need of a creative solution is what may distinguish between a creative person and one who is not creative. Therefore, knowledge itself can be equal to creativity. There are two imperative functions in creative performance within the knowledge-specific domain (Amabile, 1996): firstly, providing individuals with essential elements that could be combined to construct a creative response to a given task. Secondly, evaluating the propriety and accuracy of the responses to a task allocated to the individual, for which domain-specific knowledge serves as a basis thereof (Amabile, 1996). Moreover, seen from the view that the creative process is problem-solving, there have been studies supporting the argument that effective problem-solving relies mainly on having acquired relevant domain-specific knowledge rather than having exceptionally high intelligence (Anderson, 1987; Elio & Scharf, 1990).

ii) Domain-general knowledge and creativity

General process knowledge is also known as domain-independent knowledge about the process of solution generating and its monitoring and control (Christiaans & Venselaar, 2005). Investigating the relationship between domain-general knowledge and creativity is generally based on the process of problem-solving. It can be said that the process of solving poorly-structured or well-structured problems appears to be very similar (Greeno, 1980; Langley, et al., 1987; Simon, 1973; Weisberg, 1986). The distinction between the process of solving both types of problem is that the poorly-structured depend largely on general process knowledge, because of their heuristic nature which requires knowledge from various domains. This type of problem-solving method using common sense, heuristics, and general process knowledge has been referred to as using weaker methods, whereas problem-solving methods using algorithms have been regarded as stronger (Anderson, 1987; Langley et al., 1987). Having and using general process knowledge would facilitate creative performances in relation to organising and solving problems in the domain of design. In particular, it means using general process knowledge to review and reflect on the design process, understanding the most relevant stages and which methods should be used to solve problems most effectively. That is why those who have acquired extensive knowledge of the various kinds of problems, i.e. who are experienced problem-solvers, can typically use standard solution procedures to effectively resolve issues (Mayer, 1987).

iii) Limitations of current studies on domain knowledge and creativity

As Rietzschel, Nijstad and Stroebe (2007) stated, current studies that investigate the relationship between creativity and domain-specific knowledge usually measure creativity via creative products; whereas, the studies concentrating on creativity and domain-general knowledge evaluate creativity by relying on creative thinking tests or other tests regarding personalities. Although there is a general consensus in the relationship between domain knowledge and creative performance, no research has been undertaken that utilises performance-based methods to measure the impact of domain-specific knowledge or domain-general knowledge over creative performance, e.g. decision-making, or the fluency of generating ideas (Sak & Maker, 2006). The reason would be, as Jeon, Moon, and French (2011) proposed, that there is no performance-based measurement for creativity. As a result, there is a lack of empirical support for the argument that the amount of domain-specific knowledge obtained can decide the level of creative performance (Han & Marvin, 2002; Jeon, Moon, & French, 2011)

2.12.5 Tacit knowledge and creativity

Adams (2005, p. 9) argued, "People will be most creative when they feel motivated primarily by the interest, satisfaction, and challenge of the work itself". Dineen and Collins (2004, p. 2) argued, "Learner motivation is related to learning styles, because it is premised on the individual and the contingent nature of knowledge".

Besides domain knowledge, there is another type of knowledge, called *tacit knowledge*, firstly introduced by Polanyi in 1958. His famous assertion on knowledge is that "we can know more than we can tell" (Polanyi, 2009, p. 24). He further suggested that a "human's intellectual superiority over animals is due to our linguistic capabilities…" (ibid, p. 55) and he called the information beyond language that is difficult to transfer to others tacit knowledge. Basically, tacit knowledge refers to human experiences which are developed and accumulated across years and then gradually merged into a human's life without an explicit explanation. For example, in daily life, you recognise your friends instantly without doubt, but it is hard for you to explain exactly which characteristics of your friends lead you to recognise them immediately. In a professional context, when a successful employee is asked how they became so successful, they will often refer to their past experience, especially those they acquired through failure, rather than providing concrete or generic advice. Therefore, tacit knowledge is acquired and developed by engaging in various activities, including life experience and working experience. The process of acquiring tacit knowledge is natural and most of the time unconscious, and is typically not suitable to be articulated or communicated explicitly. Recently, tacit knowledge has been emphasised by more and more creativity researchers (e.g. Matthew & Sternberg, 2009; Kaufman, 2012).

Similarly, Nonaka and Takeuchi (1995) identified two types of knowledge, namely, Tacit (Subjective) Knowledge and Explicit (Objective) Knowledge, where explicit knowledge "can be expressed in words and numbers, easily communicated and shared in the form of hard data, formulae, codified procedures, or universal principles"

(Nonaka & Takeuchi, 1995, p. 75), which conforms to domain knowledge, while tacit knowledge "is experience-based knowledge, highly personal, hard to formalize, difficult to communicate or share with others, rooted in an individual's actions and experiences, including ideals, values, or emotions" (ibid, p. 75).

Amabile's (1996) Creativity Componential Model does not include tacit knowledge, but does include another important aspect, 'intrinsic task motivation', which is considered to be equally important to domain knowledge (the 'extrinsic' motivation is related to 'environment' and refers to the working environment, social pressure, and other external factors, which are not the focus of this study). She stated that if an individual's intrinsic motivation is at a high level, there would be a strong probability that she/he would achieve creativity. This "intrinsic task motivation" exists from "within the individual's own personal view" (Wylant, 2008, p. 5), which relates to whether a task is attractive and interesting enough to evoke people's motivation to engage in the task. Therefore, the role of motivation has been developed and supported by several other theories (Osterloh & Frey, 2000; Sternberg & Lubart, 1996), who indicate that the motivation is largely connected to and affected by people's tacit knowledge. This research project thus intended to include tacit knowledge into the knowledge categories.

Since experience-based knowledge is closely associated with actions and context, it is hard to explicitly write and pass on to others. As a result, it has been argued and demonstrated that reflective methods are useful for developing experience-based tacit knowledge in a variety of literature (Argyris, 1991, 1994, 1999; Kolb, 1984; Marsick, 1988, 1990; Raelin, 1997; Schön, 1983, 1987; Seibert & Daudelin, 1999; Watkins & Marsick, 1997). Reflecting on individuals' performance critically has been shown to guide people's design and implementation of further actions in both education and management scenarios. However, there is a lack of research on the advantages and drawbacks of various types of reflection, or on quantifying the impact of reflection on performance, or the types of experiences more likely to trigger self-reflection.

2.12.6 Critiques

This section reviewed the literature regarding the relationship between the knowledge base and creativity. In the literature, there is a debate about whether creativity is domain-general or specific. These studies favour either the domain-general view or the domain-specific view. Based on Amabile's Componential Model of Creativity, this research adopted the hybrid perspective, and three categories of knowledge in relation to creativity have been defined as *domain-general knowledge, domain-specific knowledge,* and *tacit knowledge.*

When exploring the relationship between creativity and knowledge, this literature survey found that current studies concentrated on discussing which type of knowledge (domain-specific or domain-general) is more important for creative outcomes. Domain-specific knowledge plays a significant role in creativity by providing relevant domain information resources and criteria for assessment. Domain-general knowledge is more related to ill-structured problem-solving processes and would play a key role in controlling and combining knowledge from previously disparate fields (Amabile, 1996; Christiaans & Venselaar, 2005). The study in this thesis aims to investigate the relationship between students' subject-relevant knowledge application and creativity, however, the current literature includes few references to this issue. The literature showed that great effort has been made to emphasise the significance of a specific type of knowledge (e.g. domain-specific/general) in creativity rather than interpreting their application (how they are used). As Christiaans and Venselaar (2005) claimed little is known about the way in which knowledge and skills within or across domains are actually used.

Moreover, the literature implied that there is a general consensus in the perspective on the relationship between domain knowledge and creative performance. However, as there is no performance-based measurement for creativity, this study did not obtain any further information on the way in which knowledge influences creative performance, i.e. which knowledge, if applied more constantly, may improve creative performance, and which knowledge may not. Lacking performance-based measurement in creativity research would also explain why less information on knowledge application has been found, because it is impossible without such instruments to observe whether a specific knowledge item may be related to a certain creative performance. When referring to the focus of the available research, in an FYDP process (design process), where various subject-related knowledges have been applied, it is challenging to evaluate how each knowledge may be applied in an appropriate way to improve creative performance. Therefore, with these concerns, to obtain more insight on effectively applying knowledge types to improve creative performance, a specific instrument would be essential for this study which could effectively predict creative performance, and, at the same time, can be correlated to knowledge application.

2.13 Metacognition and knowledge

In previous sections (2.11–2.12, pp. 73–100) in the chapter the relationship between metacognition and creativity and knowledge and creativity was identified through stating their definition and the outcomes of existing studies. The relationship between metacognition and knowledge was also examined and the current aim is to confirm whether it is possible to establish a connection between them.

It has been suggested that everybody has a creative side to their nature: the desire to create exists to various degrees and guides human behaviour accordingly (Guilford, 1968). However, if this assumption holds any truth, why is more creativity not seen everywhere in our lives and in every corner of the world? Mostly this concerns our way of thinking. As the oft-cited quote from Sir William Bragg stated:

> "*The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them.*"
>
> —Sir William Henry Bragg, Nobel Prize for Physics, 1915

It is believed that this principle can also be applied to design education and other aspects of daily life. Often people do not require unseen ideas or unknown information, but instead need to invent creative ways of interpreting existing rich knowledge and information. In order to achieve productive outcomes from creative activities, individuals need to carefully choose relevant topics from existing knowledge, draw fresh ideas from fusing the existing ideas, critically analyse them and organise a practical implementation. It is also important to monitor the implementation, verify the idea during its application, and make changes if necessary. After implementation, it is crucial to assess the outcomes, extend use to other scenarios, and maximise appropriateness. Therefore, it is reasonable to argue that it is creative thinking which makes people's knowledge productive.

Cognition is essential in order to obtain information and acquire knowledge, whereas metacognition is needed for people to perceive, enhance and assess these processes so that knowledge gained can be implemented in future circumstances (Gourgey, 1998). By applying Sternberg's (2006) Investment Theory, Schaub (2007) further stated that the resources (e.g. intellectual abilities, knowledge) selected by individuals for application seem more crucial to achieve creativity. Thus, metacognition can be regarded as a fundamental and necessary element in order to achieve effective cognition. In short, metacognition serves as a driving force to aid one's cognition with the use of knowledge and regulatory skills. While metacognition is used in a general sense to include a number of elements, all of which are inter-connected, the most consistent understanding is that it represents two elements: knowledge about cognition and regulation of cognition (Schraw & Dennison, 1994). Gourgey (1998) further explained that having explicit knowledge, information and skills or tacit knowledge gained from experiences does not mean such knowledge would be productive. In order for one to transform knowledge into action, one needs to make use of three crucial elements, which means knowledge and skills are essential but, more importantly, the correct mind-set, motivation and attitude are required. There are people who are full of knowledge and information, yet they fail to use their knowledge in any meaningful way, hence their knowledge is dead. Therefore, how people control and arrange the implementation of their knowledge is vital. As Gurteen (1998) pointed out most people lack the ability to organise the knowledge they obtain when they are working, which leads to less productive results.

In this study it has identified that metacognition as an appropriate and efficient element for evaluating creative thinking ability, and it is also a crucial cognitive element in people's learning process in relation to arranging or organising knowledge (knowledge application); thus it is proposed that people's metacognition may exert an impact on how personal knowledge is used to increase the effectiveness of creativity.

2.14 Design knowledge

In the previous sections (2.9–2.13, pp. 53–102) the relevant issues on creativity, knowledge and metacognition have been discussed, and have shown that there is insufficient literature in which the application of specific kinds of knowledge in a certain domain is analysed. Therefore, to further explore the relationship between creativity and knowledge application within the design domain, the knowledge items apply in product design, specifically, in the FYDP process in this study, need to be assembled and overviewed in advance.

2.14.1 Studies of design knowledge

When referring to the studies of design knowledge in relation to creativity, there are mainly two areas of literature investigating this relationship. Each stream takes a distinctive perspective. The first is concentrated on design knowledge produced during the design process, which defines it from an abstract perspective and states that design and creativity share the same process of knowledge generation. Pioneer researchers in this area include Oxman (1990), who placed great importance on knowledge construction or generation which leads to creativity. However, the concept of knowledge in her study is more abstract or generalised and does not refer to any concrete subjects in the design domain. As a consequence, it is hard to link it to design education practice.

The other research dimension is represented by Christiaans (1992), who strongly valued the application of knowledge in the design process. For instance, one of his findings suggested that domain-general knowledge is more related to creativity compared with domain-specific knowledge. Based on this point of view, several studies regarding the nature of design knowledge have been conducted and relevant discussions have been stimulated. Bokova, as Director-General of UNESCO, has indicated that knowledge should be the very core of every form of education (UNESCO, 2016). However, for a long time there has been an argument debating whether there is a clear body of knowledge within the design domain. For example, Cross (1986) and Archer (1979) suggested that design is a 'third discipline' of knowledge that is distinct from knowledge in the sciences and humanities. This point of view is widely accepted by Chinese design scholars. Nevertheless, other scholars maintain a different attitude: as Wang and Ilhan (2009) have stated, the onus of the problem in defining a design profession does not lie in isolating the content of what it knows, but rather in discerning what it does (with any general knowledge that assists in the creative act) in a sociological process of defining itself in the larger cultural context. They claim that design knowledge actually draws on the general pool of cultural knowledge for the purpose of informing creativity. Therefore, design is regarded as 'interdisciplinary' (Wang & Ilhan, 2009).

It will be much more helpful to discuss design knowledge and wisdom with the help of design education's structure as an example. Having its roots in Bauhaus discourse (art-technology-science unification), design education has always been a multi-disciplinary structure due to the essence of the subject. It has always been associated with culture, technology, art, and history; more importantly, since the subject matter of design education is nothing but all human needs (Celik & Aydinlı, 2002). "Design education is a kind of personal laboratory, a melting pot, a transposable attitude that design students are invited to apply on the most various subjects during their studies (and afterwards). It can be named as 'the mobile mental playground' that can be considered as a rich, thick and permeable membrane formed by a multitude of disciplines (scientific, technical, artistic, social, ergonomic, ethical, environmental, market, prospect)" (Handenhoven, 2001, cited in Celik & Aydinlı, 2002, p. 2).

Current studies on design knowledge indicate that the scope of design domain knowledge is argumentative. In the literature review survey presented in section 2.12 (pp. 86–100), three categories of knowledge (domain-specific, domain-general, and tacit knowledge) were identified from the view of creativity. The categories in general were examined without investigating the details such as which subject (usually in correspondence to a particular knowledge item) belongs in which category. Therefore, this study aims to investigate how each knowledge type is applied in the design process, instead of investigating this issue from a general categorical view. However, the identified three categories still provide a useful direction and focus for assembling related knowledge in product design.

2.14.2 Producing the knowledge list for product design

In product design research, relevant studies about design knowledge provide an important base to define and produce the knowledge list for this study. Assembling the knowledge applied in the FYDP can be assisted by relevant studies concerning design knowledge; investigating how to move from being a design novice to achieving expertise as a designer is considered to require possession of a frame of knowledge and the creative and analytical ability to extract, analyse and apply that knowledge (Popovic, 2004). Relevant research includes Christiaans and Dorst (1992); Cross, Christiaans, & Dorst (1994); Goldschmidt (1997); Atman, Chimka, Bursic, and Nachtmann (1999); Ahmed, Wallace, and Blessing (2003); Seitamaa-Hakkarainen and Hakkarainen (2001); Kavakli and Gero (2002); Cross (2004); Popovic (2004); Suwa and Tversky (1997); Christiaans and Venselaar (2005). Amongst these studies, Christiaans and Venselaar (2005) have clearly identified ten items of domain-specific knowledge and one item of domain-general knowledge within industrial/product design. In addition, Popovic's (2004) study referred to strategic knowledge as domain-general knowledge and mentioned experiential knowledge.

Along with the relevant information about design expertise and knowledge in the literature, product/industrial design taught programme contents were also surveyed as a means to enrich the knowledge list, as the curriculum always reflects learning from imparted knowledge. The main resources used include course module information from China's Bachelor Product Design programme from the top 10 design colleges in the country; curriculum resources from universities; technological change and industrial design education according to the report by the Council for National Academic Awards (Yorke, 1991); and the related report of Subject Benchmark Statement Art and Design: Draft for consultation, April 2016 (QAA, 2016). Three skills were added to the domain-specific knowledge category, and one was added to the domain-general category, sourced from Bachelor product design course curricula in China (HELPRC, 2015) and the UK QAA report (2016).

Finally, this study introduced tacit knowledge as a specific category. There is no relevant reference or validation of related items in this category except acknowledging its strong relationship with personal experience. This study identified three items of general experience based on Polanyi's (1966; 2009) initial ideas of working and daily life experience.

An initial knowledge list was created in three categories (domain-specific, domain-general, and tacit knowledge). The framework of knowledge categories was mainly adapted from Christiaans and Venselaar (2005). At the same time, other studies on design expertise development and design knowledge were also considered. Moreover, all items included in this list were checked by comparing with the courses in the Bachelor product design programme, which is to ensure that the list includes all the subject-relevant knowledge delivered by design education. In total, there are 19 items of knowledge that were assembled as the basis of the questions on knowledge application (Table 4, p. 108).

When referring to dealing with knowledge, several terms usually come to mind, including knowledge management, knowledge construction, and knowledge application. Knowledge management refers to the knowledge that is needed to progress a project and is generally used in an organisation; knowledge construction is associated with the process of how to transfer the information into knowledge; knowledge application mainly refers to an individual's arrangement or integration of his prior knowledge (Spiro, Collins, Thota, & Feltovich, 2003). Considering the context identified in the research problem in this study, the focus was on the knowledge application aspect, because in an educational context, students acquire knowledge via the educational approach and in our specific case, we pay more attention to the learning outcomes of a four-year study, where students apply what they have learned to progress the FYDP, rather than to how they acquire knowledge.

Table 4. Knowledge pool in product design[4]

Domain-specific knowledge:
K1. Design history: knowledge relates to style perspectives.
K2. Material: knowledge relates to specific materials to attain certain conceptual solutions
K3. Design methods: knowledge relates to the application of design research and design case studies.
K4. Aesthetics: knowledge relates to colour, structure and form.
K5. Design representation: skills relate to 2D/3D drawing (effect drawing, three views)
K6. User Trials: knowledge relates to simulations of product usage in which subjects are asked to fulfil specified tasks using a product or product simulation.
K7. Client needs: knowledge relates to analysis of the design brief.
K8. Mechanics.
K9. Ergonomics.
K10. Skills to operate relevant machines.
K11. Media technologies.
K12. Knowledge of organisation and marketing.
K13. Psychology of consumer and user.

Domain-general/independent knowledge:
K14. Knowledge of information processing: information searching and analysis.
K15. An ill-structured problem-solving process: knowledge relates to analysing situations, defining problems, finding or generating solutions.
K16. Strategies: knowledge relates to motivation, plans and goals.

Tacit Knowledge:
K17. Knowledge of existing design solutions: the precedents of similar projects learned.
K18. Personal placement experience in design companies.
K19. Other experience in daily life: travelling, reading, events, etc.

- ***Note:*** *K1 – K10, K15 are adapted from Christiaans and Venselaar's (2005) study; K11– K14 are adapted from HELPRC (2015), China, and the QAA report (2016), UK; K16 is from Popovic's (2004) study; K17 – K19 are based on Polanyi's (1966; 2009) initial ideas on human experience, and K17, K18 are adapted from HELPRC (2015), China, and the QAA report (2016), UK.*

2.14.3 The introduction of design knowledge

The introduction of all these knowledge items in the product design process has also been reviewed and listed below:

K1. Design History: knowledge relating to stylish, perspectives.

Suggested by the QAA report, the knowledge related to the history of art and design "may be studied as a component of an art and design award; it may be taught and

[4] This is not an exhaustive list.

assessed as a separate subject or in combination with many other subjects; it may be a discrete element of the art and design curriculum; or it may be fully integrated with the main practice-based components" (QAA, 2008, p. v). The essential need to learn the history of art and design is to enable students to conduct research in design practices. The Chinese design education concentrates more on the practical view. According to the HELPRC (2015) report, the history of art and design, or even architecture, provides necessary support to develop subject-relevant skills (e.g. aesthetic appreciation).

Design history is thus delivered by design schools using a range of approaches which aim to enhance students' understanding of the design discipline from the historical, theoretical and critical viewpoints, so that it can be made manifest or integrated into students' design work.

K2. Material: knowledge relating to specific materials to attain certain concept solutions

In the fuzzy front end of the design process (beginning with an idea for a new product, and ending with the decision whether to launch a formal development project or not), materials are under consideration at a relatively abstract and holistic level, and are subsequently developed to be more and more concrete and ultimately implemented to solve a certain element of the design problems at the end of the design process (Asbjørn Sörensen, Jagtap, & Warell, 2017). This means that material knowledge is integrated into the whole design process, which is further applied and developed as the design process progresses. This process constitutes a permanent part of the transformation from the design problem space to the solution space. Moreover, it is finally represented to the users via the products' surface and influences users' experience (Ljungberg & Edwards, 2003). This is corroborated by Ashby and Johnson (2013), who have indicated that materials generally have two overlapping roles: (i) the technical functionality aspect and (ii) the emotional aspect. Therefore, it is reasonable to suppose that innovative products have often been inspired by the creative use of materials (Ashby & Johnson, 2013).

K3: Design method (design research, case study)

Design methods are related to the design process

The course of design methodology taught in current product design programmes covers a variety of methods dependent upon how a design project progresses and it is conducted from the beginning to the end; this includes developing/formulating design problems/constrains by conducting design research, developing design concepts by using mood boards, mind-mapping or mental models, thinking of relevant solutions by conducting a series of case studies, and so forth (HELPRC, 2015; QAA, 2016). Therefore, several activities are usually involved when using relevant design methods, such as 'exploring' (Warr & O'Neill, 2005, p. 120); 'discovering', 'elaborating', 'continual appraisal and reappraisal' (Archer & Roberts, 1979) and "inclusive activity' which begins "by carefully observing and understanding people and sensitively shaping solutions" (Southee, 2009, p. 184). The design method is thus considered to be related to the design process.

The design process

There are a number of common considerations in the design process. For example, Gero and Maher (2013) and Lawson (2006) stated that it is equal to the creative process as both involve similar cognitive activities. Schön (1983) and Oxman (1990) regard the design process as a learning process involving knowledge construction. In the domain of product design, models regarding design phases are largely constructed based on the problem-solving process of design. As Goldschmidt (2014) claimed, the 1960s can be seen as the era of the 'design methods movement'. Abundant research focused on investigating design methods and processes during that period, which modifies and improves the process of design. Cross (1986, p. 36) has developed a cyclic process with various design methods associated with it, which contains "an analytical phase of problem definition and formulation, a synthesis phase of design solution and an analytical phase of evaluation". Roozenburg and Eekels' (1995) study provided a similar model of the design process including activities of observation, supposition, expectation, testing and evaluation, which is developed based on de Groot's (1969) framework. Lawson and Loke (1997) probed the designers' working experiences and found primary activities, namely, 'analysis, synthesis and evaluation' during the design process. Specifically, Pahl and Beitz (2013) paid more attention to design process from the viewpoint of function, and then developed the functional decomposition model. According to Roozenburg and Eekels (1995) the core activities of different design subjects, e.g. product design, graphic design, and interior design are always essentially the same.

By synthesising the relevant studies, the general design process can be categorised into 1) the preparation stage, namely, the conceptual design stage 2) the embodiment design stage 3) the detailed design stage, and 4) the implementation stage (Howard et al., 2008). However, with the development of research in this field, the focus moved to the relationship between each phase and the exploration of relevant rationales. This probably benefits from the development of AI (artificial intelligence) after the 1980s with a rapid explosion of neurological and biological research and a breakthrough in 'deep learning'. The primary concept of AI development is to implant abstract concepts in a machine dependent on a specific algorithm, so that the machine can 'think' almost like a human being. Studies of Gero (1998) and Takeda, Veerkamp, and Yoshikawa (1990) indicated that the conceptual aspect of design can be further explored by applying a specific algorithm. Oxman (1990) further pointed out that this abstract concept of machine learning, namely, "conceptualization, generalisation, indexing and analogical matching", brings valuable inspiration to refine design methods, which is also believed to provide new insights into the exploration of how design knowledge is formed. As she stated, "some problems of existing design models appeared in the empirical study, for these models [the] lack of linking each design [activity] just reflect[s] the general process of design" (Oxman, 1990, p. 18). Vermaas and Dorst (2007, p. 291) also observed that current research on design methods "largely depend[s] on past design experiences (rather than basic physical principles) to generate solution concepts, therefore, how to transform a conceptual design process into a concept (i.e., need) in the intentional world or (i.e., solution) in the objective world cannot be addressed".

Following this new direction in design method research, several models have been developed focusing on those conceptual processes (e.g. logic or rationale) between explicitly identified design activities. These include the FBS (Function, Behaviour, Structure) model explored by Gero (1990); more recently, Chen, et al. (2015) developed a new conceptual design process model named Need-Function-Principle-System (NFPS). This model, as interpreted, "can explain how a need in the intentional world is transformed into a function and then into an abstract principle in the semi-objective world, and finally into a model system in the objective world, which provides stronger rationales between each design stage" (Chen et al., 2015, p. 139).

K4. Knowledge of aesthetics

The important role of aesthetics has always been identified in the design domain, and its unique significance to product design has been specifically considered (Brunel & Kumar, 2007). Correspondingly, aesthetics is initial to art, and from a broader view, it is essential to life itself (Brunel & Kumar, 2007). Products are part of people's life today, to a large degree, and this affects or even changes our lives. Therefore, besides emphasising aesthetics in the art and nature, the aesthetic qualities of product design are emphasised by designers, as one of design's attributes is to make people feel meaningful and joyful when they use products (Veryzer Jr, 1995). To foster the abilities of aesthetics in design education is thus to bring students the comprehensive understandings of 'beauty' and relevant abilities of evaluating a product from its structures, colours, forms, and other emotional or artistic factors.

K5. Design representation

According to Goldschmidt (2004), design concepts can be visualised when design representations are produced, and the activity of design representation generally covers the whole design process however the final design product has been formulated, constructed, or manufactured. He further states that the design goal will finally be achieved by a perfect representation of the designed object. Scholars generally argue that the aim of design is to represent, and there is no design conducted without design representation (Goldschmidt & Klevitsky, 2004). Therefore, as the QAA report (2008, p. 5) states, in the education of designers "the constituent disciplines traditionally emphasise the development of visual literacy. And drawing ability is regarded as a prerequisite skill for observation, recording, analysis, speculation, development, visualisation, evaluation and communication".

Within design education, the knowledge of representation embraces various forms and approaches. Generally, design representations are more precise focusing on showing the details of a certain designed object, whereas in certain conditions, they are 'quickies', just providing a few thumbnail sketches of rough ideas (Goldschmidt, 2004). Therefore, representations are either concrete or abstract, and reflect different aspects of the designers' thinking. Seen through techniques of expression, they may involve drawings, sketches, or illustrations expressed by brief writings. These expressions are either two-dimensional or three-dimensional, comprising paper drafts (or they can be computer-aided). They are associated with relevant drawing/painting conventions, such as the principles of perspective, or they may be conducted in free styles to interpret the designed object. From the content of design representation, it can be seen that representations involve different content according to the specific aims. For example, they may either provide a comprehensive figure with many details of a designed object, or just provide a specific part of a designed entity, which emphasises the details of the various elements (Herbert, 1988). It is not surprising that certain types of representation are approximate and only outline a general idea, and others pay more attention to articulating operational properties by applying diagrams rather than expressing details of physical properties. Therefore, the knowledge/skill of design representation is emphasised in design education as it is considered the standpoint of designers, and its flexibilities bring almost endless possibilities to design concept development.

Design representation and creativity

Many consider design representation an important approach to facilitate or achieve design creativity. Acuna and Sosa (2011) conducted a study to investigate the correlation between creativity factors – ‘originality’ and ‘functionality’ and two approaches of design representation – ‘sketching’ and ‘rapid model-making’. Their study indicates that designers would like to accept the perspective that hand-drawn sketches and other representation skills may facilitate the process of conceptual development. They also suggest that those designers who spend more time on sketching tend to produce more original ideas within a limited time scale and under the same conditions; those designers who invest more time in model-making are apt to produce solutions of a higher quality. Therefore, their primary insight is that "sketching is a suitable representation aid for the originality component of creativity, whilst realistic models and prototypes are media more suitable for the functionality component of creativity" (Acuna & Sosa, 2011, p. 266). Nevertheless, Demirkan and Afacan's (2012) study found that only three indicators (fluency, flexibility and overall creativity) out of nine (fluency, flexibility, elaboration, functionality, innovation, fulfilling design requirements, considering context, mastery of skills related to representation and overall creativity) are related to creativity, and therefore representation is not on the creative indicators list.

K6. User Trials: knowledge relating to simulations of product usage in which subjects are asked to fulfill specified tasks using a product or product simulation.

Accordingly, user trials play a significant role in investigating how a product performs and how the users evaluate its performance, which subsequently impacts the conclusion as to whether it is a functional and attractive product (Lawson, 2006). For example, there is beta testing (for computer games), where, copies of a pre-released game are sent out to trial individuals to collect information about their experience in playing the game. In such cases, when an error is found, the individual reports the error and the producer reviews the error to refine the product.

User trials are usually conducted in the last stage of the design process; however, they should occur at the very beginning, as early as when the firm decides on the tester. This late inclusion of user trials could be attributed to the need to determine the target customer, which involves relevant information about the current market and company strategy, and thus is time-consuming and not an easy task (Brown, 2009).

K7: Client needs

The knowledge of client needs in product design is related to the analysis of a design brief, which is a document regarding a design project. A design brief is developed by a designer individually, a consultant design team or in a company. This opens a discourse and sets up the relationship between designers and their clients, so that it is possible to outline and circulate reasonable goals. It also defines the scope of a design project including any relevant information that may support or constrain it, e.g. the functions or any other emotional requests of a product, timing, and budget (Phillips, 2004). Therefore, a design brief specifically provides abundant and crucial information, which is useful for formulating design problems at the initial stage (Ryd, 2004). However, its important role cannot be ignored as it is also applied during and after the design process in order to keep the budget of the project under control, and even to evaluate and examine the final design product made (Phillips, 2004). Therefore, the design brief is generally changed and adjusted over time as the project progresses. It is a frame for design work which is a flexible rather than a fixed working plan.

K8 Ergonomics & K9 Mechanics

The knowledge items K8 and K9 are considered to be engineering-based within a design context. Ergonomics knowledge is related to technological development and the compatibility of human and product when they are working together. To be efficient and less costly, the ergonomic approach should be involved throughout the whole design process with a need analysis at the initial design phases (Sagot, Gouin, & Gomes, 2003). The ergonomics are reflected when the end-user uses the product and is related to the functions of products and the feeling of using them. The mechanics would not be represented in the images of products directly, however, they determine how a product will be formed. In other words, these aspects influence the users' experiences (Lawson & Dorst, 2009).

The relevant knowledge of mechanics in a product design context usually refers to this basic knowledge in terms of identifying structures of perceived products or how to construct a product as designed (Sagot et al., 2003). Similarly, Bingham, Southee, and Page (2013) in their study indicated the important role played by engineering-based knowledge, which should be integrated into the design context to facilitate the design process. Moreover, they further stated that the physical product outcomes from the FYDP module demonstrate a general trend of significant engineering-based learning application, as it improves students' modelling skills.

K10. Skill to operate relevant machines

This type of knowledge/skill is directly related to the craft of products. To develop the skill to operate relevant machines in a product design programme actually reflects the history of modern design development, in other words, the traditional view of design (Pevsner, 2005). From the viewpoint of design history, the pioneers of the Arts & Crafts Movement (e.g. John Ruskin and William Morris), which began in Britain around 1880 and quickly spread to America, Europe and Japan, advocated “a revival of traditional handicrafts, a return to a simpler way of life and an improvement in the design of ordinary domestic objects” (Cabannes & Ross, 2015, p. 206). Even in the early years of the 20th Century, the Bauhaus Design School (Weimar/Dessau 1919–1933) carried out teaching as ‘form masters’, together with ‘work masters’ (trained craftsmen) instead of ‘tutors’ (Triggs, 2014). This brief introduction of design education history illustrates why design schools currently maintain such craft skills within the curriculum.

K11. Media technology

The knowledge of media technology refers to social media (technology), which is a developing phenomenon and has several different definitions used in academia or in public. In product design, media technology is usually related to the application of web-based technologies enabling designers and their teams to share information, e.g. new user-generated ideas or existing valuable information within the digital environment context through various approaches of communication (Piller, Vossen, &

Ihl, 2011). Additionally, media technology is also emphasised as useful in improving the exhibition of the products (HELPRC, 2015).

K12. Knowledge of organisation and marketing

The knowledge of organisation and marketing generally includes knowledge of the structure, culture and behaviours of firms, and more specifically, the relevant information and methods of market research, e.g. the market survey, interview, and focus groups. Accordingly, K12 and K7 (Client needs) both refer to design management which includes the integration of design and business (Best, 2006) and the new requests for designers (Barnett, 2000). The emphasis of this application in design education is reflecting the blueprint of the design industry in the future.

K13. Psychology

Psychological knowledge is sometimes necessary in the design process. Customer needs specific to the utility and functionality of a product have received more attention in product design studies. In the marketplace, it is not surprising that a successful product may largely depend on the pleasure and the satisfaction that it creates and brings to the users, or its aesthetic appeal. Therefore, psychological knowledge in product design usually refers to customers' emotions and emotional responses. More specifically, relevant knowledge is related to those emotional matters which determine the products' sales potential, how to measure emotions, or the interactions between a customer's emotion and behaviour (Khalid & Helander, 2006). As customer psychology emphasises the product development life-cycle, it is suggested that it be input at the early stage of the design process (Jin, Ji, Choi, & Cho, 2009). Furthermore, culture issues are also stressed when delivering this kind of knowledge. Students are usually encouraged to discuss the relevant aspects of this issue, because culture influences what customers require from a certain product and how they evaluate it (Khalid & Helander, 2004).

K14: Information processing

Information processing is regarded as an important knowledge/skill that needs to be mastered in the design process. It provides methods and guidance in searching for information for designers when they face the challenge of uncertainty; it can fill previous knowledge gaps by comparing newly processed information. A well-conducted process of searching and analysing new information facilitates the generation of new design knowledge, and by applying this, perceived uncertainty will gradually be reduced (Love & Roper, 2009). This is then turned into knowledge in order to make it applicable to the needs of designers and businesses (Cousins, Lawson, Petersen, & Handfield, 2011).

Accordingly, information processing is related to both information acquisition and processing (Cousins et al., 2011). Acquisition comprises collecting, recording, reviewing, and the filing of new information (Lynn, Skov, & Abel, 1999), while processing refers to the application of this mastered information through interpretation, reasoning, and interference analysis (Daft & Lengel, 1983). Aurisicchio, Bracewell, and Wallace (2013) investigate the application of information sources and information-seeking activities conducted during the design process, and the results indicate that these manipulations of information are playing an essential role in the initial stage of design and are useful for engineering and product designers. Therefore, it is believed that positively seeking for more appropriate information would help to form a rationale for carrying out effective activities when challenged by those uncertain situations during the design process, which would bring benefit to the whole design project.

K15 The ill-structured problem solving process

The ill-structured problem

Design is generally considered to be a process of problem-solving, or to be more specific, the ill-structured problem-solving process (Roozenburg & Eekels, 1995). Identified by Simon (1973), the ill-structured problem refers to complex problems in various contexts, such as social, cultural, political, and economic. The ill-structured problem is also regarded as a 'wicked problem' that is difficult to solve or appropriately defined for several reasons, which include (i) "incomplete or contradictory knowledge"; (ii) "the interconnected nature of these problems with other problems"; (iii) "the large economic burden"; (iv) "the number of people and opinions involved" (Kolko, 2012, p. 10). According to Kunz and Rittel (1972), who first introduced the concept of the 'wicked problem', there are no conclusive laws for formulating a 'wicked problem', but once a wicked problem has been formulated, the corresponding solution will exist. Therefore, as Buchanan (2010) illustrated, the solutions of wicked problems cannot be evaluated by the general criteria used in well-structured problems, such as true or false, but only by good or bad. He further states that "[f]or every wicked problem there is always more than one possible explanation, with explanations depending on the Weltanschauung of the designer." (Buchanan, 2010, p. 15).

Conclusively, the chief distinguishing feature of these problems is that there are no clear approaches or correct answers to them; therefore, there may be several solutions for an ill-structured problem (Christensen, 2006). An example for distinguishing the ill-structured problem and the well-structured problem is 'how to start a car': this is considered to be a well-structured problem as people can follow a series of pre-setup directions to solve it. Differently, 'how to design a car' is usually considered to be an ill-structured problem as the solution differs depending on the situation. Therefore, the ill-structured problem is generally considered to be a design problem and the related knowledge is delivered via design education e.g. what is its essence and how can it be defined and analysed.

Design problems have been regarded as a crucial component in the design process, which can be reflected from the model of design processes. These models commonly show that design begins with problems that are ill-structured, although they are defined by different issues, such as requirements (Archer, 1979), customer needs (Andreasen & Hein, 1987; Hales, 1993; Svensson, 1974), tasks (Pahl & Beitz, 2013), or constraints (Lawson & Loke, 1997). Correspondingly, the procedures for dealing with design problems are also different, including activities of finding, determining, formulating, defining, or analysing design problems.

The design problem and creativity

Several scholars of creativity research notice that it is the ‘ill-structured’ or ‘wicked problem’ that provides the preconditions that fertilise creative thinking and products (Camillus, 2008). The design problem became a focus when Simon (1973) stated its features and differences compared to the well-structured problem. As design problems are always solved with open or abductive ends, they are thus considered ‘ill-structured’ problems. The likeness of a design problem and an ill-structured problem leads to the relationship between design and creativity. As Williams et al., (2010b, p. 14) stated, “the common definition of design problems as ‘wicked’ or ‘ill-defined’ implies the importance of creativity to design; these problems require a particular (creative) approach in order for them to be solved”.

The interpretation of the correlation between design and creativity from the view of ‘ill-structured problem’ stimulates a discussion on the design problem, which focuses on whether creativity will be achieved through problem definition or problem solution. The former viewpoint focuses on defining and analysing problems from new perspectives so that they can be solved; the latter statement, however, suggests that creativity should be achieved through seeking the creative solution of the problem, which focuses on decision-making or selection. Lawson (2006) has identified two contrasting styles of operation, ‘problem-focused’ and ‘solution-focused’.

K16. Strategies: knowledge relating to motivation, plan and goals.

K16 is leading the direction of the whole design process as it refers to strategic knowledge involving motivations, goals and plans, as well as focusing on the aim of solving design problems and generating the final designed product (Alexander & Judy, 1988; Popovic, 2004).

The knowledge items K14, K15, and K16 are grouped into the domain-general knowledge category, according to the current literature (Christiaans, 1992; Popovic, 2004). Christiaans and Venselaar's (2005) study also implied students whose designs have a higher creativity rating would elicit on average a greater amount of domain-general knowledge than other students.

K17, K18, & K19: Tacit knowledge in relation to the experiences of designers

In their major study, Dorst and Cross (2001) identified that the design process is a 'co-evolution' process varying with the problem space and the solution space, rather than a technical ill-structured problem-solving process. Moreover, Cross (2004) pointed out that the designers' perceptual activities underlying creative insight is not so much a 'leap', but more akin to a 'bridging' between the problem space and the solution space. This 'bridging' is achieved dependent on the magnitude of the designer's reflective activities (Dorst & Cross, 2001). Tacit knowledge is, thus considered to be a significant factor, possibly because it is one of the key materials to facilitate the process of reflection in such a 'co-evolution' and 'bridging' process (Cross, 2004).

Kolb (1984) stated that to obtain this so-called experience-based knowledge, reflection on experience has thus been advocated as a primary component in management and educational literature.

The literature shows that investigations focusing on designers' experience are usually related to studies of the knowledge base in the design process. Accordingly, designers' experience is considered to be designers' prior knowledge (Oxman, 1990), or is viewed as design-related precedents (exemplars) (Doboli & Umbarkar, 2014), while it is also regarded as the designers' previous experience of designing (Sarkar & Chakrabarti, 2011). It is these specific kinds of knowledge that contribute to design creativity (Dorst & Cross, 2001). For example, Gero (1992) argued that these knowledge-based elements provide the predominant material for memory organisation, indexing, and flexible retrieval, which are extremely important for decomposition, search, exploration, analogy, and mutation. As Oxman (1990) interpreted, these activities, e.g. searching and exploring, promote the classification and adaptation, which are the key elements for achieving creative design. She further stated that the designers' knowledge construction depends on their memory. In other words, designers will search for similar solutions when they encounter design problems. Precedents or designers' designing experience provide relevant solutions or approaches to design projects.

Design fixation

However, a number of studies discussing designers' experiences have argued that the precedents or experiences may lead to a design fixation occurring, which inhibits the creative process (Ward, 1995). Doboli and Umbarkar's (2014) study, one of the updated studies, suggested that using precedents may reduce the diversity of design solutions rather than having an effect on the novelty of design. Moreover, Smith, Ward, and Schumacher (1993) suggested that the designers' originality of ideas may be constrained by dependence on examples, though the total number of produced ideas may not be influenced. These studies suggest that knowledge or experience, which are considered as the basis of creativity by many researchers, is a double-edged sword. On one hand, one cannot achieve creativity in a professional area without domain knowledge and experience; on the other hand, a fixation may occur if designers largely depend on precedents to stimulate inspiration or find a solution.

Relevant studies also provided relevant suggestions for overcoming the design fixation, including the following:

> "Fixation relate to the problems and processes that are being considered and to the initial ideas that designers develop" (Crilly, 2015, p. 75).
>
> "Designers need not sketch concepts in isolation from other people and other techniques (as is often the case in the experiments) but might actively seek fixation breaking feedback from their team and from the 'physical reality' of making models" (ibid, p. 75).

> "Although wide-ranging concept exploration may be desirable in design (and is often requested in the experiments) the constraints of commercial practice may mean that the cost of such exploration discourages conceptual breadth" (ibid, p. 76). "By accumulating experience of multiple projects (as has seldom been possible for the experimental participants), professional designers draw on their experience when maintaining a balance between openness and persistence" (ibid, p. 76).

Sio, Kotovsky, and Cagan (2015) found that providing examples leads to more example-related generation with fewer categories of ideas, but surprisingly, the production of more novel ideas. The current literature provides related suggestions on how to break through fixation, whilst ignoring the essential role of prior knowledge or experience in the design process, which is the key material for reflective activities. For example, Toh, Miller, and Kremer (2013) argued that design fixation would be diminished by focusing on physical objects, and Crilly (2015) suggested that the designers may overcome fixation through representations of problems.

2.14.4 Critiques

In summary, all the knowledge items assembled have been reviewed based on the current literature. The main purpose is to further understand each item and establish how they have been researched so far. The literature regarding the relationship between creativity and a certain knowledge item are summarised below:

1. The relationship between the creativity and knowledge of ill-structured problem (K15): a number of studies have focused on investigating whether

design creativity is problem-focused or solution-focused (Jonas, 1993; Lawson, 2006; Cross, 2004), i.e. the problem-solving process (Howard, Culley, & Dekoninck, 2008) vs. specific domain knowledge (Bingham, Southee, & Page, 2013; Moreno et al., 2014)

2. The relationship between creativity and the knowledge of design presentation (K5): there are a series of studies that consider design representation as an important approach to facilitate or achieve design creativity (e.g. Goldschmidt & Klevitsky, 2004; Acuna & Sosa, 2011)
3. Several studies (e.g. Christiaans & Venselaar, 2005; Popovic, 2004) claim that creative students apply domain-general knowledge to a much greater extent than less creative students (K14, K15, & K16).
4. The relationship between designers' experience (K17, K18, & K19) and design fixations: several studies (Cross, 2004; Dorst & Cross, 2001; Oxman, 1990; Sarkar & Chakrabarti, 2011; Sio, Kotovsky, & Cagan, 2015) have particularly emphasised the relationship between creativity and designers' experience; while others argued that the designers' experiences or precedents may lead to design fixation occurring, which inhibits the creative process (Doboli & Umbarkar, 2014; Ward, 1995).

These issues have been studied from the perspective of whether they may lead to creative outcomes in the design process, but there are still few studies that probe into their application in the design process, as Christiaans and Venselaar (2005) have stated. The reason for this situation is similar to that of creativity research, as Razzouk and

Shute (2012) stated, there lacks valid performance-based assessments in design research to help researchers develop related hypotheses that set up the relationship between applying a specific knowledge item and a specific performance. Furthermore, when integrating with the conclusion obtained by reviewing related literature on creativity and knowledge (section 2.12.6, pp. 98–100), it is more challenging to identify the amount of subject-related knowledge that is applied in a design process than to simply investigate the general categories of knowledge, e.g. domain-specific or domain-general knowledge.

In addition, these studies that have been reviewed regarding design knowledge are mainly based on the data collected from a single school in a country (mainly Western countries), and therefore, may not apply in general. This situation echoes Harris and Wilson's (2003) argument that the literature on the impact of design and technology lacked what they term research-based evidence, and that literature on impact was largely based on small-scale case studies drawn from practitioner research and concentrates on a narrow area of research interests associated with the context of practice (Harris & Wilson, 2003). As in creativity-related research, an increasing number of researchers pay attention to the socio-cultural aspect of creativity (see section 2.5, pp. 39–46), and therefore cultural issues will be taken into account in this study. Based on these concerns, the application of each knowledge item (applied in the FYDP) in the target, China, and in the UK's universities will need to be examined and studied.

2.15 Theoretical ground

This chapter further discussed the relevant issues regarding the research problem. First of all, a comprehensive understanding of creativity has been formed by an extensive literature survey from the perspectives of person, product and process. This study defined creativity as a cognitive process and argued that understanding creativity from the process perspective is proposed as most suitable in the context of this research, which is design education. More specifically, this process involves interactions between divergent thinking and convergent thinking. According to the Cognitive Creative Sifting Model, metacognition can be regarded as a moderator in this process of creative thinking to efficiently indicate and predict people's creative performances, while creativity is also considered to be knowledge-based. Based on Amabile's (1996) Creative Componential Model and Polanyi's theory of tacit knowledge, three types of knowledge related to creativity have been determined: domain-specific knowledge, domain-general knowledge and tacit knowledge.

Several conceptual ideas of the main issues in this study have been extracted from this literature survey, framing its theoretical base, which are outlined as follows:

- Creative thinking abilities may produce creative performance;
- Metacognition evaluates creative thinking abilities;
- Knowledge (or knowledge application), as one of the cognitive activities during a design/creative process, may be considered to be associated with creative performance;

- Metacognition is likely to exert an impact on knowledge application, specifically, the application of tacit knowledge via people's reflection.

Based on these assumptions, it is possible for this study to outline the relationship between metacognition, knowledge application and creative performance, which is shown in Figure 8.

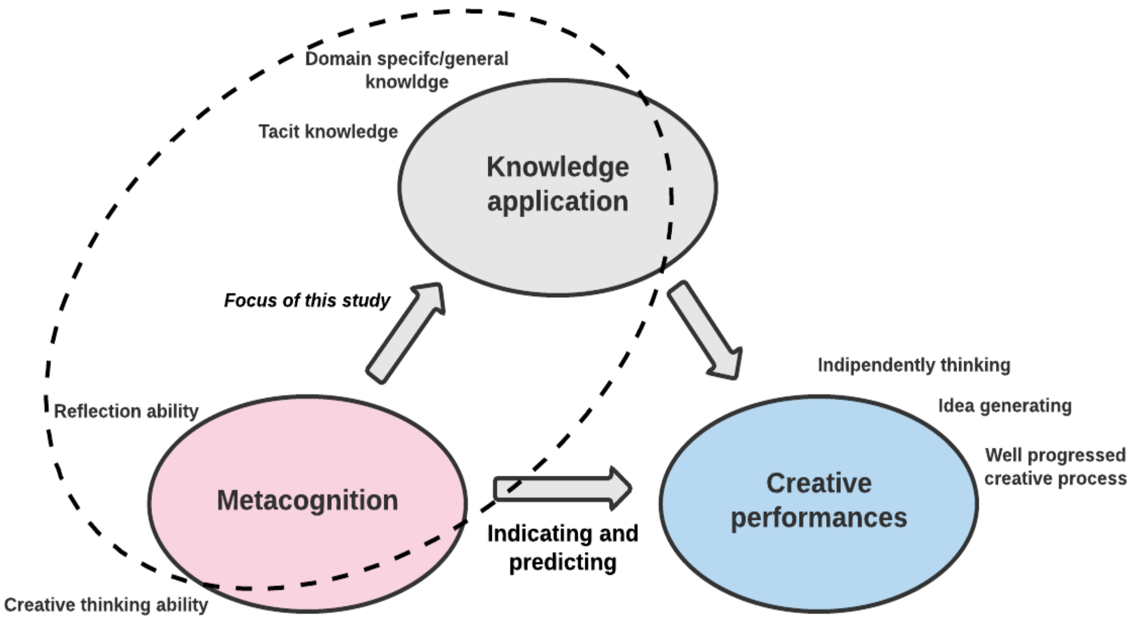

Figure 8. The theoretical framework for this research

In this study, metacognition was intended to be applied as a criterion for measuring students' creative thinking abilities; moreover, a claim was made (section 2.4.4, pp. 36–37) that creative students may perform better in the FYDP process than those non-creative students. Therefore, it is reasonable to assume that if applying a specific knowledge item would improve the FYDP process, then the students with better creative thinking abilities, identified by metacognition measurement, will probably apply this knowledge item to a greater degree than those students who are less creative. Therefore, this study tried to probe which knowledge item is applied more frequently by the students who obtain higher metacognition scores compared to the students who obtain lower scores. As there is no performance-based measurement, this study focused on investigating the impact of metacognition on knowledge application, as highlighted in Figure 8 (dotted line circle area).

2.16 Identifying the knowledge gaps

The main knowledge gaps in the current literature were found and outlined as follows:

1. There is no further research or empirical studies on how metacognition affects cognitive activities (the knowledge application in this study);
2. There is a debate about whether creativity is domain-general or domain-specific. One perspective argues that better understanding of domain-specific knowledge leads to more creative products (the domain-specific view). The other argues that better comprehension of domain-general knowledge helps to achieve more creative products (the domain-general view). Additionally, there is a hybrid view which believes that both categories of knowledge co-work in improving creativity. But as Christiaans and Venselaar (2005) argued, little is known about the way in which knowledge and skills within or across domains are actually used. It is also unclear as to the kinds of experiences are involved in certain processes (Matthew and Sternberg, 2009);
3. The literature on design knowledge so far, to my best knowledge, focuses on a single university within one country.

So far, the metacognition has been identified as a creativity-related construct in this study. Therefore, the focus and scope of this study is finally determined and fitted on metacognition and knowledge application. To address the identified literature gaps in this study, the research questions have then been updated and specified by asking a series of sub-questions for each main question.

- For RQ1. What kinds of knowledge are applied under the impact of metacognition?

  Sub-question 1. Is each specific knowledge in the category of domain-specific/domain-general/tacit knowledge applied as a consequence of metacognition?

  Sub-question 2. Can we gain more insights on the debate as to whether design creativity is 'problem-based' or 'solution-based' from the results of sub-question 1?

  Sub-question 3. Is metacognition the main factor that makes an impact on knowledge application?

- For RQ2. Does metacognition exert the same impact on the different kinds of knowledge?

  Sub-question 4. Can the impact of metacognition on the application of tacit knowledge bring insight on its relationship to design fixation?

  Sub-question 5. Does metacognition make the same impact on the different kinds of knowledge in different cultural contexts, e.g. the Western and Eastern, the UK and China in this study?

2.17 Research purpose

The literature survey indicated that the relationship between knowledge application and creativity has not been studied in sufficient depth. As identified in section 2.6 (p. 48), creative students would be better adapted to the FYDP. Therefore, to solve the research problem and bring valuable insight to the research question, this study aimed to identify specific subject-related knowledge items which are more frequently applied by creative students. This study expects to provide further insight in applying knowledge appropriately in a design project. Furthermore, regarding the knowledge gaps identified in section 2.16 (p. 133), specifically, there is a gap in the related research on how different types of knowledge are applied in a design process; little is known about the way in which knowledge and skills are actually used. Therefore, the purpose of this study is as follows:

> *To identify specific knowledge for application by students classified as creative in product design.*

Chapter Three: Research Methodology

3.1 Chapter overview

This chapter informs readers about the methodology of this research. This was determined by taking certain factors into consideration such as research questions, developed hypotheses and the limitations of current research on this topic. Therefore, this chapter provides relevant information as to how the research methodology has been developed in this study. Section 3.2 refers to a literature review on methodology. It outlines the basics of the methodology of the research in general, and analyses several studies in related research topics, in order to justify the methodology adopted by this research. Section 3.3 describes the survey design. An online questionnaire along with two psychometric instruments was used to collect data. The reliability and validity have been examined with more details including a pilot study in section 3.4. In section 3.5, data analysis strategy is interpreted, followed by section 3.6 which narrates the procedure of the data analysis. Finally, this chapter concludes with section 3.7, which provides a map towards the development of the research methodology in all stages.

3.2 A literature review on methodology

3.2.1 Research paradigm

The type of methodology that is appropriate for the research depends on the nature of the research and its unique features. Hickman (2008, p. 16) stated that methodology is more than simply 'the study of methods', but is also "the theoretical background to research and its implications for the particular research method employed". He (2008) further claimed that depending on different paradigms, different types of methodology could be used, e.g. the interpretive approach, the phenomenological approach or mixed approaches. Saunders, Lewis, and Thornhill (2009) declared that choosing an appropriate research philosophy is fundamental to the understanding and development of knowledge in any research area. They also pointed out that the chosen research philosophy often reflects a researcher's view on how knowledge-developing processes are connected to knowledge acquired, whether it is facts-driven or attitude-based (Saunders et al., 2009). Slife, Williams, and Williams (1995) stated that philosophical ideas, though not usually expressed explicitly, should be identified, because they explain and justify choices and practices in research. In addition, the research philosophy and paradigm influence researchers' beliefs and knowledge and therefore impact on the validity of their arguments and the reliability of results (Gliner, Morgan, & Harmon, 2001). As a result, a literature review on methodology and paradigms plays an important role in specifying the most appropriate and relevant approaches (Creswell, 2014).

Research paradigms are often described in terms such as positivism/post positivism, constructivism, or criticism, according to different ontological and epistemological perspectives. As Easterby-Smith, Thorpe, and Lowe (2002) suggested, a research paradigm or philosophy consists of three different components: ontology, epistemology and methodology. Ontology was described as "common assumptions that are created to understand the real nature of society" (Easterby-Smith, Thorpe, &

Lowe, 2002, p. 18). Epistemology refers to "common parameters and assumptions which are associated with the excellent way to investigate the nature of the real world" (ibid, p. 21), and methodology could be interpreted as a "combination of different techniques that are used by the researcher to investigate different situations" (ibid, p. 25). In general, understanding researchers' ontological, epistemological and methodological stances facilitates understanding the combination of various research methods. As a result, it is necessary to understand the issues related to research philosophy before it is possible to create the most appropriate methodology. From an ontological and epistemological point of view, a paradigm can be divided into three categories: post-positivism (i.e. built upon positivism), interpretation (or referred to as 'constructivism' or 'anti-positivism' by others) (Creswell, 2014), and realism (also regarded as 'pragmatism') (Creswell, 2014).

The idea of post-positivism is derived from positivism but focuses more on assessing and revising positivism. Since positivism is considered to be closely related to objectivism, scientists, by applying this philosophical approach, use objectivity rather than subjectivity to evaluate the social world and establish their viewpoint (Cooper, Schindler, & Sun, 2006). Rather than focusing on details of analysis, researchers aim to gather quantitative information from a large social sample. By using this paradigm, a researcher's prior opinions carry no weight and should not influence the outcome or results of the study. Positivism is a philosophy driven by the collection of numerical data and quantifiable observations from experiments (Easterby-Smith et al., 2002). Using a post-positivist approach means to evaluate and determine the causes of effects, using data collected from experiments. Thus, it is considered to be deterministic. The intention is also to reduce ideas to a smaller and more manageable scale for testing, e.g. hypotheses and research questions (Creswell, 2014). Hence it is also reductionist.

Interpretivism is a philosophy which places importance on the beliefs of the researcher. Using an interpretive approach means that instead of focusing on facts gathered from experiments, people's opinions and viewpoints and their justification of these are obtained to derive an answer to a research question (Easterby-Smith, Thorpe, & Lowe, 2002). In specific social circumstances, small-scale samples have been used and investigated in depth to interpret the views of a larger group of people (Kasi, 2009).

Realism in general focuses on existing beliefs and reality in the environment. According to McMurray et al. (2004), there are two major branches of realism: direct realism and critical realism. Direct realism refers to reality according to individuals' direct senses, e.g. sight, hearing and feeling, whereas critical realism derives from arguments about experiences in a specific situation (Sekaran & Bougie, 2010). Critical realism is related to social constructivism, due to the fact that people attempt to attest and validate their beliefs and values.

In the same research paradigm, a different methodology would be appropriate depending on the specific requirements and characteristics of the particular research area. Since answering research questions and achieving research aims is the ultimate goal, a methodology could be interpreted as the steps taken during the process of linking research questions to objectives from an operational point of view. The following section (3.2.2) represents the review of different methodologies and relevant research methods embedded within.

3.2.2 Research approaches and methods

According to Creswell (2014), there are three main approaches to conducting research. They are quantitative, qualitative and mixed approaches. Each approach further embraces several research methods.

i) Quantitative approach

Early quantitative approaches stemmed mostly from psychology and invoked a post-positivist philosophical stance (Creswell, 2014). Creswell further divided quantitative approaches into three categories: true experiments, quasi-experiments and non-experimental methods. One example of non-experimental methods was referred to as the correlational design, where correlational statistics were employed to quantify the level of association between different variables or various sets of scores (Creswell, 2014). The quantitative approaches follow the procedure of hypothetico-deductive research, which is the "most commonly accepted method as a typical scientific method" (Gao, 2012, p. 69). Hayes (2000) explained that a hypothetico-deductive approach means "testing hypotheses-predictions about what will or won't happen if a particular theory is true and making deductions from the results of those tests" (p. 4).

ii) Qualitative approach

Qualitative approaches originated from anthropology. A great variety of qualitative approaches emerged around the late 20th Century, including an explanation of the full procedures of each respective approach. For instance, the narrative inquiry approach was thoroughly investigated by Connelly and Clandinin (2000), and a complete picture of what narrative inquirers do was described with practical procedures to follow. The phenomenological approach was described by Moustakas (1994), with a clear theoretical background and practical guidance on how phenomenological research should be conducted. Grounded theory is another example of a qualitative and inductive approach where the procedures have been reviewed (Corbin & Strauss, 2008); Moreover, Stake (1995) and Yin (2009, 2012) analysed processes of conducting an effective case study. Compared with quantitative methods, qualitative methods follow the inductive research procedure. Inductive research means the research starts from obtaining a series of observations instead of creating a hypothesis, and the interpretation of the observations leads to the formation of theory (Hayes, 2000). Therefore, it is an interpretivist philosophical stance.

iii) Mixed methods

Apart from the quantitative and qualitative approaches, the third approach – mixed methodology – involves the combination or integration of quantitative and qualitative approaches. In this scenario, both quantitative and qualitative methods are used for data collection, evaluation and interpretation. "Instrument data may be augmented with open-ended observations, or census data may be followed by in-depth exploratory interviews" (Creswell & Creswell, 2017, p. 21), and the researcher makes inferences across both sets of data.

iv) A comparison between quantitative and qualitative approaches

A great number of complicated evaluations and disputes have developed concerning research methodology for social science and the appropriate procedures that inquirers should follow (Buckingham & Saunders, 2004). These disputes are caused largely by different beliefs as to whether quantitative methods or qualitative methods are better or more 'scientific' to apply in a research. Depending on social, political, cultural or historical factors, different approaches gained popularity in different periods. According to Dawson (2009), all methodologies are simply different, and have their specific advantages and disadvantages, and it is important for a researcher to address and understand their differences. Therefore, based on current literature regarding qualitative and quantitative research methodology, a comparison between both approaches was made from the six aspects and is summarised in Table 5 (p. 143):

Although each research approach has its strengths and weaknesses, in certain conditions, its strengths can turn into weaknesses (Buckingham & Saunders, 2004). For example, a qualitative approach is believed to increase the depth of understanding of the cases and situations studied. However, as researchers taking this approach immerse themselves in a culture or situation and directly interact with it, they are more likely to become biased in the way of data collection, interpretation and presentation.

Table 5. A comparison between qualitative and quantitative approaches

	Qualitative	**Quantitative**
Sample size	A much smaller number of people and cases (Anderson, 2010)	A broader study involving a greater number of subjects (Anderson, 2010)
Research aim	Allowing the researcher to describe existing phenomena and current situations, and producing a wealth of detailed information (Denzin & Lincoln, 2000; Anderson, 2010)	Summarising vast sources of information (e.g. trend, attitude) and making comparisons across categories and over time (Denzin & Lincoln, 2000)
Genralisation of the results	Less generalised (Anderson, 2010)	More generalised (Anderson, 2010)
The relationship between the researcher and the research subject	Immersion in a culture or situation and direct interaction with participants (Merriam, 2009)	Keeping a 'distance' from participating subjects (Merriam, 2009)
Ways of conducting research	Developing flexible ways to perform data collection, subsequent analysis, and interpretation of collected information, and offering the flexibility to shift the focus of the research (Merriam, 2009; Babbie, 1998)	Applying well established standards that the research can be replicated, and then analysed and compared with similar studies (Merriam, 2009; Babbie, 1998)
Data	Providing a holistic view of the phenomena under investigation; Creating a descriptive capability based on primary and unstructured data flexible ways to perform data (Babbie, 1998)	Allowing for greater objectivity and accuracy of results; Using a static and rigid approach and so employing an inflexible process of discovery (Babbie, 1998)

- *Notes: this content is adapted from Anderson (2010); Babbie (1998); Denzin and Lincoln (2000); Merriam (2009)*

Moreover, different conclusions can be drawn from exactly the same data due to different personal characteristics possessed by researchers. Similarly, the quantitative approach, although allowing more objective and accurate results because of its numerical nature, provides less detailed narratives and elaborate accounts of human perception. It has been widely observed that no type of methodology is better than other methodologies (Benbasat, Goldstein, & Mead, 1987; Kaplan & Duchon, 1988), and therefore, there is no preferable or ideal approach, but only the one most appropriate for a particular research study.

v) Research databases and tools

Following these research approaches, different kinds of data are generated. Quantitative research usually deals with numbers, figures, and statistics, and generates numerical data, employing statistical testing for the purpose of quantifying research problems. Its results usually reveal the correlation, difference or trend of variables using statistical tools. Qualitative research mostly deals with texts, scripts, and images, and is primarily used to gain an understanding of underlying reasons, opinions or motivations. The results of this approach usually involve visual work analysis, schema, protocol analysis, and using social science analysis software. Therefore, in the case of mixed methods, both kinds of databases are generated.

So far, the three main elements (research paradigm, research approaches, and research methods) have been reviewed that attribute to forming a research design/strategy. Typical scenarios of research are summarised in Table 6 (p. 145) to illustrate how these elements combine into a research design, which includes the relevant procedure from the operational perspective.

Table 6. Typical scenarios of quantitative, qualitative, and mixed method research (Creswell, 2014, p. 18)

Tend to or Typically…	Qualitative approaches	Quantitative approaches	Mixed method approaches
Use these philosophical assumptions Employ these strategies of inquiry	Interpretivist/constructivist knowledge claims Phenomenology, grounded theory, ethnography, case study, and narrative	Post-positivist knowledge claims Survey and experiments	Realistic/pragmatic knowledge claims Sequential and concurrent
Employ these methods	Open-ended questions, emerging approaches, text or image data	Close-ended questions, predetermined approaches, numeric data	Both open- and close-ended questions, both emerging and predetermined approaches, and both quantitative and qualitative data and analysis
Use these practices of research as the researcher	Positions him or herself Collects participant meanings Focuses on a single concept or phenomenon Brings personal values into the study Studies the context or setting of participants Validates the accuracy of findings Makes interpretations of the data Creates an agenda for change or reform Collaborates with the participants	Tests or verifies theories or explanations Identifies variables to study Relates variables in questions or hypotheses Uses standards of validity and reliability Observes and measures information numerically Uses unbiased approaches Employs statistical procedures	Collects both quantitative and qualitative data Develops a rationale for mixing Integrates the data at different stages of the inquiry Presents visual pictures of the procedures in the study Employs the practices of both qualitative and quantitative research

After reviewing these elements in research study design, a general map for generating a research strategy was formed as a framework to guide and determine the appropriate methodology in the study on hand. Moreover, as this study assumed that there would be a relationship between metacognition and knowledge application and intended to identify specific knowledge for application by students classified as creative in product design, it tended towards the perspective of post-positivism and following the hypothetico-deductive approach. By keeping consideration of this framework in mind, the next section (3.2.3) overviews methods applied in relevant domains, which leads to the formation of the most appropriate research strategy for this study. As identified in the former three chapters, this research involves creativity, design and design education. Therefore, studies regarding these topics need to be overviewed respectively.

3.2.3 An overview of studies on creativity

Creativity studies are usually embraced in the domain of cognitive psychology, a branch of psychology. Accordingly, psychology is a complex discipline and involves multiple disciplines; hence, most scientific methods have been contemplated in psychology research in the modern era (Howitt & Cramer, 2003). Typically, a mixed approach was found to be the most appropriate for psychological research. For this reason, different methods in psychology are applied in studies from natural science to social science.

However, there is a debate on which perspective, behaviourism or cognitivism, should be adopted inside the boundaries of psychological research. Behaviourism started to gain popularity during the 1920s and reached its peak in the middle of the 20th Century. Later on, in the 1960s, cognitivism began to have greater influence in educational theory. Since then, there has been a significant shift in the research focus from observing external behaviours to interpreting internal cognitive processes (Denyer &

Peacock, 2016). Simply put, both behaviourism and cognitivism have been influencing various areas of research.

For instance, in the area of education research, scholars supporting behaviourism suggested that using both positive and negative reinforcement would achieve the best learning outcomes (Eichenbaum, Cohen, & Packard, 2003). This theory is still practised by teachers at schools and has a tremendous impact on classroom management. Behavioural psychologists recommend that it is beneficial to break down learning tasks into small steps that are logically linked to one another (Eichenbaum et al., 2003). They also emphasise that it is of significant value to create explicitly specified objectives and a well-structured curriculum. On the contrary, cognitivism, concentrates on what internal cognitive processes occur during the acquisition of knowledge, the study of inner processes of individuals, and the necessity for balancing opposing influences (Baars, 1986). Cognitivism puts the individual students, rather than teachers, at the centre of learning, which is based on the understanding that they are the main drive to learning. It is suggested that cognitive theory should be applied throughout the question and answer stages before, during and after teaching instructions are given (Jonassen & Land, 2012). It is also highlighted that the instructions should be centred around the targeted students. Additionally, it is important to facilitate group learning through interaction and cooperation, learning by exploration and active play, and presenting core contents in a number of diverse ways. As suggested by Niess, Kajder, and Lee (2008), starting lessons by discussing topics that students already know is one way of following cognitive theory, such as asking students to find answers to real-life questions. Last but not least, it is cognitivism that has influenced teaching practice to guide students' learning and support them to be ultimately self-reliant, i.e. to scaffold their learning (Larkin, McDermott, Simon, & Simon, 1980).

This study involved investigating creativity issues within the context of design education. Additionally, creativity in this study was defined as a cognitive process that oscillates between divergent thinking and convergent thinking. The main objective was to observe how students' metacognition influences their knowledge application in FYDPs, which is largely related to design students' internal mental processes and inner knowledge. Therefore, this study tended to accept the perspective of cognitivism. From this perspective, the following section provides an overview of the relevant literature, focusing on studies of cognitive processes in both the design and design education domain.

3.2.4 An overview of studies on the design cognitive process

To gain the overall idea of methods applied in studies similar to this research, literature has been reviewed with a focus on design journal papers (mainly from *Design Studies* and *Design Issues*). The essential and updated papers presented and discussed in this section are concerned with three aspects: i) Studies of design cognitive process; ii) Design knowledge development; and iii) Design knowledge and creativity. These papers were briefly analysed focusing on their research aims and questions, the relevant methods they applied, and their data analysis strategies, in order to see how these research strategies address research questions to achieve the research aims. A synthesised discussion of these methods in relation to the study on hand is provided subsequently in section iv) to shape the final research strategy.

i) Essential and updated papers on studies of design cognitive processes

Paper 1. Cognitive styles in design problem solving: insights from network-based cognitive maps, (Kim & Kim, 2015)

This research identified the lack of elaborate studies on distinguishable styles of using precedents (i.e. domain knowledge) to solve design problems and create new ideas, although it had been commonly agreed that precedents are related to design abilities. Therefore, in their study, an attempt is made to identify designers' cognitive characteristics and classify them into a limited number of styles. 24 Masters' students in industrial design were presented with different design tasks, and their verbalised thinking processes were recorded. An innovative method, i.e. 'cognitive map', was proposed to intuitively analyse the designers' cognitive processes, in particular, how various elements e.g. precedents, interpreters, and ideas are connected in a networked style. As a result, four different types of cognitive styles were identified, namely focused probers, treasure hunters, selectors, and explorers.

Paper 2. Visual accessibility in graphic design: A client -designer communication failure, (Cornish, Goodman-Deane, Ruggeri, & Clarkson, 2015)

This paper targeted the issue that there seems to be poor communication between graphic designers and clients, which leads to the lack of visual accessibility in product designs. Through the survey of 122 graphic designers and clients, the hypothesis was confirmed. As a result, it is necessary to create more inclusive tools to facilitate accessibility design and to use the ethical code of practice to improve client-designer communication.

Paper 3. Investigating design: A comparison of manifest and latent approaches, (Cash & Snider, 2014)

The aim of this study was to explore and synthesise manifest and latent, the two commonly but individually used research approaches. The authors first set up a conceptual framework of the two approaches and found the way to link the two approaches is by considering their order of interpretation from data, e.g. the 1st order (raw characteristics), the 2nd order (patterns), the 3rd order(decisions). Therefore, they observed the design behaviours of the selected groups of Master students' finalists after being presented with a design task and compared the strengths and weaknesses of the two approaches. The authors' main contribution is the four combined approaches proposed to achieve more effective design outcomes.

Paper 4. Designers' perception during sketching: An examination of Creative Segment theory using eye movements, (Sun, Xiang, Chai, Yang, & Zhang, 2014)

Sketching can be modelled as a Creative Segment tree according to Creative Segment theory. Nevertheless, how designers perceive the sketches and whether their perception corresponds to the Creative Segment tree has not been studied. Based on this assumption that designers' eye movements may show distinguishable features at different branches in the Creative Segment tree, this study tried to examine several hypotheses via conducting an experiment. In this experiment, participating designers' eye movements were recorded and found to correlate to segments of the tree, hence it provided convincing evidence for the Creative Segment theory. The visualised approach was used for analysing data, and statistical analysis 'correlation' was also applied.

ii) Essential and updated papers on studies of design knowledge development

Paper 5. Expertise development in product design – strategic and domain-specific knowledge connections, (Popovic, 2004)

In this paper, the aim was to study designers' activities during the stage of early conceptual product design, in the hope of finding how strategic knowledge and domain-specific knowledge have been used and any connections between them. Conceptual sketches of products created by designers with different levels of expertise (novice, intermediate, and expert) were analysed to identify their respective knowledge connection models and associated characteristics. By comparing the ways in which novice and expert designers use knowledge and strategies, it was discovered that the use of domain-specific knowledge was a distinguishing factor among different levels of design expertise. It also highlighted how novice designers (first year undergraduates) adapted and changed the way they used domain-specific knowledge and strategies as they progressed through their education to become experts (postgraduates).

Therefore, this study selected the method of visual work analysis (from the educational context) to explore the research question. The design work (drawing drafts) was selected from undergraduate design students, and a schema approach was applied for visual work analysis.

Paper 6. Conditions influencing the development of design expertise: As identified in interior design student accounts, (Smith, 2015)

The author conducted interviews with 38 interior design students about their experiences in design education. The collected data was then compared to analyse what the common conditions are that give the greatest influences in the development of design expertise.   It was found that the participants perceived "personal knowledge and skills" to be the primary influencing factors, whereas "supportive interpersonal relationships, teaching culture, resources" were regarded as the secondary factors. It was concluded that expertise in design was not gained by the increase of personal knowledge alone: it also relied heavily on interpersonal matters and the opportunity to expand personal knowledge using available and functioning resources.

Paper 7. Expertise in design: an overview, (Cross, 2004)

The author conducted a comprehensive literature review on a series of design studies in relation to design cognitive processes. Most of these studies applied the method of protocol study. For instance, Christiaans and Dorst's (in Cross, 2004) protocol studies of junior and senior industrial design students revealed that most junior students tend to struggle to move on from collecting information to actually designing their own products However, Atman and Chimka's (ibid) protocols study on information processing in the design process showed that compared with freshmen, senior students tended to collect a wider range of information, thus producing better design outcomes. Ahmed, Wallace, and Blessing's (ibid) study discovered that experienced engineer designers would apply a more strategic approach to ensure the design is worthwhile before implementing it as a product design, whereas novices mostly adopted a "trial and error" method. Goel and Pirolli's (ibid) protocol studies were undertaken with architects, engineers and instructional designers, and the significance of constructing and reconstructing the problem recursively was highlighted. Last but not least, Fricke's (ibid) protocol studies with engineering designers found that having too little or too many design alternatives would both result in poor designs and were both equally weak strategies; hence maintaining the best balance was vital to effective designs.

Among these studies, different approaches were applied for specific purposes. For example, the 'think aloud' approach was employed to obtain the data, the in-depth interviews were used for data collection, and, other approaches such as the experimental approach involving self-reporting were adopted.

iii) Essential and updated papers on studies of design knowledge and creativity

Paper 8. Can creativity be taught? (Osmond & Bull, 2013)

This paper discussed 'can creativity be taught' in order to seek ways of improving industrial design students' creativity. The authors took the perspective that creativity is domain-specific. With this perspective they measured creativity by creative product.

As the authors claimed, creative design is represented through relevant expertise, skills or abilities. For example, creativity in music was expressed through a specific giftedness in the realm of music, creativity in writing was expressed through the organisation of narrative, and so forth. As a result, they argued that a 'creative baseline' in a specific field needed to be defined before it is possible to discuss whether creativity could be taught or not. Based on this assumption, the authors wanted to explore whether the 'spatial understanding' could be the 'creative baseline', and whether it could be the 'threshold knowledge'. If the answer is yes, then creativity could be taught by cultivating students' 'spatial understanding', and the improvement in creativity could be evaluated by measuring students' development of spatial understanding. Then the students' creativity would be improved as relevant capabilities develop.

They conducted interviews with design staff from Coventry School of Art and Design. They found that it was neither too difficult to define the creative baseline of spatial understanding that underpins the Transport and Product Design course, nor to consider it to be a threshold concept. As the feedback collected was so different, it was hard to generate a consistent conclusion. Instead, several candidates supporting spatial understanding (e.g. components or potential threshold concepts) were identified, which, as they suggested, can be used as an early sign of skill during a student's application process.

Paper 9. Creativity in Design Engineering and the Role of Knowledge: Modelling the Expert, (Christiaans & Venselaar, 2005)

This work by Christiaans and Venselaar (2005) investigated the relationship between the creativity and domain knowledge in the design field, which is quite similar to the study on hand. To achieve this aim, the author analysed freshmen design students' knowledge retrieval and the standard of their designs (using creativity as a measuring criterion).

In this study, design students' project reports were the main data source to gather reflection on their acquisition of design knowledge. The two authors gave an independent evaluation of the reports, and classified the reflected learning experiences into three categories, namely, 'basic' knowledge, 'design' knowledge and 'general process' knowledge. The agreement between the judges was also measured to provide a reference on how reliable the evaluation was. To collect relevant data on the quality of students' designs, Amabile's 'Consensual Assessment Technique' (CAT) was also applied to measure the creativity of design products in this study. A correlation analysis using a statistical approach was applied for analysing data and addressing the research hypothesis.

The author also conducted another study following the same data collection and analytical approaches in order to provide more evidence for their previous study.

iv) Discussion

Among these studies in the design cognitive process, and the design knowledge and creativity in particular, research strategies like protocol study, visual work analysis, interview, observation and survey are widely applied. These reviewed methods are summarised in Table 7, with reference to how they are conducted in relation to data collection and analysis:

Table 7. Summarised methods applied in design cognitive process research

Research methods	**Materials for data collection**	**Forms of data received**	**Data analysis approaches**
Visual work analysis Observation Interview Experiment Survey Protocol study	Design tasks/works Scripted questions Questionnaires Guidance for think-aloud	Video/speech records Visual works Design works Reports (learner reports, self-reports, lab-based reports, design diary) Questionnaires Interview transcripts	Schema/cognitive map Verbal protocol analysis Constant comparative approach Statistical analysis

From a general perspective, the methods selected by these studies serve their research purposes, help to handle research questions, and fit into a certain research design scenario. For example, studies represented in Papers 1, 5, and 6 followed the methodologies which might be interpretive employing particular qualitative research methods, such as interviews, and working within a constructivist paradigm, whereas, authors of Papers 2, 4, and 9 applied the quantitative approach by conducting an experiment or survey, while the others adopted the hybrid approach.

The research purpose of this study was to explore the interactions between knowledge application and creativity, to further identify the role of different kinds of knowledge applied in the FYDP, and to finally provide suggestions about knowledge application that can be applied as guidance to improve educational practice (FYDP) in the context of China's product design education. The main research question refers to the kinds of knowledge are applied under the impact of metacognition in the FYDP. Therefore, the research strategy applied in this study would be expected to help achieve the aim and answer the question. First, an empirical method should be included to test the research hypotheses regarding the relationship between metacognition and knowledge application. Second there should be a proper way to collect the relevant data of metacognition and knowledge application. It is hoped that the implications of the results would provide suggestions for the current syllabus and curriculum structure in the context of China's design education.

As these studies reveal, Paper 6 and Paper 8 apply the interview strategy, as their aims were to identify people's (students/teachers) in-depth feedback on their design experience or collect information about specific opinions. As Smith (2015) stated, the results do not provide support for generalisation, but can be helpful in pioneering new ways of understanding. This does not seem to conform with the research aim of this study, as it aims to explore the interactions between knowledge application and creativity. The study in Paper 5 conducts a visual work analysis, as it investigates categories of knowledge (two categories in total) applied in the design process. However, in the study on hand it is planned to investigate each kind of knowledge within categories applied to a certain design process (the FYDP). Therefore, visual work may not be a proper choice for this study as the knowledge items involved were so abundant and complex, and it seems to be impossible to elicit from them a visual work for analysis. The approach of 'observation' involves investigating participants' activities when conducting artificial works within design research (in Paper 3). The study on hand involved the whole process of design students' FYDPs, which lasts for six months. Therefore, it poses a challenge to organise and manage the procedure of observing and recording activities during such a long period, and would not be suitable for this study. To conclude, the methods mentioned, based on the qualitative approach, were not suitable to apply in this study.

The research in Papers 4 and 9 conduct experimental studies taking the quantitative approach. The experiment in Paper 4 is more related to a lab-based experiment which applies equipment for tracking eye movements. Paper 9 employs the 'learner report' to record the participants' processes in conducting design work. However, once again, as one of the most important elements involved in this research, the FYDP lasts for several months. Many constraints may arise during such a long-term study, such as time demand, cost and labour. As a result, updating and validating records via such a procedure seemed problematic, at least in this study. Moreover, this experimental strategy is usually applied to achieve the research aims through comparing the target groups with the control groups, which was not the same situation as the proposed study.

As reviewed in Papers 1 & 7, protocol study is widely applied in investigating design cognitive process. The strategy is often used to investigate those invisible cognitive processes. It has its origins in information-processing theory, which checks how the human mind works in terms of how it deals with information – including both the newly- inputted information and that which has already been stored in memory (such as knowledge). As Ericsson and Simon (1993) proposed, it is possible to record and analyse a few aspects of the individual's information processing by asking them to 'think aloud' when they are carrying out a task. The 'think aloud' technique is the main approach to collect data in a protocol study; however, this approach would not be very suitable to apply to a long-term task for the same reason that rules out the experimental approach. Hayes (2000) suggests an alternative instrument of psychometric study, which can be used to investigate cognitive processes, in the form of a questionnaire to collect data. Therefore, the psychometric approach would be the most appropriate to obtain relevant data about the cognitive process involved in this study.

There exists another strategy survey (in Paper 2) that is also widely applied in the studies of design education (Mertens, 2014). This approach is to access larger samples compared to other approaches discussed. This seemed to be suitable for this study, because it aims to obtain results for generalised suggestions which requires a sufficient sample size, rather than focusing on a specific case or phenomenon in full detail via investigation and as a priority of study. Its results can serve a certain population.

3.2.5 Methods applied in this study

This study involved two cognitive relevant elements to be investigated – metacognition and the application of knowledge. Moreover, these elements are involved in a long-term process – the FYDP. Therefore, the psychometric approach would be adopted for collecting data. Survey-based research may not dig deep into a specific topic like interview or case study research does, which is conducted to investigate a limited number of interviewees (Buckingham & Saunders, 2004). However, it can cover a broader range of issues with a much broader base of respondents, which makes it more suitable for this study (Buckingham & Saunders, 2004).

To conclude, survey-based research in the form of a questionnaire is the most appropriate for this study and it follows the quantitative approach within the typical scenarios of research (see Table 6 in section 3.2.2, p. 145). The next step would be to determine the appropriate psychometric instruments to measure the variables and design a questionnaire to collect data for this study.

3.3 Survey design

As discussed previously, two variables should be measured in the current study. One is students' metacognition ability, and the other is to what degree a specific kind of knowledge has been applied in the FYDP process. Therefore, the aim of conducting this survey was to further examine how the independent variable (metacognition) influences the dependent variable (to what degree a specific kind of knowledge has been applied in the FYDP process). Although it is assumed that not only one parameter exerts influence on the knowledge application in the FYDP, this study considered creative thinking to be one of the most important factors measured by metacognition. Therefore, to conduct this survey, several conditions should be clarified in advance: 1) The participant should be sharing similar knowledge backgrounds. 2) Two survey instruments are needed for measuring the two variables. 3) Those variables that may influence the independent variables should be considered and included in the questionnaire.

3.3.1 Participants

It is intended to collect data from universities who are providing product design programme in China and the UK in this study. The reason is to make the results of this survey as generalised as possible and to make sure that the data collected from the two countries would be comparable. Therefore, it is fundamental to examine whether there is a specific difference existed in the design education between the two countries from the view of higher education system. The data in China were intended to be collected from the top 10 design colleges and universities (section 2.1.1, p. 8), while that in the UK data were mainly from the top 10 design colleges and universities issued by the Complete University Guide 2015 including 1. Oxford, 2. University College London, 3. Lancaster, 4. Newcastle, 5. Brunel, 6. Reading, 7. Edinburgh, 8. Loughborough, 9. Heriot-Watt, and 10. Leads. In addition, the QAA design curriculum syllabus were also a reference for examining the product design education in the UK.

The main similarities and differences between the two countries are outlined below: First of all, undergraduate education in product design is basically a four-year system in both countries. However, the specific syllabus in each country has a slightly different focus. China focuses on the foundation of fine art in its first year i.e. courses like Sketch, Forms, and Colours are emphasised; while the UK focuses more on industrial and engineering knowledge, i.e. courses like Entrepreneurship and Innovation, Mechanics for Design are set, which are usually set in the second and the third year in China.

Second, although the total length of undergraduate product design programme in both countries is four-year, the length of 'placement' is different between the two countries. In the UK, there is a selected one-year placement programme which is set in the third year; whereas, Chinese colleges and universities have a set placement stage in the fourth year, which typically only lasts 1-3 months. The commence is that the FYDP in both countries is set following the placement stage, which is the final stage of the undergraduate study of product design and considered the final test of the undergraduate learning and comprehensive ability of the students. Therefore, it is reasonable and feasible to take the design colleges and universities in these two countries as the main research object in this study, because both in terms of syllabus and academic system have great similarities, and the slight differences between them are also acceptable in this study.

Finally, the survey was conducted among product design students from the UK and China's universities, who have just completed their FYDPs but have not yet received their marks. The Chinese participants were from the top ten Colleges (as listed in the research background) in the design domain in China. The UK data was from those participants with a background in Product Design who have attended the '2017 New Designer Exhibition'. This exhibition showed the best final-year design projects from institutes across the UK. It is expected that participants from either country have a relatively similar knowledge base, which conforms with the description of participants required for this study.

Although there were cultural contexts involved in this study, it may not be seen as a comparative study. Comparative study is the act of comparing two or more things with a view to discovering something about one or all of the things being compared (Antal, Dierkes, & Weiler, 1987). When it comes to the cross-cultural aspect, the aim of a comparative study is generally to identify similarities and differences between social entities (Bryman, Liao & Lewis-Beck, 2004). To be more precise, a comparative study seeks to compare and contrast nations, cultures, societies, and institutions (ibid). However, this study did not intend to state or interpret the differences between the two countries of using knowledge in FYDP, but to obtain a more comprehensive understanding of knowledge application which may be influenced by different culture contexts. Therefore, this study is primarily considered to be an empirical study rather than a comparative study.

3.3.2 Questionnaire design

According to the established research purpose (see section 2.17, p. 135), the data of participants' knowledge application and metacognition level needed to be collected through a designed questionnaire. The aim was as follows:

i) *To measure the frequency of using subject-relevant knowledge in the design process of the FYDP*

The concept of knowledge covers a very large scale, which makes it hard to define. According to the definition of knowledge in the *Oxford Dictionary* (2010), "Knowledge can refer to a theoretical or practical understanding of a subject. It can be implicit (as with practical skill or expertise) or explicit (as with the theoretical understanding of a subject); it can be more or less formal or systematic". Another definition is "The term knowledge refers to an individual's personal stock of information, skills, experiences, beliefs and memories" (Christiaans & Venselaar, 2005, p. 219). To locate knowledge in this research within the design education background, it is here considered as a range of principles, skills, and subject-relevant information.

Overviewing the current research on design knowledge

There is abundant research that explores the knowledge used in a design process. The literature indicates that in the context of design research, the topic of knowledge has been investigated by document analysis, protocol analysis, and interview. These methods mainly focus on exploring the structure of knowledge, the domain specific knowledge in a design discipline, and the levels of knowledge acquisition by design novices and design experts. However, there is little in the literature which identifies the knowledge items for a certain discipline, thus to make sure that the questionnaire would embrace as much of the knowledge used in the final year as possible, a pool of knowledge items will firstly be developed for constructing the questionnaire.

The pool of knowledge within product design

The literature review identified three categories of knowledge (domain-specific, domain-general, and tacit knowledge), which have been applied as a framework for developing a list of knowledge subject areas, known to be expected and applied in FYDPs. The knowledge pool has been produced and each knowledge item in the list has also been reviewed in section 2.14.2–2.14.3 (pp. 105–127), and all the knowledge items assembled are shown in Table 4 in section 2.14.2 (p. 108).

The psychometric approach

There is a challenge in collecting relevant information about the modus operandi of students' knowledge application during FYDPs. The cognitive process of knowledge acquisition occurring without consciousness or realisation by the individual, as it occurs, and the limitation of direct observation or measurement, is problematic (Baartman & De Bruijn, 2011).

As discussed in section 3.2.4–3.2.5. (pp. 148–160), the psychometric approach can be used to investigate cognitive process in the form of a questionnaire to collect data and is suitable for this study. The primary advantage of this method is to provide the participants with relevant cues for retrospection on a certain process experienced by them. This ensures that the data collected is focused on a specific topic. Moreover, pre-set answers for selection (usually in numerical, ordinal, or categorical) make the data collection easier for coding and more suitable for statistical analysis: for example, in the studies conducted by Longo, et al., (2008) and Swets, et al., (2007), Likert scales were used to collect data. This method is efficient and cost-effective and is feasible for a large sample size analysis if applied in the form of a survey (Swets et al., 2007). The limitation of a survey is that it cannot reveal qualitatively deep information concerning the rationale of cognitive activities, but this is not the focus of the current research.

This study thus adopted the psychometric method in the form of a survey and constituted the first attempt in examining the effects of metacognition on knowledge application. The study aimed to provide insight into whether metacognition influences knowledge application and how this process is represented, rather than interpreting the reason as to why this process occurs and under what conditions.

Scaling

The term scaling is applied to the attempts to measure the attitude objectively. Attitude is a resultant of a number of external and internal factors (Michell, 1999). Depending upon the attitude to be measured, appropriate scales are designed. Scaling is a technique used for measuring qualitative responses of respondents such as those related to their feelings, perception, likes, dislikes, interests and preferences (Michell, 1997). The Likert Scale produces ordinal data (Benoit, 2012), enabling the ranking of attitudes, but not measuring the difference between attitudes. They take about the same amount of effort to create as the Thurston scale (another attitude scale) and are considered more discriminating and reliable because of the larger range of responses typically given in the Likert scale (Michell, 1999). In this study the intention was to collect information of the extent to which students apply various types of knowledge in the design process, thus the *frequency* of knowledge application (FKA) will be assessed by responding on a 7-level Likert scale as 'never used, very rarely used, rarely used, occasionally used, frequently used, very frequently used, and always used'.

An instrument called 'Self-Reported Psychometric Test: How do you apply your knowledge?' was created for this survey to measure how design students apply their knowledge (sample questions in Table 8; for detail of this instrument, see Appendix 1, p. 387):

Table 8. Sample questions in 'Self-Reported Psychometric Test: How do you apply your knowledge?'

How do you apply your knowledge?

Please retrospect carefully about how you applied your knowledge in the process that you implemented in your Final Year Design Project, then select the appropriate scale of each statement of the following knowledge using '√' to indicate to what extent you employed it in that project.

Scale / Domain-specific Knowledge	Never used	Very rarely	Rarely	Occasionally	Frequently	Very frequently	Always used
1. Design History: knowledge relating to styling, perspectives.							
2. Material: knowledge relating to specific materials to attain certain concept solutions							

ii) To measuring Metacognition

Reason for applying MAI

The Metacognitive Awareness Inventory (MAI) has been widely applied to measure people's metacognition (Akturk & Sahin, 2011), and several items of relevant literature have been reviewed. There are consensuses on its efficiency as a measurement and therefore MAI is recommended. This study employed the MAI as the instrument to evaluate students' creative thinking abilities via their metacognition. As described in the literature, the MAI has been supported by several studies with good reliability and validity for metacognition assessment, effectively covers various aspects of metacognition in-depth, and can be used to obtain scores for individual areas of metacognition, such as monitoring, planning, and comprehension (AL-khayat, 2012; Corebima, 2009; Schraw & Dennison, 1994; Yildiz et al., 2009). It has also been validated to support the evaluation of creative thinking abilities (Puryear, 2015, 2016). It is suitable for a large size sample, and is inclusive enough, compared with other methods for measuring metacognition e.g. the tasks based on experiments in a controlled lab environment; think aloud approaches in in-depth interviews; and other classroom learning observational approaches. Moreover, Corebima (2009) has studied students' metacognition abilities in the context of an Indonesian school; Dong (2010) applied the MAI to test the Chinese undergraduate students' metacognition. These studies supported the validity of the MAI test in a different cultural context.

Calculating and scoring

The literature introduces two general ways of applying the MAI. If researchers intend to investigate the details of metacognition or the effect of a specific aspect of metacognition on other cognitive constructs, they will calculate the score of each aspect of MAI (eight in total) (e.g. Magno, 2010; Puryear, 2015). At the same time, when researchers focus on the general understanding of people's metacognition levels, they will treat metacognition as composed of multiple factors and have the total score of MAI calculated (e.g. Magno, 2010; Yildiz et al., 2009). In this study, our intention was not to investigate how each component of metacognition works to influence people's cognitive process, but we have treated metacognition as a whole to evaluate creative thinking ability. Therefore, we intended to measure a participant's overall level of metacognition and calculate the total scores.

Scaling

The MAI is a self-reported Likert scale based instrument. The scale of MAI responses is flexible according to the different focus of studies, ranging from a simple binary True/False through to a 7-point 'strongly agree' to 'strongly disagree'. Examples include, Young and Fry's (2012) study which applied a 5-point; Puryear's (2015) 4-point Likert scale; Sperling, Howard, Miller and Murphy (2002) who used a 3-point scale; and Tyfekçi and Dujaka (2017) who used the original 2-point scale. According to Finley (1999), a multiple-point Likert scale is more suitable for investigating a deeper level of detail in the responses. Therefore, the more variance you have, the better you know the nuances of respondents' thinking; whereas, the dichotomous scale would be easier for respondents to make a quick and effective choice. Since this study does not explore fine detail about people's metacognition, the simple binary scale was considered more suitable.

Therefore, this study applied the original MAI version (Schraw & Dennison, 1994), (available via the following link:
https://www.harford.edu/~/media/PDF/StudentServices/Tutoring/Metacognition%20Awareness%20Inventory.ashx).
as it utilised the original dichotomous variable, which is consistent with the requirements of this study and has the total score of 52 points in answer to questions

relating to the categories in Table 3 (in section 2.11.5, p. 83). The sample question is represented in Table 9 (for detail of this instrument, see Appendix 1, p. 387).

Table 9. Sample question in MAI

Check True or False as appropriate. Use the Scoring Guide after completing the inventory.

	True	False
1. I ask myself periodically if I am meeting my goals.		
2. I consider several alternatives to a problem before I answer.		

The choice of 'true' scores 1 and that of 'false' scores 0. Each participant would be asked to choose an answer for each question according to their true situations, and at last the total score of MAI for each participant would be calculated. In Tyfekçi and Dujaka's (2017) study, which applied the same MAI version, the respondents' MAI scores were proven to be consistent with the normal distribution.

iii) Other information about participants

There are other factors that may exert an impact on the results of the correlation between independent and dependent variables. These factors are not changed throughout an experiment (the FYDP process in this study), and are therefore, called control variables (Kleinbaum & Klein, 2010). The reason for this is that their unchanging state allows the relationship between the other variables being tested to be better understood (Kleinbaum & Klein, 2010). Essentially, a control variable is maintained throughout the experiment, and it is not of primary concern in the experimental outcome (Ruane, 2005).

According to Gao (2012), the factors influencing a design project may include two aspects – the internal factors and external factors. This study followed this view to identify those factors. The internal factors would probably include the basic attributions of participants, such as their gender and age. The external factors would probably include the educational environment, such as participants' learning environment. It is assumed that participants from the same institute would probably conduct their FYDP under a similar educational environment (e.g. previous course modules, teaching and learning methods, other physical elements). Therefore, the information concerning educational environment will be collected by asking participants their institutions. In addition, the different topic of projects conducted by participants may also be a key factor that may exert an impact on their knowledge application, and should be included.

In summary, this study also planned to collect related information about participants, which were control variables. These types of information included participants' age, gender, institutions and the topics of projects they conducted, which were located in the first part of the questionnaire – participants' basic information.

iv) The structured questionnaire

Therefore, this questionnaire consisted of three parts 1) participants' basic information, 2) an instrument developed to measure participants' knowledge application, 3) an instrument to measure participants' metacognition level [see Appendix 1, p. 387]. This survey was based online, and the online portal was created for this questionnaire by using a web software, called Qualtrics, which is developed to conduct social surveys and is commonly recommended (Snow & Mann, 2013). It was also accessible via the link:

https://qtrial2017q1az1.az1.qualtrics.com/jfe/form/SV_4MZFhrTY7k18TDT

3.3.3 Ethical issues

The ethical issues regarding the participants should be considered during the data collection process. The British Educational Research Association Guide (BERA, 2011) has been used as a reference to help in addressing such ethical issues. One of the main principles of this guide was informing the participants about the research project from the beginning. For this reason, all participants were informed of the aims, questions, and scope of the research. They were also informed that all information collected for the project is confidential and would only be used for research purposes. In addition, all data and conclusions will be checked with the participants before publishing them. Privacy would have been maintained by not using their names (i.e. anonymising their responses). Another consideration that was involved in the early stages of this research was gaining permission from Loughborough University to conduct the experiment. Therefore, the Ethical Clearance Approval Form and Risk Assessment Template (interview/questionnaire) was completed by the researcher and signed by Dr. Samantha Porter, the supervisors, and the researcher himself. The Participant Information Sheet and Informed Consent were also given to participants and they were asked to sign before the survey started [please see the Appendix 1, p. 387 and Appendix 2, p. 397]. The copy of ethics approval is attached [see Appendix 4-1, p. 408 and Appendix 4-2, p. 416].

3.4 Reliability and Validity

Generally speaking, reliability means the overall consistency or repeatability of a survey, i.e. how well the questions would produce the same answer regardless of who asked them and when they were asked. Validity plays a significant role due to the fact that it guides researchers to verify the choice of survey questions, and ensures they serve the intended purposes. According to Gipps (1994, p. 67), the term reliability is regarded as "the extent to which an assessment would produce the same, or similar, score on two occasions or if given by two assessors"; and validity is considered to be "the extent to which an assessment measures what it purports to measure" and "if an assessment does not measure what it is designed to measure then its use is misleading" (ibid, p. vii). In other words, validity corresponds highly to assessment accuracy. Therefore, the reliability and validity of the designed questionnaire need to be considered before its distribution.

3.4.1 Reliability

There are several methods to test the reliability of a questionnaire including *Temporal stability, Form equivalence, Internal consistency* and *Inter-rater reliability* (AERA, 1985). 'Temporal stability' tests the questionnaire on the same participants more than once at different times (Test-retest); 'Form equivalence' requires the use of two different forms derived from the same information (Alternate form); 'Internal consistency' (Cronbach's Alpha, the most commonly recommended model to test the reliability of surveys) measures the correlations between scores of different items on a questionnaire; 'Inter-rater reliability' assesses agreement between two raters, coders, or observers (AERA, 1985).

The designed instrument for the survey in this research consisted of two tests: the "Self-reported Psychometric Test: How do you apply your knowledge?" and the "Metacognitive Awareness Inventory (MAI)". Their reliability was then checked.

i) Reliability of "Self-Reported Psychometric Test: How do you apply your knowledge?"

This test was developed to fulfill the aim of investigating how design students apply their knowledge in the FYDP. The main question is 'to what extent do you apply each kind of knowledge' [19 items in total, see Appendix 1, p. 387]. Therefore, there are 19 questions which are totally different to each other. On many occasions, the first approach – 'temporal stability' – is impractical since repeating the questions might have an impact on the participants' behaviours. The second approach – 'form equivalence' – expects alternative forms derived from the same information, which is also not suitable for testing this instrument as there is no other similar test on this topic. The last one – 'Inter-rater reliability' – would be useful if what is being assessed is mostly subject to personal tastes or opinions, e.g. photography or painting; however, it was not the case in this research, and therefore not suitable to be employed here. 'Internal consistency' aims to check whether items testing the same feature lead to similar scores. Cronbach's Alpha[5] is the most commonly recommended model to test internal consistency (Tavakol & Dennick, 2011), which produces an overall coefficient ranging from 0 to 1; a coefficient value greater than 0.7 would be regarded as passable (Tavakol & Dennick, 2011). This study's instrument has been tested with a Cronbach's Alpha score of >0.8, indicating good reliability. In addition, Mason (2007) suggested a series of special strategies which increase the reliability by maximising the trustworthiness, such as utilising quantitative methods, or applying closed-ended questions. The design of the instrument here conformed with Mason's suggestions as all questions are closed. Moreover, Robson (2002) stated that it would help to improve reliability if "studies that take place in the participant's natural setting or freedom to complete tasks in their own way and in their own time are applied" (cited in Mason, 2007, p. 55). Thus, it is assumed that there was slight problem with the reliability of the collected data in this research.

[5] For a fuller treatment of Cronbach's Alpha see Cronbach (1951), doi: 10.1007/bf02310555

ii) Reliability of MAI

The MAI has been trialed and supported by significant studies, demonstrating good reliability for metacognition assessment and effectively covering various aspects in depth (Yildiz et al., 2009), and as a good indicator and metric for creative thinking (Puryear, 2015, 2016; Corebima, 2009; Batey et al., 2010; Feldhusen & Goh, 1995). As reviewed, the reliability of MAI has been checked by many studies applying this instrument (e.g. Coutinho, 2007; Sperling et al., 2002). The Puryear (2015) study was the updated and featured one among these studies, which has shown that overall correlation between items (1–52) in MAI is above 0.7, hence it is considered to be acceptable.

3.4.2 Validity

According to the literature (Hernon & Schwartz, 2009), for evaluating the validity of surveys, the three main approaches are recommended: *Face Validity, Criterion Validity* and *Construct Validity*.

The first approach, 'Face Validity' includes a pilot study or pre-test (Moskal & Leydens, 2000), which suggests ways of improving the face validity of assessments:

1. Define clear and practical goals and objectives. Keep notes of students' expectations.
2. Create assessments to match the defined goals and objectives. Ask a third-party person for feedback and review.

3. Involve the students. Identify issues with wording or any other ambiguity of the assessments.

The second approach 'Criterion Validity', also called Concrete Validity, can be classified into two categories: concurrent validity and predictive validity (Moskal & Leydens, 2000). Concurrent validity means measuring the validity of the assessment in question and comparing it with a different assessment whose validity has been well-established previously. If the assessment in question produces scores that highly correspond to the scores of the well-established assessment, then concurrent validity is established. Besides, predictive validity focuses on how well the assessment score is an indicator of the real-world construct.

The third approach 'Construct Validity', uses Kaiser-Meyer-Olkin (KMO) Test. The KMO Test provides a measure of sampling adequacy used in a Factor Analysis, which shows if the ratio between case and variable is sufficient (Moskal & Leydens, 2000). The KMO & Bartlett's test is used to check the acceptability of sampling frequency in most academic and business studies. The KMO, which has a range of 0 to 1, is largely considered to require an index above 0.6 to be considered acceptable.

i) Validity of "Self-Reported Psychometric Test: How do you apply your knowledge?"

Among the validity assessment approaches reviewed, the second one – 'Criterion Validity' – is limited by several conditions as the proper criterion is hard to determine for assessing an instrument (Winter, 2000). Moreover, the third approach does not fit this instrument, which studies the modus operandi of knowledge application rather than defining specific factors. Therefore, the second approach (in relation to selecting a well-established criterion) and the third approach (in relation to Factor analysis) would not be suitable for assess the validity of this instrument. The first approach, a pilot study, was employed to check the questionnaire's validity.

ii) Pilot study

A pilot study was designed and conducted, and the purpose was twofold:

1. to identify questions in the developed instrument 'Self-psychometric report' that don't make sense to participants, or problems with this section that might lead to biased answers;
2. to identify major problems in the statistical analysis system.

Participants

The pilot study was conducted in two steps: 1) to collect comments for this questionnaire form from experts, a Ph.D. student and a design lecturer from the Design School, Loughborough University; 2) to organise a group of students to fill in questionnaire forms. They were recruited from Masters' students at the Design School, Loughborough University.

According to the suggestions from design experts, the questionnaire was revised and finally ready for the pilot study [Appendix 2, p. 397]. It was estimated that the number of valid responses of the subsequent large-scale survey would be 30% of approximately 500 target participants (around 160). According to Wong et al. (2009), a feasible sample size would be at least 10% of the estimated size; thus a sample size of 15 would be enough for this pilot study. In fact, 35 target participants in total (Masters' students at the Design School, Loughborough University) were recruited to take part in this study, and, finally, 24 of them responded, including 19 Chinese students. Although the expected participants of the later survey are those design students who have completed their FYDP, most of them had not finished their FYDP at the time of completing the questionnaire. These students at Master level have completed their FYDPs. Although there was a month-long period after their FYDP, it would not affect their understanding of the knowledge that they have applied, as the aim of this pilot study was to examine whether the questionnaire is effective. As important was the possibility that after a period of Master's programme study, these students may provide more valuable suggestions for improving the questionnaires, compared to undergraduate students.

The procedure of the pilot study

Students spent about 15 minutes completing all sections including reading the information sheet, signing the consent form and filling in the questionnaire form.

The results

- For purpose 1

A few comments were collected. These comments were for Question12, 18, and 19 in Section II in the questionnaire [Appendix 2, p. 397], which are also listed below:

Question12. Please retrospect carefully about how you applied your knowledge in the process that you implemented in your Final Year Design Project, then select the appropriate scale of each statement of the following knowledge using '√'. To what extent you employed 'Knowledge of organization and marketing including project management and understanding organizational behaviour'.

Answer selection: Never used; Very rarely used; Rarely used; Occasionally used; Frequently used; Very Frequently used; Always used

1) Student 19: 'In my university, I didn't learn the relationship between business and product'.

Question18. Please retrospect carefully about how you applied your knowledge in the process that you implemented in your Final Year Design Project, then select the appropriate scale of each statement of the following knowledge using '√'. To what extent you employed 'Personal placement experience in design companies to indicate it in that project'.

Answer selection: Never used; Very rarely used; Rarely used; Occasionally used; Frequently used; Very Frequently used; Always used

2) Student 5: '…never had working experience before'
3) Student 12: 'I didn't have any experience in industry at the time'.

Question19. Please retrospect carefully about how you applied your knowledge in the process that you implemented in your Final Year Design Project, then select the appropriate scale of each statement of the following knowledge using '√'. To what extent you employed 'Other experience in daily lives'?

Answer selection: Never used; Very rarely used; Rarely used; Occasionally used; Frequently used; Very Frequently used; Always used

4) Student 12: 'I didn't have any experience in industry at the time'
5) Student 20: 'Unsure in what context this applies too'.

Comments 1), 2) and 3) all showed that if the students have not learned relevant knowledge, they could not provide the answers to these questions. There were no more suggestions to add new knowledge into the questionnaire. This further supported the fact that in the later survey, the participants' knowledge background should be included in the questionnaire, in other words, the more the better. If a student found that he/she has not acquired certain knowledge, he/she has the right to skip this question; but if there was some knowledge that was not included in the questionnaire, then the results would not be as ideal as expected. According to comment 4) and 5), the statement of question 19 should be revised by adding related examples such as travelling and reading. There were no other comments that showed a misunderstanding of the question in the questionnaire.

- For purpose 2

The statistical analysis followed the selected strategies for the subsequent large-scale survey. The main tools for data analysis were determined to be Ordinal Logistic Regression, to further analyse the relationship between independent (MAI) and dependent variables (the frequency of knowledge application: K1–K19). Statistical analysis has been conducted by applying Excel (Microsoft version 15.24) and Stata[6] (version 13.0). All collected data has been entered into Excel first and arranged in a format suitable for statistical analysis. The small sample size may cause statistical concerns and lead to biased results. Therefore, the results from the pilot sample were duplicated 6 times to simulate a decent sample size which is expected in a subsequent survey. This means that if the sample size in the later survey is larger than 144 (24 x 6), the statistical analysis will progress well, and the results will be more reliable.

To sum up, the results indicated that the instruments in the questionnaire and the statistical tools that were employed in this pilot study were feasible to apply in the later survey.

iii) Validity of MAI

The factor analysis is the most widely applied method by current studies to assess the validity of the MAI. Schraw and Dennison (1994) tested this instrument in a factor replication analysis to support the validity of the eight factors of Table 3 (see section 2.11.5, p. 83) in their framework. Yildiz et al., (2009) conducted a similar study to

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[6] Stata is a general-purpose statistical software package applied in this study to run the relevant statistical programs (StataCorp, 2007).

examine the same eight factors of metacognition, validating the results of Schraw and Dennison's study; they also conducted Confirmatory Factor Analysis (CFA), which confirmed the validity of the eight factors in MAI and found that all the criteria had significant paths underlying their specific factors.

In further studies undertaken by Puryear (2015, 2016), the impact of the eight factors of metacognition on creative thinking was analysed and found to be of considerable significance to idea generation and idea selection processes. Subsequent studies have suggested that metacognition be considered a criterion to evaluate creative thinking abilities, with the MAI instrument demonstrating high confidence levels of 95% (Corebima, 2009; Batey et al., 2010; Feldhusen & Goh, 1995).

3.5 Data analysis strategy

This survey study involved a group of product design students with a relatively large sample, and the Likert scale was employed to quantify those qualitative responses. As all the data collected is quantitative data, a statistical analysis would be most suitable. However, statistics refers to a large group, so there is a need to select the most suitable methods for a certain study according to the research hypothesis, the nature of variables and the features of the collected data (Michell, 1997).

3.5.1 An overview of the statistics methodology

An overview of statistics methodology was conducted first to determine which instruments would be appropriate for data analysis in this study. Generally, when relating to the types of statistic, there are mainly two types, descriptive statistics and inferential statistics (Ruane, 2005). As this section involves extensive terminology regarding statistics, a number of footnotes are provided correspondingly for checking these terms.

i) Descriptive statistics

Descriptive statistics explain the main characteristics of a study's data. They are used to provide a summary regarding the measurements and sample. Descriptive statistics, along with graphical analysis, are invariably used as the basis for all quantitative analyses. Descriptive statistics offer a quick overview of the data and its content by calculating and representing mean, medium, mode, and deviation score of the data collected (Loether & McTavish, 1980). Thus, the descriptive statistics are the first and basic step when analysing data.

ii) Inferential statistics

Inferential statistics[7] are based on the analysis of descriptive statistics to further test the relationship between variables (Bordens & Abbott, 2002), which is used to find inferences that are beyond what is immediately apparent in the raw data (Loether & McTavish, 1980). Inferential statistics might, for example, be used to conclude the opinions of a population based on sample data. Additionally, it may be used to find the likelihood that a difference observed between two groups in a study is significant or whether it may be a random occurrence.

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[7] Inferential statistics is a branch of statistical analysis, which provides inferences or explanations about populations using data drawn from the population (Lowry, 2014).

Accordingly, if a researcher needs to examine the difference between samples with two or more groups, T-test, F-test, likelihood ratio test, and Chi-square can be employed (Preacher, 2001). The likelihood ratio test is suitable for comparing the 'fit' of two models. TheT-test, F-test (ANOVA), and Chi-Square identify whether two groups have significantly different opinions (Thomas, 1990). Alternatively, if a researcher has observations on two variables for a group of individuals, it is usual to analyse such data using regression and correlation (Gadsden, 2007; Ruane, 2005). The difference between regression and correlation analysis is that the former considers the causation between independent and dependent variables, whereas the latter does not.

As this study's purpose was to identify specific knowledge for application by students classified as creative by metacognition in product design, metacognition plays the role of an indicator here. We thus intended to explore the impact of metacognition on knowledge application, rather than examining the differences between groups. In other words, this study needed to consider the causation between metacognition (independent variable) and knowledge application (dependent variable). Therefore, the regression model would be selected as the main statistical analysis tool.

iii) Scales of measurement

There are various instruments for inferential statistics, so in choosing an appropriate statistical procedure for a study, the data type would be the most important factor and should be identified first (Mertens, 2014; Michell, 1997).

According to Mertens (2014), four types of data exist, namely nominal, ordinal, interval, and ratio. The nominal data refers to categorical data, such as colour (red, green, blue) or label (male, female). Ordinal data refers to ranked data such as weight classes in a competition, or grades in an exam; these can be ordered by decreasing or increasing value, such as largest to smallest or weakest to strongest, and by scales of measurement in the Likert scale. Interval data has standardised intervals[8] and has an arbitrary zero point, such as temperature. Ratio data also has standardised intervals but has no negative values, such as IQ, age, weight in many personality and educational tests. Accordingly, the data types of interval and ratio can be analysed using parametric statistics, and nominal and ordinal data are always analysed using non-parametric statistics (Mertens, 2014).

3.5.2 Statistical tools applied in this study

Ordinal Logistic Regression (OLR) was preferred in this study, which is a linear regression model. The main reason was that it is a causal analysis and assumes a dependence or causal relationship between one or more independent and one dependent variable (Peng, Lee, & Ingersoll, 2002). In this study, we wanted to identify specific knowledge for application by students classified as creative in product design, and thus we assume that metacognition, as a key creative construct, may exert an impact on the application of a certain knowledge item. If we could observe such a

[8] The standardised intervals means the equal interval. In equal interval classification each class occupies an equal interval along the number line. They are found by determining the range of the data. The range is then divided by the number of classes, which gives the common difference (Stevens, 1946; Weiss, 2007).

relationship between metacognition and knowledge application, i.e. the frequency of knowledge application increases as the MAI score increases, then we would be able to identify the specific knowledge which is considered to play a significant role in the design process. Therefore, metacognition (MAI) would be the explanatory variable (independent), whereas the frequency of applying a specific knowledge item (FKA) would be the dependent variable. Therefore, the focus of this study is to examine whether the independent variable (MAI) can explain the variance of the dependent variable (FKA). Moreover, the OLR is a type of logistic regression analysis when the response (dependent) variable has more than two categorises having natural order or rank. In this study, the independent variable – the MAI score – is a series of continuous number ranging from 0~52 and proved to be consistent with the normal distribution by several studies (e.g. Tyfekçi, 2017); whereas, the FKA has been measured by a 7-point Likert scale, so the results would be a 7-category with ranking. Therefore, the OLR would be the best choice for this study as the dependent variable is categorical (Benoit, 2012; Harrell, 2015).

3.5.3 Building up an Ordinal Logistic Regression model (OLR)

i) The regression equation:

A regression model uses the 'line of best fit' to predict the values of a dependent variable from given values of an independent variable by calculating the shortest vertical distances. This line is also known as the 'regression line', which is shown in Figure 9 (p. 188):

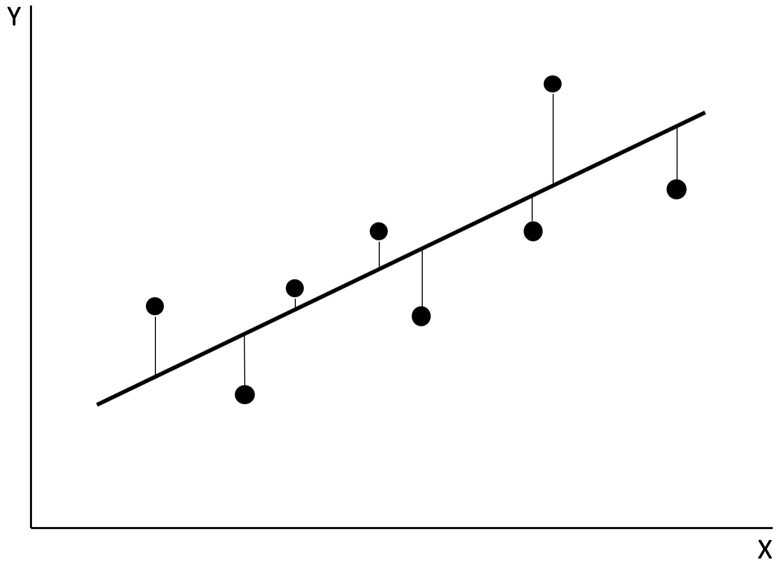


Figure 9. Minimising the vertical distances to fit the regression line

Like any straight line on a graph, the regression line can be expressed as an equation:

$$Y = \alpha + \beta X + \epsilon \qquad \text{Equ. 1.}$$

Where:

- α is the intercept. This is the value of Y at the point where the regression line crosses the Y axis.
- β is the coefficient of the regression line (the slope). It indicates the number of units by which Y changes for each change in a unit of X.
- ϵ is the error. It means the distance between the observed value (black dots in Figure 9) into the regression line.

Both parameters are represented in Figure 10 (p. 189):

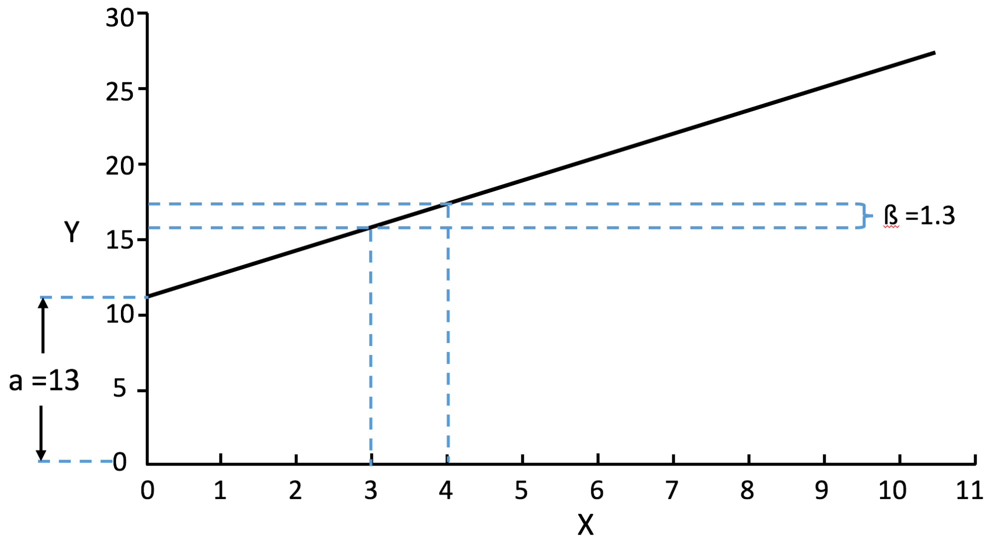


Figure 10. A geometric interpretation of the regression equation

If ß =1, the line is 45 degrees. If ß>1 then the slope is steeper, and if ß<1, then it is less than 45 degrees. If ß=0, it means changes in X have no effect on values of Y. If ß is positive, it means Y increases as X increases (the line rises from left to right), and if it is negative, it means Y decreases as X increases (the line falls from left to right).

This study applied the model of Ordinal Logistic Regression. The independent variable[9] is the MAI score of the participant (MAI), the value of which is X. The dependent variable[10] is the frequency of knowledge application (K1, K2, …K19), the value of which is Y. Therefore, the equation in this study can be expressed as:

$$Yij = \alpha + \beta Xj + \epsilon \qquad \text{Equ. 2.}$$

[9] In this study, the independent variable referred to the MAI score of participants (MAI)
[10] In this study, the dependent variable referred to the frequency of knowledge application (FKA)

Where:

- Yij is the logarithm of odds (log-odds) of the dependent variable[11] – the frequency of using a specific knowledge item 'i' given by participant 'j'
- Xj is the MAI score of participant 'j'
- i=(1,19), and it means Knowledge 1, Knowledge 2,…and Knowledge 19.
- j=(1, n), and it means participant 1, participant 2,…and participant n, 'n' means the total number of participants.

Apart from the key variable, there are many other factors that may influence knowledge application, such as gender, project type and universities. Omitting these factors may lead to misspecification of the model. The usual way to deal with this is to include all these variables in the regression as control variables[12]. When their impact on the dependent variable Y is controlled, it helps to narrow down the influence attributable to the key variable under investigation (MAI). Otherwise, the MAI may capture the impact that actually comes from other factors and the interpretation of the results may be misleading. Therefore, the equation applied in the study is finally represented as below:

$$\mathrm{Yij} = \alpha + \beta_1 \mathrm{Xj} + \beta_2 \mathrm{j} \sum \mathrm{Xj} + \epsilon \qquad \text{Equ. 3.}$$

[11] In this study, "log-odds of the dependent variable" means the probability of there being a higher frequency of application of a knowledge item. For a fuller treatment of Logistical Regression and logarithms of odds ratios see doi: 10.1080/00220670209598786 (Peng, Lee & Ingersoll, 2002)
[12] In this study, control variables refer to what is kept the same throughout the experiment, and it is not of primary concern in the experimental outcome.

Where:

- Yij is the score for log-odds of the frequency of using a specific knowledge item 'i' given by participant 'j'
- Xj is the MAI score of participant 'j'
- $\beta j \sum Xj$ is the 'sum' of other factors (such as gender, projects and universities) in the process that influence the knowledge application of participant 'j'.

ii) Null hypothesis

This study has identified 19 knowledge items applied in the FYDP (Table 4 in section 2.14.2, p. 108), based on which a corresponding 19 questions were developed to investigate the modus operandi of applying the 19 items of knowledge in FYDP. Therefore, nineteen regression analyses were conducted for each of the knowledge items in relation to MAI scores for the respondents.

In a regression analysis, both values of the coefficient and p value work together to indicate which relationships in the model are statistically significant and the nature of those relationships, e.g. the slopes and directions of the regression lines.

The value of 'coefficient' is generated from the value of 'ß' in the regression equation (Equ. 3) and reflects the degree and direction of the slope of the regression lines. This study focused on the coefficient generated from '$ß_1$', which refers to the coefficient of metacognition against the log-odds of knowledge application frequency. The value of ß ranges from -1 to +1. When ß=0, we obtain a horizontal line, which means the dependent variable would not change as the independent variable changes and indicates that there is no relationship between independent and dependent variables. When $ß \neq 0$, then however close it is to -1 or +1 will result in the greater dependent variable changing as the independent variable changes. Therefore, a null hypothesis of a regression model would be H_0: ß=0; and the alternative hypothesis H_a: $ß \neq 0$. As this study assumes a relationship between metacognition and knowledge application, the null hypothesis and its alternative are represented as:

- *H_0: there is no relationship between metacognition (MAI score) and the frequency of applying a knowledge item: FKA1/FKA2/FKA3, …FKA19 (β_1=0)*
- *H_a: there is a relationship between metacognition (MAI score) and the frequency of applying a knowledge item: FKA1/FKA2/FKA3, …FKA19 ($\beta_1 \neq 0$)*

The p value is an indicator as to whether the relationship of the MAI score to the frequency of applying a knowledge item could have occurred by chance. It thus defines whether this relationship is statistically significant. In OLR, the z test[13] is a statistical test of significance (Peng, So, Stage, & St. John, 2002). The z score is calculated (Equ. 4), and the z distribution calculator is used to obtain the associated p value.

$$z = \frac{\beta}{\text{standard error}} \qquad \text{Equ. 4.}$$

[13] For z test and p>|z| of OLR see doi: 10.1023/A:1014858517172 (Peng, So, Stage, & St. John, 2002)

Where,

- 'β' is the regression coefficient (Equ.3), and its 'standard error' is calculated according to the observed and estimated values of variables and the number of samples.

iii) Interpreting the result of the regression

Peng and So (2002) have reviewed six widely used statistical software programs and found that STATA provides the most detailed information on parameter estimates, and thus they recommend STATA for running logistic regression for both beginners and experienced researchers. Therefore, this study applied the STATA[14] (version 13.0) for the data analysis.

As this is the first attempt at identifying the knowledge items whose application is associated with metacognition from a range of subject-related knowledge, we set the significant level to 10% (threshold of p value = 0.1). A low p value ($p<0.1$) indicates the relationship exceeds the 90% significance level. We can be fairly confident that the association between MAI and the frequency of knowledge application does exist in the population from which our sample was drawn. Then we would reject the null hypothesis (H_0) and suggest the alternative hypothesis (H_a). Otherwise ($p>0.1$), we would fail to reject H_0.

The results can also be visualised by graphs (Figures 11 & 12, p. 194):

[14] 'STATA' is a general-purpose statistical software package applied in this study to run the relevant statistical programs (StataCorp, 2007).

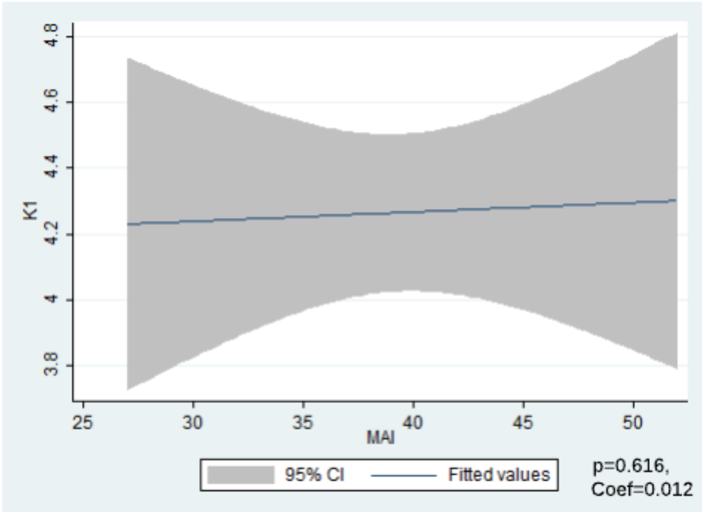


Figure 11. Sample: regression coefficient for MAI against FKA1

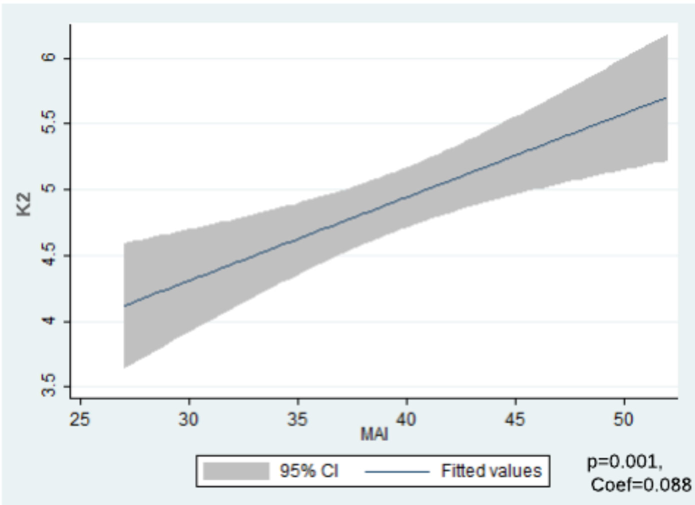


Figure 12. Sample: regression coefficient for MAI against FKA2

In Figures 11 & 12, the 95% confidence interval reflects that 95% values are distributed in the shadow area. If the p value is below 0.1, then the values are largely concentrated to the line, so the shadow area is narrower, indicating the relationship between variables is statistically significant, and vice versa. The value of 'coef' (coefficient) reflects the slope of the regression line. It illustrates how much the probability of the dependent variable will increase as the independent variable increases by one score, as well as what the direction of the regression line would be, i.e. upward (if coef >0) or downward (if coef <0). According to the values of 'coef' and 'p', we will then have the implications of the impact that the independent variable exerts on the dependent variable, e.g. how significant, influential, and in which direction. The results in this sample indicate that the relationship between MAI and FKA1 is insignificant ($p>0.1$), whereas such a relationship between MAI and FKA2 is significant and positive ($p<0.1$, Coef>0).

3.6 The procedure and tools of data analysis

Based on the literature of statistical methodology and considering the context of this study (the research purpose, the feature of variables and the data), the main tools for data analysis in this study were determined as 1) descriptive statistics 2) Ordinal Logistic Regression, that further analysed the relationship between independent and dependent variables.

Statistical analysis in this research was conducted by applying tools Excel (Microsoft version 15.24) and STATA (version 13.0).

3.7 Summary

In conclusion, the methodology determined to answer the research question and examine the research hypotheses was located in the schema shown in Figure 13 (p. 196), and the methods applied in this research are in the white text and connected by the purple lines:

Figure 13. The research methodology path

Chapter Four: Results

4.1 Chapter overview

The first two chapters introduced the research background, discussed the research problems and developed the theoretical framework and related hypotheses. The third chapter discussed the methodology used to address the research questions and complete the goals. This chapter presents and analyses all the data collected, stating the main findings.

4.2 The circumstances of the responses

The survey study has been conducted among product design students from UK and Chinese universities, in which the target group have just completed their FYDPs without receiving their marks. The total number of valid responses are 375, 147 from the UK and 228 from China. The time duration of data collection is 51 days from the 19th, May, 2017 to 8th, July, 2017.

The Chinese data was drawn from the top 10 design colleges. 228 valid responses were collected (from 19th, May 2017 to 30th, June 2017). All participants from China in this study were volunteers. The researcher contacted the school counsellors at each target institute in advance to arrange permission for this survey. Target participants were then emailed by their school counsellors to check whether they were willing to participate by providing the participant Information. If yes, they could access the questionnaire through a website link (highlighted) at the bottom of the email [Appendix 3, p. 407].

Prior to starting the formal survey, they had to click the 'Informed Consent Form' of the survey. The details of the responses from each university are represented in Table 10.

Table 10. Details of the responses in China

Institute	Number of valid responses	Number of final year students in product design programme	Percentage of the valid responses
1. Tsinghua University	4	15	26.7%
2. Central Academy of Fine Art	4	20	20.0%
3. China Academy of Art	25	50	50.0%
4. Jiangnan University	50	115	43.5%
5. Nanjing University of the Arts	52	60	86.7%
6. Tongji University	8	15	53.3%
7. Donghua University	32	80	40.0%
8. Zhejiang University	2	15	13.3%
9. China Communication University	15	20	75.0%
10. Luxun Academy of Fine Arts	19	30	63.3%
11. Soochow University	11	25	44.0%
Total	228	445	51.2%

The UK data was collected from those participants with a background in product design who attended the '2017 New Designer Exhibition'. This was an exhibition of qualified students' final year design projects from institutions across the UK (from 5th, July 2017 to 8th, July 2017). This is an independent event which is held annually in London, and it is the UK's most important graduate design exhibition. During this event, more than 3,000 graduates from universities all over the UK came together to exhibit their products, creations and artistic works (https://www.newdesigners.com/). The researcher attended the exhibition and asked students involved to take part in this survey as volunteers. At the event, all the participants were allowed to complete the questionnaires in their own time as available, iPads were provided, and the results were collected when the questionnaires were finished. 28 colleges agreed to provide the product design projects on the exhibition attendees list, and the responses were gained from 23 of these colleges. The details of the responses from each university are presented in Table 11.

Table 11. Details of the responses in the UK

Institute	Number of valid responses	Institute	Number of valid responses
1. Birmingham City University	5	13. Ravensbourne	5
2. Brunel University	14	14. Staffordshire University	2
3. Central Saint Martins	1	15. Sussex University	4
4. Coventry University	15	16. Swansea College of Art, UWTSD	6
5. Edinburgh Napier University	3	17. UCA	3
6. Kingston University / Kingston School of Art	6	18. University of Brighton	8
7. Loughborough University	18	19. University of Dundee	2
8. Manchester School of Art at MMU	2	20. University of Huddersfield	3
9. Middlesex University	4	21. University of Leeds	9
10. Northumbria University	17	22. University of Lincoln	12
11. Nottingham Trent University	3	23. UWE	3
12. Plymouth University	2	Total	147

4.3 Names of variables redefined

All variables included in this study were redefined for the purpose of input into the software and describing the results later. Control variables in this study including age, gender, institution, and project were defined in the same way as their original forms. Independent and dependent variables were redefined in Table 12 (p. 200):

Table 12. Redefining variable names

Independent variable		
The score of each question included in the MAI test (52 items in total)		M1, M2, M3, … M52
The sum score of the MAI test of one participant, which measures the metacognition level and reflects the creative thinking ability of this participant.		MAI
Dependent variable		
Each category of knowledge in the psychometric report:	Domain-specific knowledge	DSK
	Domain-general knowledge	DGK
	Tacit knowledge	TK
The score of each question in the psychometric report on FKA (19 items in total), which reflects the frequency of a certain knowledge item applied by one participant.		FKA1, FKA2, FKA3, … FKA19

4.4 Quantifying data

The collected data has been quantified first for further analysis. This step was conducted by using Excel. The data included an independent variable, dependent variable and controlled variables, which were organised in the Tables 13–16:

Independent variable

Table 13. Independent variable

Data Type	Coding	
M1, M2, M3…M52	TRUE	FALSE
	1	0

Dependent variables

Table 14. Dependent Variables

Data types	Coding						
FKA1, FKA2, FKA3, …FKA19	Never Used	Very Rarely	Rarely Used	Occasionally Used	Frequently Used	Very Frequently Used	Always Used
	1	2	3	4	5	6	7

Controlled variables:

Table 15. Age

Data types	**Coding**			
Age	Under 18	18-20	21-24	Over 24
	1	2	3	4

Table 16. Gender

Data types	**Coding**	
Gender	Male	Female
	1	0

The information about the institutions and projects was also controlled variables in the data analysis process. As there were over 10 categories, most of them were listed as originally and arranged in Excel. For the details of participants from each institution and the projects they conducted refer to Appendix 5-1, p. 421 and Appendix 5-2, p. 422.

4.5 The descriptive analysis

The descriptive analysis of data tells the basic 'story' of the collected data and provides an important reference for the next stage of explanatory analysis; the data was categorised as follows: 1) basic information about control variables (age, gender, institutions, and projects); 2) basic information about independent and dependent variables; and 3) the correlation matrix. As the data was collected from China and the UK, all the results of descriptive analysis were reported in the China and the UK section for primary comparison.

4.5.1 Basic information about control variables

This section represents the data of respondents' age, gender, institution and project.

i) *Age*

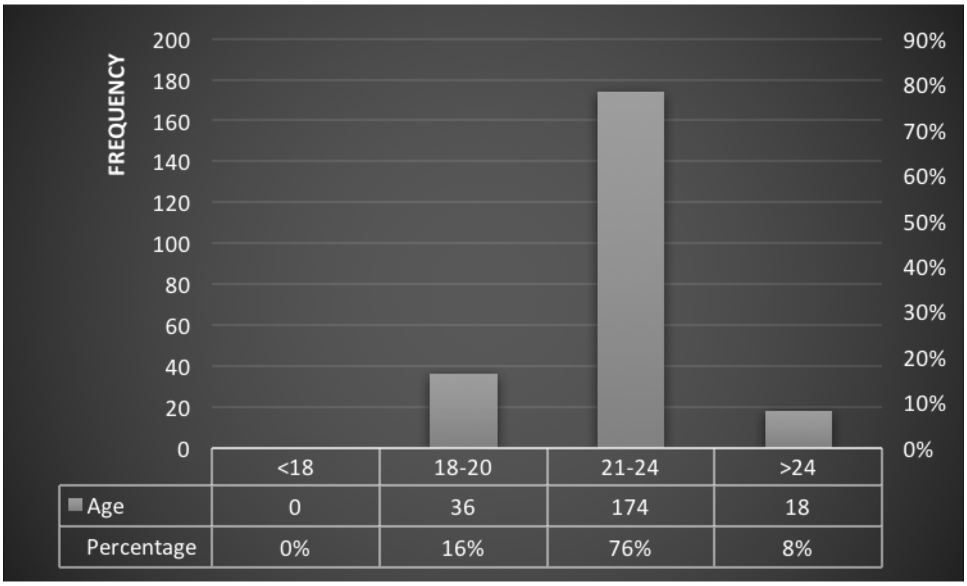


Figure 14. Frequency percentage of participants' age (China)

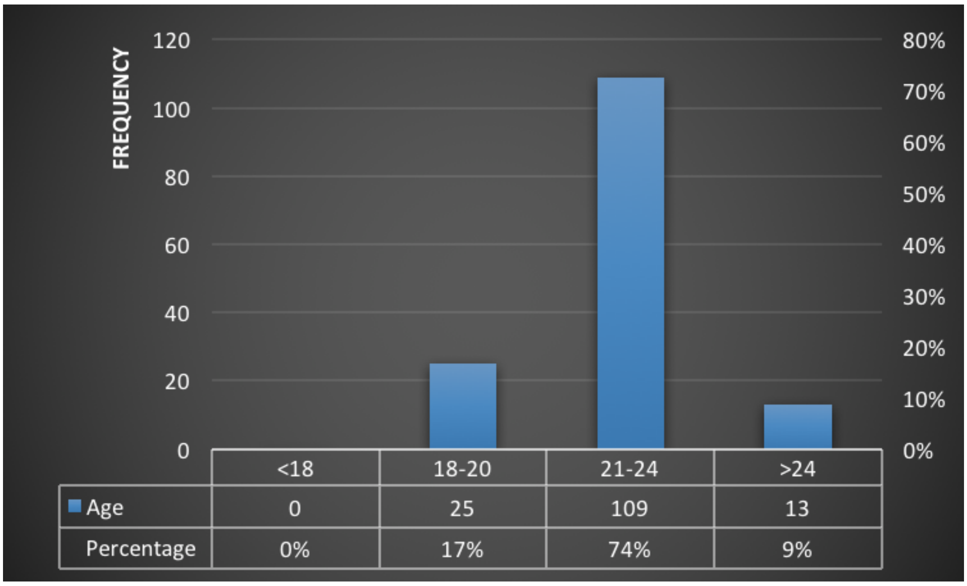


Figure 15. Frequency percentage of participants' age (UK)

Figures 14 & 15 show the basic information about the age of respondents. They show that the age of most participants from China and the UK is between 21 and 24 years (China 76%, and UK 74%).

ii) Gender

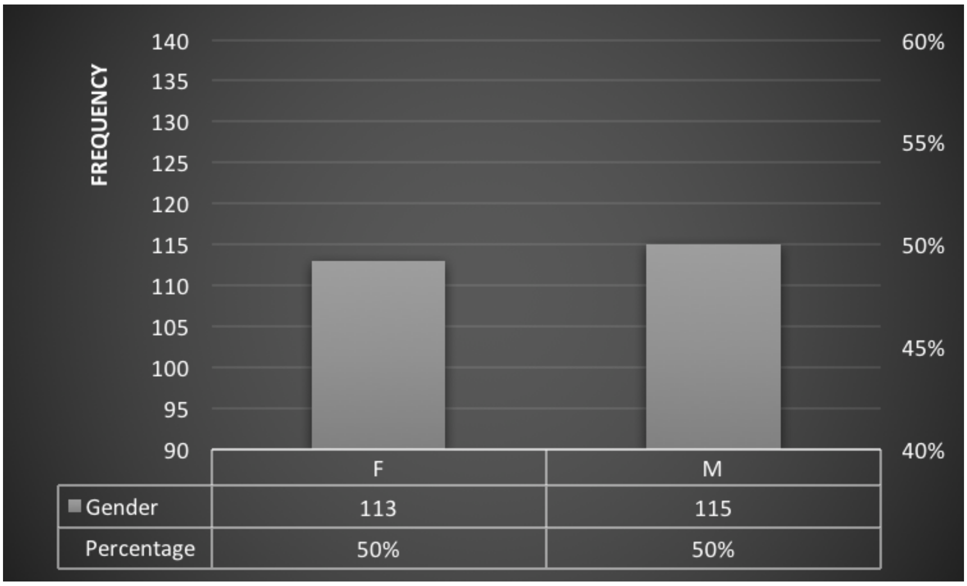


Figure 16. Frequency percentage of participants' gender (China)

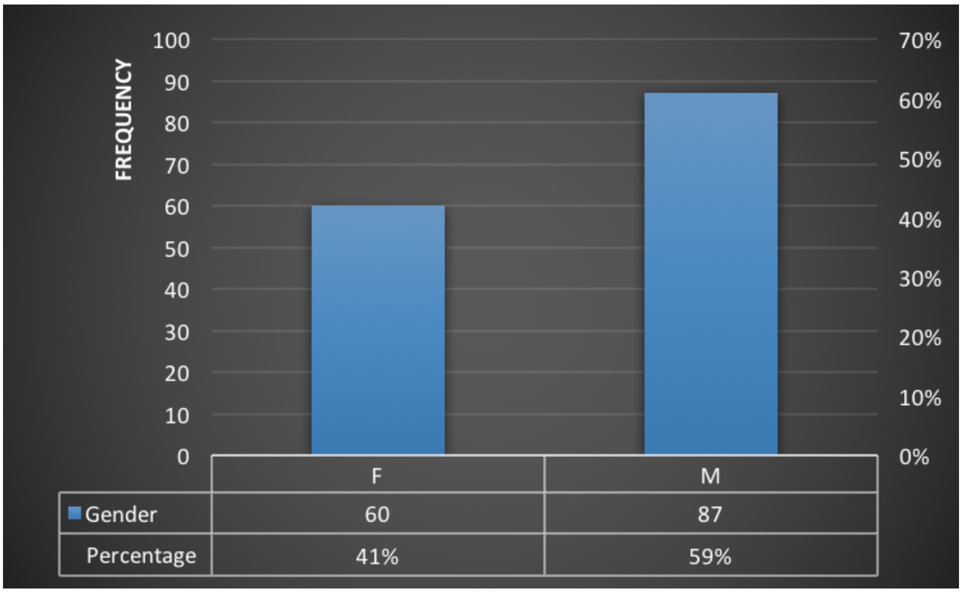


Figure 17. Frequency percentage of participants' gender (UK)

Figures 16 & 17 show that the gender status of respondents in the two countries were similar to each other, with 50% male vs. 50% female in China and 59% male vs. 41% female in the UK.

iii) Institutions

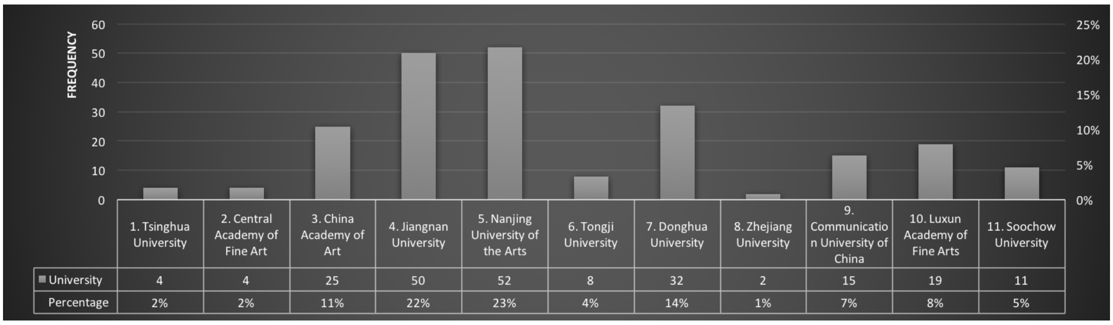


Figure 18. Participants from Chinese institutions in the survey

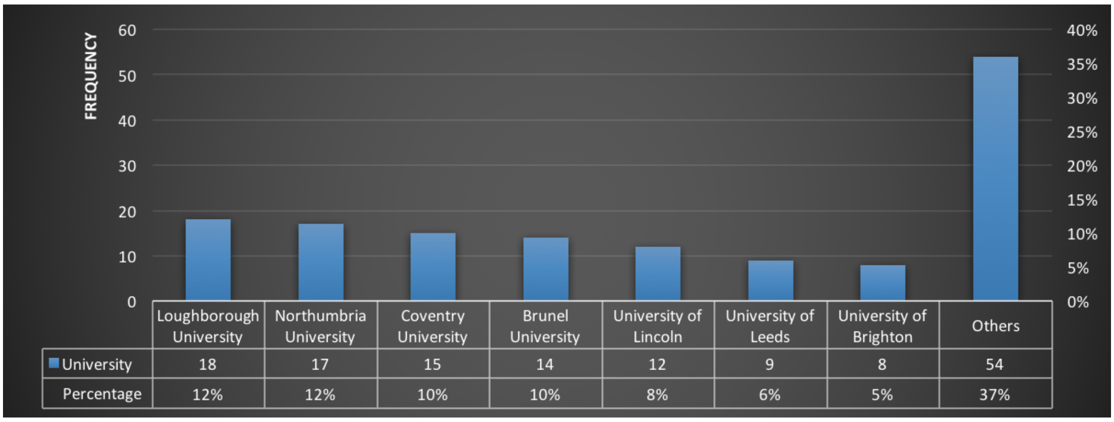


Figure 19. Participants from UK institutions in the survey

Figures 18 & 19 show the distribution of participants in both countries. As UK participants were from over 20 universities, the item 'others' in Figure 19 refers to the total number of participants from at least 12 universities (this means less than 6 participants from each university).

iii) Projects

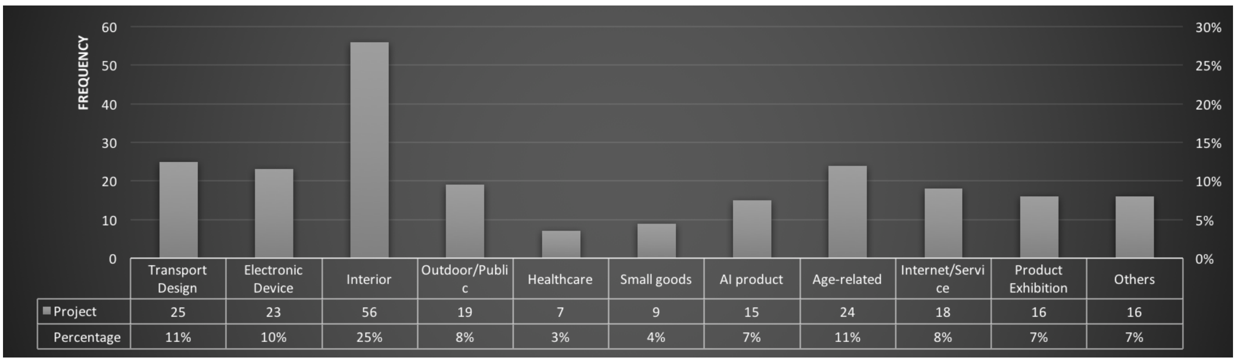
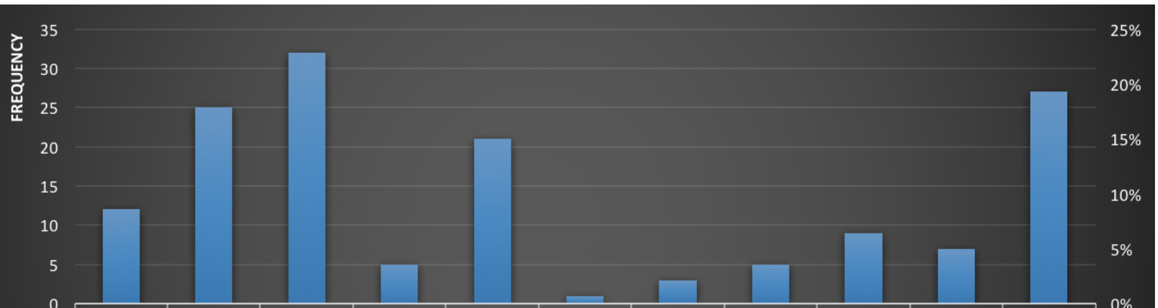


Figure 20. Frequency percentage of participants' choices in projects (China)



	Transport Design	Electronic Device	Interior	Outdoor	Healthcare	Packaging	Pets	Age-related	Service	Sport	Others
Project	12	25	32	5	21	1	3	5	9	7	27
Percentage	8%	17%	22%	3%	14%	1%	2%	3%	6%	5%	18%

Figure 21. Frequency percentage of participants' choices in projects (UK)

From Figures 20 & 21, it can be seen that 'Interior product' has been chosen by the most participants in both countries with 25% in China and 22% in the UK. 'Transportation and Electronic device' have also been selected by many participants in both countries. There was a large percentage of UK participants conducting projects in relation to 'Healthcare and Pets', whereas the situation was quite different in China. China's participants were more interested in design of 'Outdoor/public space' and 'Age-related design' compared to the UK participants.

All the information about age, gender, institutions and projects were treated as controlled variables in the OLR analysis, rather than as explanatory (independent) variables. Control variables were those which influence the knowledge application, but are not the key variable (MAI) on which this study is focused. Omitting these control variables may lead to inaccurate estimates of the coefficient in the key variable (MAI), and the results would be biased accordingly. Moreover, from the figures and charts shown in this section (4.5.1), it can be observed that the participants' responses to the three survey questions (gender, university, project) were widely spread amongst their respective choices while the responses to ‘age’ were highly concentrated on the category of 21–24 years old. For example, the ratio between females and males was 1:1 in China and the proportion of females to males was also close to each other in the UK. The participants were involved in multiple projects with particular concentration on one or two. Thus these variables were further examined to see whether they play a certain role in influencing the dependent variable after the OLR analysis.

4.5.2 Basic information on variables

i) Data of MAI score (independent variables)

Table 17 below demonstrates the mean scores and standard deviation of the MAI test, followed by Figures 22 & 23 (p. 205) showing respondents’ frequencies of five score ranges of the MAI test.

Table 17. Mean score of MAI

MAI (Score: 0~52)				
	Mean (China)	Sd. (China)	Mean (UK)	Sd. (UK)
MAI	38.9	8.04	39.4	5.86

It can be seen from the Figures 22 & 23 (p. 207) that most students’ score on the MAI test falls in the range of 31–40. The general distribution of the percentages of the ranges is very similar between China and the UK, but China has fewer students in the range 51–60 than the UK (China 4% vs. UK 6%). The mean score of the UK respondents’ MAI test is 39.4, and that of Chinese respondents’ MAI test is 38.9, which is lower than that of the UK. However, China’s standard deviation is 8.04, much higher than the UK’s 5.86. This means that most of the UK’s numbers are closer to their average level than the that of China.

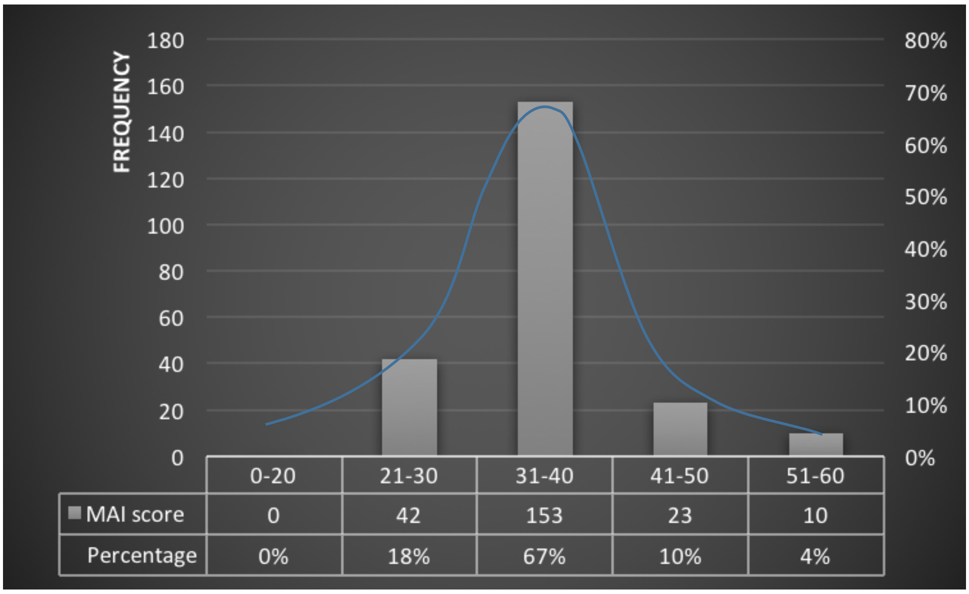


Figure 22. Frequency/percentage of different ranges of the MAI score (China)

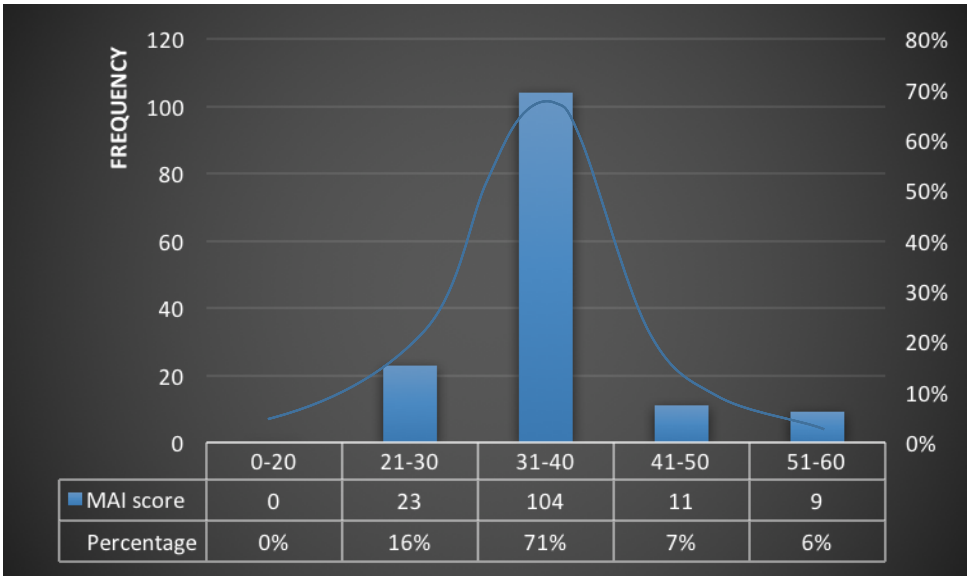


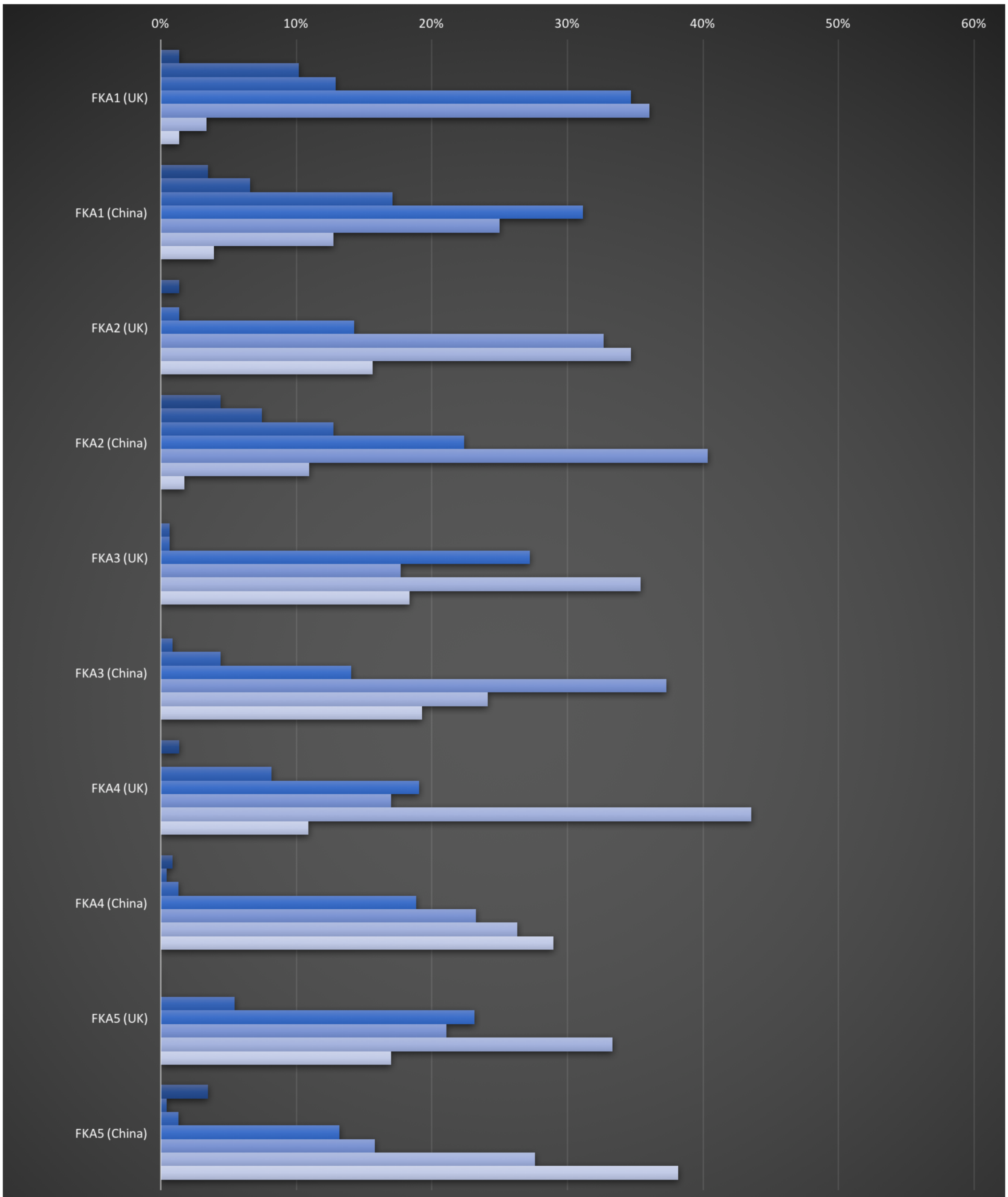
Figure 23. Frequency/percentage of different ranges of the MAI score (UK)

The skewness and kurtosis have also been examined to examine the distribution of the MAI scores. This study obtained the skewness of 0.03 in China's data and 0.05 in the UK's data, which are near the expected value of 0, and the kurtosis of 2.96 in China's data and 2.87 in the UK's data, which are both near the expected value of 3. Therefore, the MAI score distribution indicates a normal distribution (skewness close to 0, skewness close to 3), which is consistent with the results in Yildiz et al., (2009) and Tyfekçi's (2017) studies.

ii) Data of knowledge application (dependent variables)

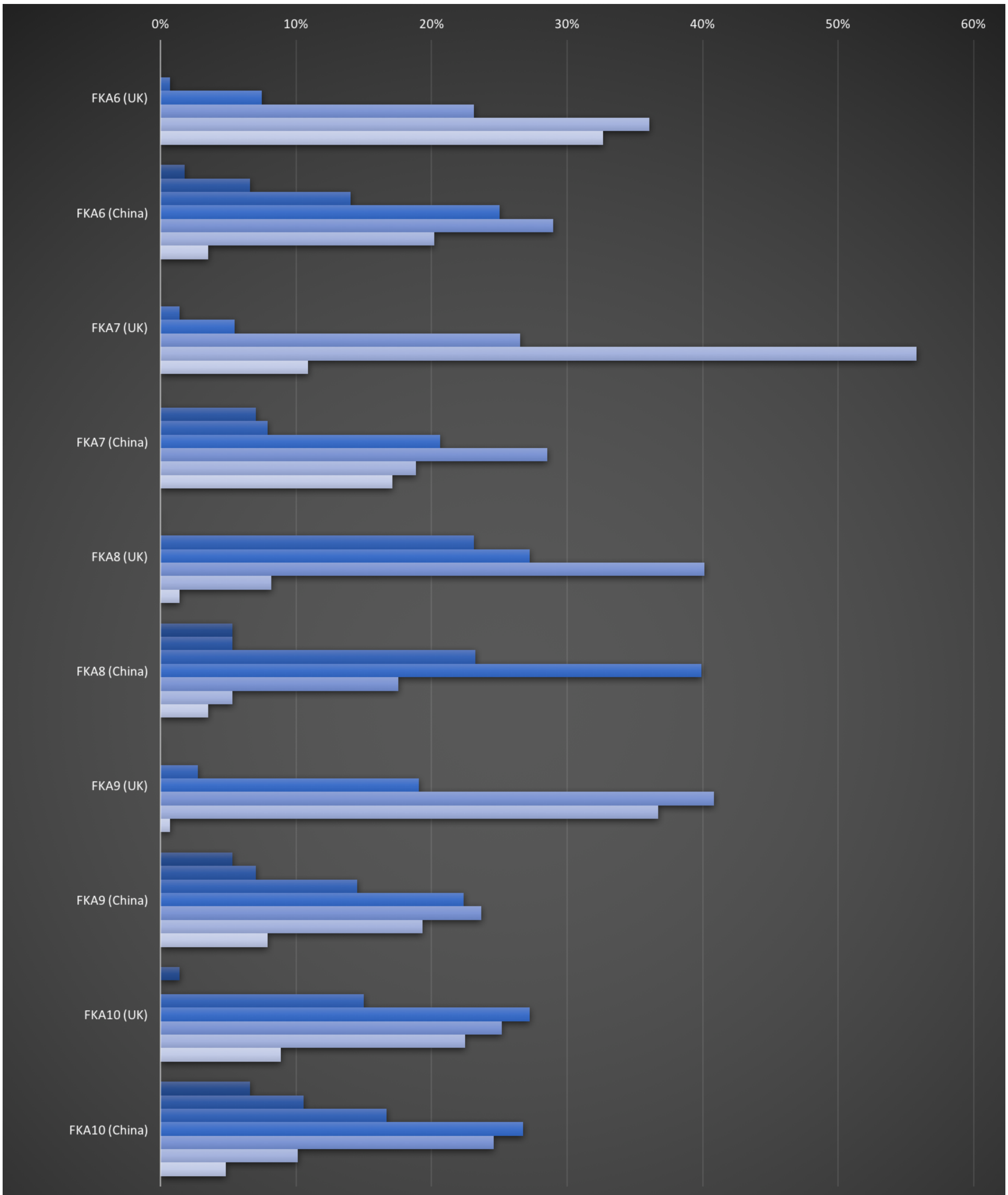
For every knowledge item (from K1 to K19) in each country, a series of figures (Figures 24–27, pp. 209–212) were created which show the percentages of participants choosing each response over the total number of participants. Every UK figure is followed by a corresponding Chinese figure for comparative purposes. For example, the UK figure for K1 is next to the Chinese figure for K1, and so on and so forth. As the number of participants from each country was quite different, in order to better compare the modus operandi of applying each knowledge item between each country, all frequencies were thus transferred to percentages.

Figures 24–27 (pp. 209–212) primarily compare the knowledge application in China and the UK via checking the frequency of each scale. It can be seen that most participants selected answers within the range between 'occasionally used' and 'very frequently used'. Furthermore, it was also found that very few UK participants selected the responses 'never used' and 'very rarely used' for each kind of knowledge.



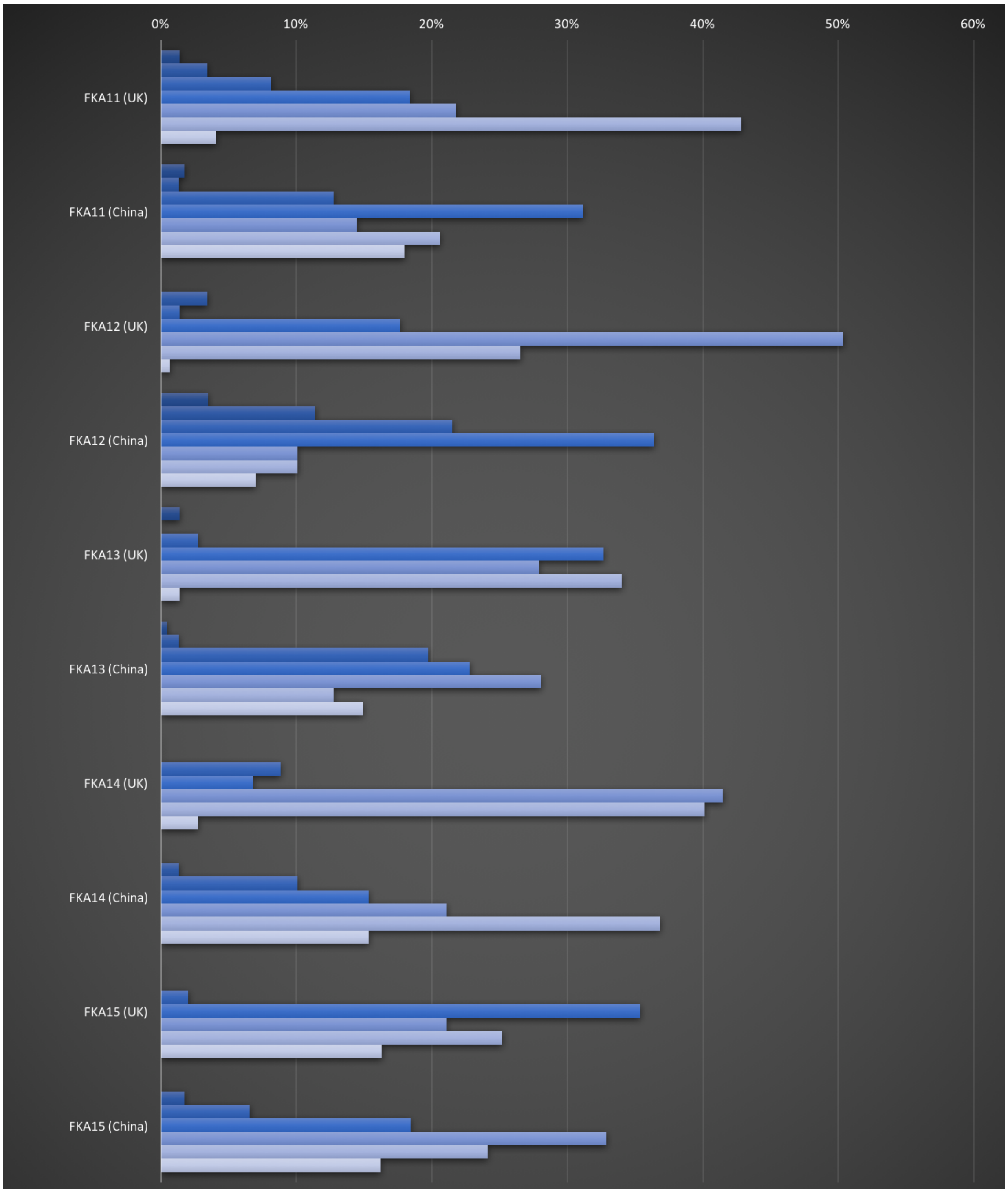
	FKA5 (China)	FKA5 (UK)	FKA4 (China)	FKA4 (UK)	FKA3 (China)	FKA3 (UK)	FKA2 (China)	FKA2 (UK)	FKA1 (China)	FKA1 (UK)
Never used	4%	0%	1%	1%	0%	0%	4%	1%	4%	1%
Very rarely used	0%	0%	0%	0%	1%	1%	7%	0%	7%	10%
Rarely used	1%	5%	1%	8%	4%	1%	13%	1%	17%	13%
Occasionally used	13%	23%	19%	19%	14%	27%	22%	14%	31%	35%
Frequently used	16%	21%	23%	17%	37%	18%	40%	33%	25%	36%
Very frequently used	28%	33%	26%	44%	24%	35%	11%	35%	13%	3%
Always used	38%	17%	29%	11%	19%	18%	2%	16%	4%	1%

Figure 24. Frequency/percentage of FKA (K1–K5) (China and UK)



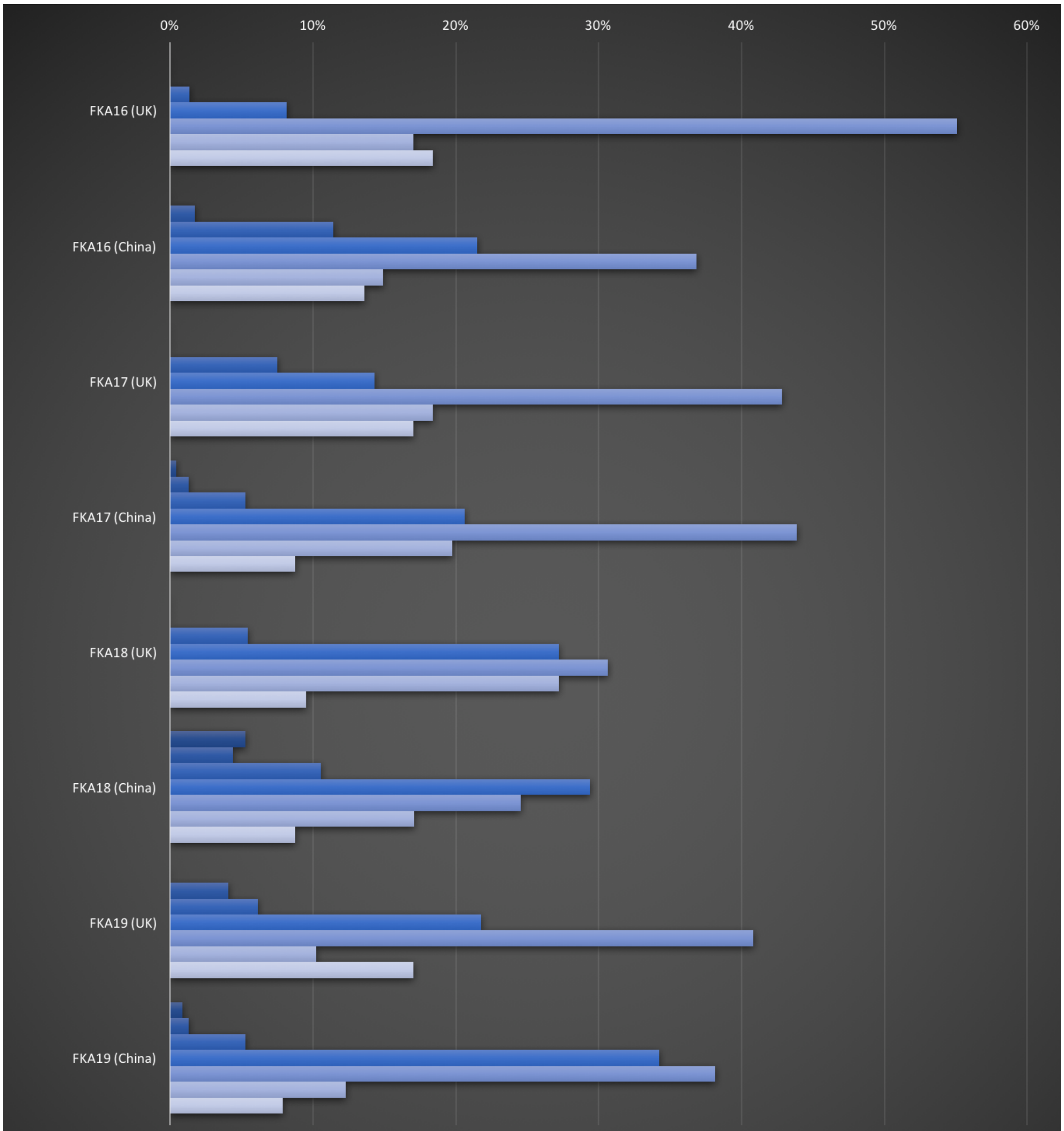
	FKA10 (China)	FKA10 (UK)	FKA9 (China)	FKA9 (UK)	FKA8 (China)	FKA8 (UK)	FKA7 (China)	FKA7 (UK)	FKA6 (China)	FKA6 (UK)
Never used	7%	1%	5%	0%	5%	0%	0%	0%	2%	0%
Very rarely used	11%	0%	7%	0%	5%	0%	7%	0%	7%	0%
Rarely used	17%	15%	14%	3%	23%	23%	8%	1%	14%	1%
Occasionally used	27%	27%	22%	19%	40%	27%	21%	5%	25%	7%
Frequently used	25%	25%	24%	41%	18%	40%	29%	27%	29%	23%
Very frequently used	10%	22%	19%	37%	5%	8%	19%	56%	20%	36%
Always used	5%	9%	8%	1%	4%	1%	17%	11%	4%	33%

Figure 25. Frequency/percentage of FKA (K6–K10) (China and UK)



	FKA15 (China)	FKA15 (UK)	FKA14 (China)	FKA14 (UK)	FKA13 (China)	FKA13 (UK)	FKA12 (China)	FKA12 (UK)	FKA11 (China)	FKA11 (UK)
Never used	0%	0%	0%	0%	0%	1%	4%	0%	2%	1%
Very rarely used	2%	0%	1%	0%	1%	0%	11%	3%	1%	3%
Rarely used	7%	2%	10%	9%	20%	3%	21%	1%	13%	8%
Occasionally used	18%	35%	15%	7%	23%	33%	36%	18%	31%	18%
Frequently used	33%	21%	21%	41%	28%	28%	10%	50%	14%	22%
Very frequently used	24%	25%	37%	40%	13%	34%	10%	27%	21%	43%
Always used	16%	16%	15%	3%	15%	1%	7%	1%	18%	4%

Figure 26. Frequency/percentage of FKA (K11–K15) (China and UK)



	FKA19 (China)	FKA19 (UK)	FKA18 (China)	FKA18 (UK)	FKA17 (China)	FKA17 (UK)	FKA16 (China)	FKA16 (UK)
Never used	1%	0%	5%	0%	0%	0%	0%	0%
Very rarely used	1%	4%	4%	0%	1%	0%	2%	0%
Rarely used	5%	6%	11%	5%	5%	7%	11%	1%
Occasionally used	34%	22%	29%	27%	21%	14%	21%	8%
Frequently used	38%	41%	25%	31%	44%	43%	37%	55%
Very frequently used	12%	10%	17%	27%	20%	18%	15%	17%
Always used	8%	17%	9%	10%	9%	17%	14%	18%

Figure 27. Frequency/percentage of FKA (K16–K19) (China and UK)

4.5.3 Correlation matrix

As noted in the statistical principles, before applying the Ordinal Logistic Regression model, the multicollinearity[15] problem should be conducted to ensure that no statistical bias will arise (Harrell, 2015). The correlation matrix is the recommended approach to check this problem (Harrell, 2015). The results are shown in Tables 18 & 19.

Table 18. Coefficient matrix (China)

China	Age	Gender	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	SumMAI
Age |	1.0000																					
Gender |	-0.0168	1.0000																				
K1 |	-0.1567	-0.1218	1.0000																			
K2 |	-0.1118	0.0082	0.5582	1.0000																		
K3 |	-0.0429	-0.1158	0.1523	0.2069	1.0000																	
K4 |	0.0031	-0.1185	0.3091	0.4558	0.2562	1.0000																
K5 |	0.0771	-0.1451	0.2593	0.2603	0.0383	0.3659	1.0000															
K6 |	-0.1138	0.0764	-0.0128	0.0655	0.0905	0.1445	0.1072	1.0000														
K7 |	-0.0307	-0.0121	-0.0294	0.0179	0.1552	0.1627	-0.0832	0.3094	1.0000													
K8 |	-0.0575	0.1634	0.1165	0.3315	0.0440	0.0577	0.0632	0.2298	0.1287	1.0000												
K9 |	-0.0613	-0.0332	0.2571	0.5549	0.1085	0.3473	0.3438	0.2651	0.0674	0.4458	1.0000											
K10 |	-0.0284	0.0407	0.2901	0.4452	0.1540	0.1418	0.2827	0.0840	0.0516	0.5439	0.4332	1.0000										
K11 |	-0.0999	0.1058	0.0075	0.0152	0.0515	0.0281	0.1365	0.3357	0.2679	0.1783	0.0776	0.2484	1.0000									
K12 |	-0.0604	0.1026	0.2316	0.1142	0.1817	-0.1064	0.0773	0.2955	0.2088	0.3305	0.1682	0.3966	0.4497	1.0000								
K13 |	-0.0641	-0.0176	0.1440	-0.0085	0.2327	-0.0168	0.0632	0.3168	0.4592	0.1613	0.1338	0.1858	0.2719	0.4563	1.0000							
K14 |	-0.0287	-0.0229	0.1948	0.0789	0.3506	0.0368	0.2759	0.2050	0.1688	0.0248	0.0967	0.0508	0.0885	0.1563	0.3457	1.0000						
K15 |	-0.0185	-0.0196	0.1357	0.1565	0.3943	0.1804	0.2742	0.0651	0.2196	0.1374	0.1679	0.2421	0.1243	0.1936	0.3711	0.6402	1.0000					
K16 |	-0.1657	0.0112	0.2289	0.1631	0.3805	0.0750	0.0630	0.1779	0.2284	-0.0586	0.1551	0.1996	0.1393	0.2529	0.4477	0.5067	0.5588	1.0000				
K17 |	-0.1184	0.0694	0.2083	0.2740	0.3286	0.1644	0.1033	0.3166	0.2900	0.1679	0.2993	0.2606	0.3862	0.3365	0.3506	0.2916	0.3884	0.4181	1.0000			
K18 |	-0.0980	0.0735	0.0185	0.2680	0.1136	0.2204	-0.0144	0.3225	0.0868	0.1056	0.2041	-0.0059	0.2326	0.0343	-0.0108	-0.0140	-0.0573	0.1158	0.2588	1.0000		
K19 |	-0.0698	0.0220	0.1187	0.3789	0.0910	0.3857	0.1766	0.3343	0.1033	0.1647	0.3184	0.0854	0.1127	-0.0026	0.1265	0.2284	0.1793	0.2019	0.2216	0.4594	1.0000	
SumMAI |	0.0257	0.0364	0.0377	0.1308	-0.0504	0.1501	0.0611	0.1666	0.0549	0.0493	0.2261	0.1363	-0.0032	0.1012	0.0379	0.0263	0.1286	0.1779	0.1264	0.2042	0.2937	1.0000

[15] In statistics, multicollinearity (also collinearity) is a phenomenon in which one predictor variable in a multiple regression model can be linearly predicted from the others with a substantial degree of accuracy (Belsley, 1993).

Table 19. Coefficient matrix (UK)

UK	Age	Gender	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	SumMAI
Age |	1.0000																					
Gender |	0.1131	1.0000																				
K1 |	0.0672	0.0088	1.000																			
K2 |	0.0082	0.0419	0.3671	1.0000																		
K3 |	-0.1019	-0.0288	0.0908	0.0325	1.0000																	
K4 |	0.0219	0.0122	0.3725	0.5581	0.1266	1.0000																
K5 |	0.0292	0.1147	0.2927	0.2190	0.0684	0.3218	1.0000															
K6 |	-0.0366	-0.0281	0.0797	0.3881	-0.0914	0.1309	0.2001	1.0000														
K7 |	-0.1125	-0.0250	-0.0237	0.2538	-0.0277	0.2156	0.0977	0.4129	1.0000													
K8 |	0.1178	-0.0357	0.0898	0.5235	0.0934	0.2337	0.4400	0.3289	0.2214	1.0000												
K9 |	0.1271	0.0049	0.1641	0.6824	-0.0014	0.4321	0.3568	0.3123	0.3273	0.6892	1.0000											
K10 |	0.2082	-0.0655	0.2956	0.4521	0.0620	0.3629	0.4073	0.1555	-0.0183	0.5792	0.4484	1.0000										
K11 |	-0.0480	-0.0017	0.1842	0.0322	0.0380	0.1708	0.2710	0.2006	0.0332	0.1379	0.0775	0.2625	1.0000									
K12 |	0.0060	0.0305	0.2251	0.0390	0.1851	-0.0107	0.1699	0.1275	0.0969	0.0952	0.0721	0.2278	0.3408	1.0000								
K13 |	0.0541	0.1106	0.2486	0.1624	0.1658	0.1037	0.0934	-0.0023	0.1751	-0.0069	0.0336	0.1780	0.2521	0.2329	1.0000							
K14 |	0.0575	0.0582	0.2548	0.2010	0.1717	0.0660	0.1660	0.2569	0.1495	0.1242	0.2161	0.1583	0.0204	-0.0091	0.4308	1.0000						
K15 |	0.1257	-0.0304	0.1599	0.0625	0.0459	0.0699	0.1985	-0.0295	0.1799	0.1227	0.0787	0.2803	0.1632	0.0992	0.4112	0.5136	1.0000					
K16 |	0.0985	-0.1267	0.1550	0.0022	0.2181	-0.2301	-0.1416	0.0956	0.1059	-0.1449	-0.0945	0.1200	-0.1690	0.2581	0.2408	0.3150	0.3458	1.0000				
K17 |	0.0659	-0.0235	0.1464	0.0044	0.2739	-0.0634	0.1098	0.0275	0.1830	0.1273	0.1440	-0.0003	-0.1543	-0.0160	0.2757	0.3550	0.3242	0.2776	1.0000			
K18 |	0.0003	-0.0543	0.2147	0.3119	-0.0914	0.2718	0.1245	0.6075	0.3857	0.2033	0.3025	0.0422	0.0156	0.1104	-0.1235	0.1991	0.0373	0.1527	0.2547	1.0000		
K19 |	0.0053	0.1384	0.2957	0.3573	0.1200	0.2164	0.0788	0.2558	0.2865	0.2718	0.4074	0.0532	0.0118	0.0928	0.1407	0.4276	0.2400	0.0829	0.5555	0.6043	1.0000	
SumMAI |	-0.0618	-0.0730	0.0130	0.2966	-0.0366	-0.0062	0.0508	0.3335	0.3037	0.1897	0.3162	-0.0743	-0.1428	0.1554	0.0417	0.2516	0.0828	0.3132	0.2830	0.3414	0.3150	1.0000

The results from both China and the UK indicate that there are no such issues in the data as most values were below 0.5 (Harrell, 2015), thus the subsequent OLR model can be applied effectively.

The descriptive data analysis reflected the overall status quo and the distributions of the data collected, including independent variable, dependent variable, and all the control variables. It was found that the participants' responses to the three survey questions (gender, university, project) were widely spread amongst the respective choices. The participants' age was highly concentrated in the range of 21 – 24 as they were all final-year design students. Therefore, the elements of gender, university, and project may have influenced the dependent variable (FKA) and needed to be further examined. The data of the MAI and FKA were also presented but it was not possible to reach any conclusions from simply comparing the descriptive data; a regression model was needed to further examine these results. Additionally, a correlation test was conducted to guarantee that there was no multicollinearity problem.

4.6 Results of Ordinal Logistical Regression

4.6.1 The calculated results of OLR

The OLR model was applied to further examine the relationship between metacognition (independent variable) and the frequency of application of each knowledge item (dependent variables) with other factors under control. The results of one of the regressions are shown in Table 20 below:

Table 20. Regression coefficient for MAI in estimating FKA1

Ordinal logistic regression						
FKA1	Coef	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI	.0124154	.0247797	0.50	0.616	-.0361521	.0609828
Age	-.0361521	.0609828	1.24	0.216	-.2286042	1.01181
Gender	.0681693*	.3284993	0.21	0.836	-.5756776	.7120162
Loughborough	-.1173701	.533390	-0.22	0.826	-1.162796	.9280558
Northumbria	.0928861*	.535566	0.17	0.862	-.956804	1.142576
Coventry	-.2643391	.5528732	-0.48	0.633	-1.347951	.8192724
Brunel	-.5183443	.671558	-0.77	0.440	-1.834574	.7978851
Lincoln	1.288575	.6257114	2.06	0.039*	.0622029	2.514946
Leeds	-1.044798	.6911073	-1.51	0.131	-2.399344	.3097471
Brighton	-.246223	.6894148	-0.36	0.721	-1.597451	1.1050
Others	0 (omitted)					
Project 1	.5955879	.722714	0.82	0.410	-.8209003	2.012076
Project 2	.4252591	.5279864	0.81	0.421	-.6095751	1.460093
Project 3	.5328891	.4930996	1.08	0.280	-.4335683	1.499347
Project 4	.5550444	.8518483	0.65	0.515	-1.114548	2.224636
Project 5	1.113192	.5824235	1.91	0.056*	-.0283372	2.254721
Project 6	3.728964	1.773065	2.10	0.035*	.2538216	7.204107
Project 7	1.439313	1.045059	1.38	0.168	-.6089646	3.487591
Project 8	.6521498	.9693793	0.67	0.501	-1.247799	2.552098
Project 9	-.0548894	.7142615	-0.08	0.939	-1.454816	1.345037
Project 10	.3565694	.9327097	0.38	0.702	-1.471508	2.184647
Project 11	0(omitted)					
					Number of ods =147	
					chi2 = 22.32	
					Pro>chi2 = 0.3814	
Log likelihood = -247.29456					Pseudo R2 = 0.0432	

- *Notes: *p<0.1. Except independent variable MAI, all specifications include age, gender, 8 institution dummies, and 11 project dummies.*

Table 20 shows the regression coefficient for metacognition (MAI) against FKA1 in the UK with other factors (age, gender, institutions and projects) controlled. This result reflects that the coefficient of metacognition against the application of K1 is statistically insignificant. There were 38 tables in total as the metacognition level was regressed against every knowledge item (19 tables for China and 19 tables for the UK as well), and the results showed that most of the control variables were insignificant since the corresponding p values were above 10% (0.1). Consequently, these results of control variables were not reported in the main text (the results in the format of *.log are attached in Appendix 6-1, p. 423 and Appendix 6-2, p. 442).

The regression coefficient of MAI against each FKA and related p value were reported in particular (Table 21, p. 217), as both values in regression analysis work together to indicate which relationships in the model are statistically significant and the nature of those relationships, i.e. the slops and directions of regression lines (see the interpretation of the values of 'coef', and 'p', in section 3.5.3, part iii, pp. 191–193)

From the results, we can see that the coefficients of metacognition against the frequency of the application of K2, K6, K8, K9, K16, K17, K18, and K19 (8 items out of the total 19 items) in both China and the UK are statistically significant, with the p values below 0.1 (marked in bold). The related coefficient values are all above zero, meaning the relationships between metacognition and the frequency of applying these knowledge items are positive. In other words, the higher the metacognition score obtained, the higher the frequency of application of these kinds of knowledge by the participants.

Table 21. Regression coefficient for MAI in estimating FKA (1–19)

	Coefficient		**P value**	
	China	UK	China	UK
MAI/FKA1	.0178451	.0124154	0.354	0.616
MAI/FKA2	.0390951	.0880546	0.058*	0.001*
MAI/FKA3	.0042632	-.0227451	0.829	0.358
MAI/FKA4	.0418545	.0048117	**0.034***	**0.853**
MAI/FKA5	-.0095757	.0071817	0.633	0.774
MAI/FKA6	.042094	.0707227	0.037*	0.007*
MAI/FKA7	.0135135	.0790986	**0.474**	**0.002***
MAI/FKA8	.048247	.0679747	0.026*	0.012*
MAI/FKA9	.0570645	.0836136	0.004*	0.002*
MAI/FKA10	.0465495	-.0098781	**0.022***	**0.691**
MAI/FKA11	.0129069	-.0342168	0.523	0.171
MAI/FKA12	.0620578	.0423462	**0.003***	**0.103**
MAI/FKA13	.0102593	.0355244	0.609	0.164
MAI/FKA14	-.0049528	.1101319	**0.803**	**0.000***
MAI/FKA15	.0280019	.0287052	0.165	0.264
MAI/FKA16	.040478	.0960231	0.048*	0.001*
MAI/FKA17	.0671738	.1129527	0.00*	0.000*
MAI/FKA18	.0670912	.0984483	0.001*	0.000*
MAI/FKA19	.0797108	.1019051	0.000*	0.000*

- *Notes: *p<0.1; inconsistent results between China and the UK are marked in **bold**.*

The coefficients of metacognition against the frequency of the application of K4, K10, and K12 are statistically significant only in China’s responses (p<0.1, marked in bold in China’s column), but not in the UK (p>0.1, marked in bold in the UK’s column). Whereas the coefficients of metacognition against the frequency of the application of K7 and K14 are statistically significant only among the UK’s responses (p<0.1, marked in bold in the UK’s column), but not in China (p>0.1, marked in bold in China’s column).

The results also show that the coefficients of metacognition against the frequency of the application of K1, K3, K5, K11, K13, and K15 (6 items out of the total 19 items) are statistically insignificant in both China and the UK, with the p values above 0.1.

4.6.2 Visualising the results of the OLR

The results of the OLR can also be observed directly in the frames of axes as explained in section 3.5.3 (p. 194). Therefore, the relationships between metacognition and applying each knowledge type were shown in a series of graphs in Figures 28 & 29 (pp. 217–223), which clearly show whether the changes of metacognition can explain the changes of FKA (p value) and the amount of the regression coefficient for MAI in estimating FKA (coefficient). The Chinese results are shown in Figures 28-(1–19) (pp. 219–221); the UK results are shown in Figures 29-(1–19) (pp. 223–225).

From a series of figures in Figure 28 (the China results, pp. 219–221), it is noticeable that the coefficient of MAI against FKA2, FKA4, FKA5, FKA7, FKA9, FKA10, FKA12, FKA16, FKA17, FKA18, and FKA19 is significant with the shadow area very concentrated around the line ($p<0.1$). A 95% confidence interval (CI) reflects that 95% values are distributed in the shadow area. As the p values of MAI against the frequency of applying these aforementioned knowledge items are below 0.1, then all the values are deemed largely concentrated around the line, and the shadow area is relatively narrow. Therefore, each correlation shown in the graphs of these knowledge items represents a linear relationship between the two variables measured.

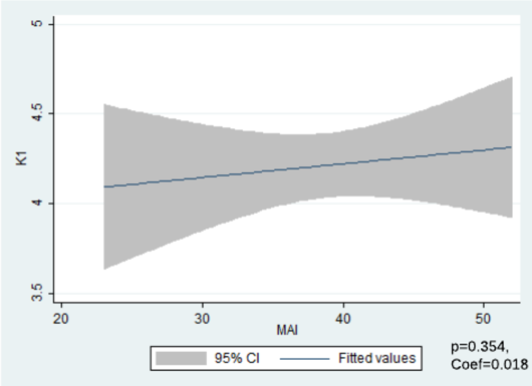


Figure 28-1. The relationships between MAI and FKA1

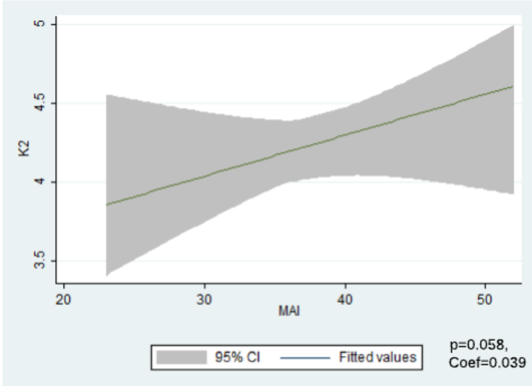


Figure 28-2. The relationships between MAI and FKA2

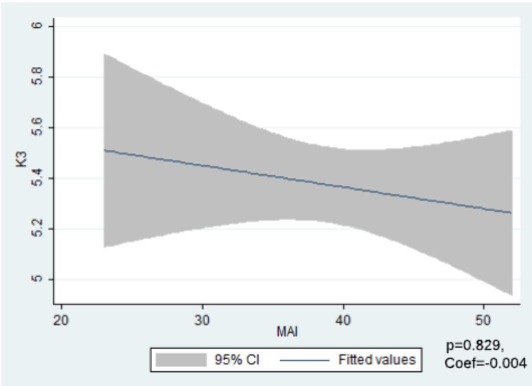


Figure 28-3. The relationships between MAI and FKA3

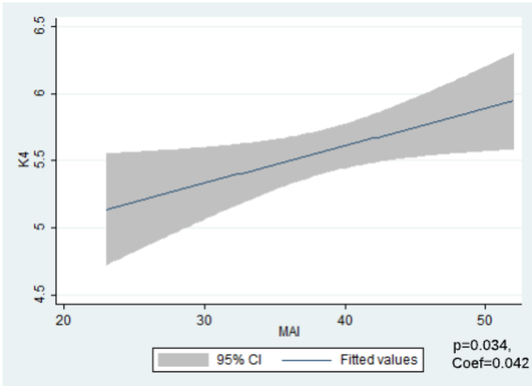


Figure 28-4. The relationships between MAI and FKA4

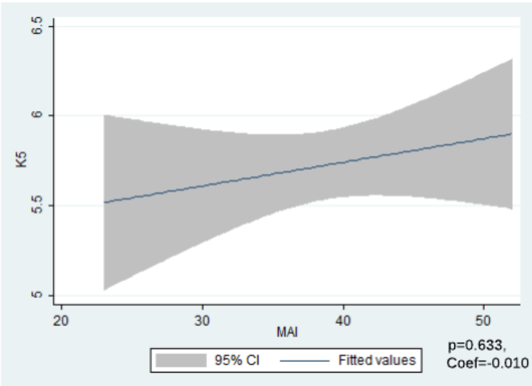


Figure 28-5. The relationships between MAI and FKA5

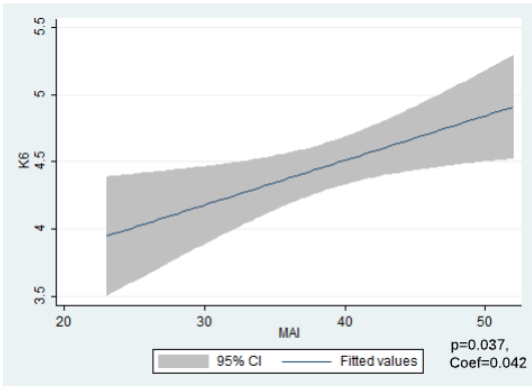


Figure 28-6. The relationships between MAI and FKA6

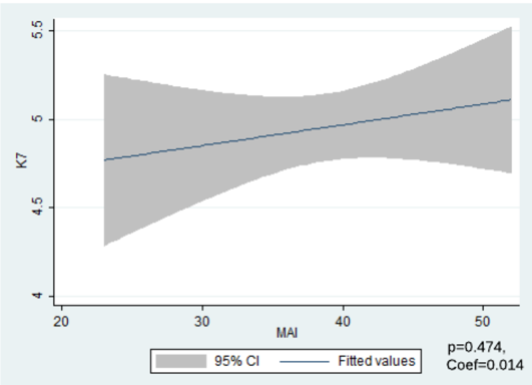


Figure 28-7. The relationships between MAI and FKA7

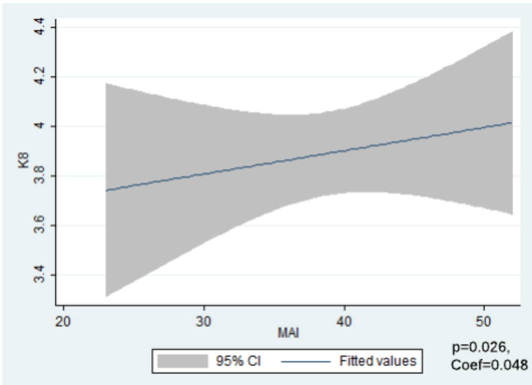


Figure 28-8. The relationships between MAI and FKA8

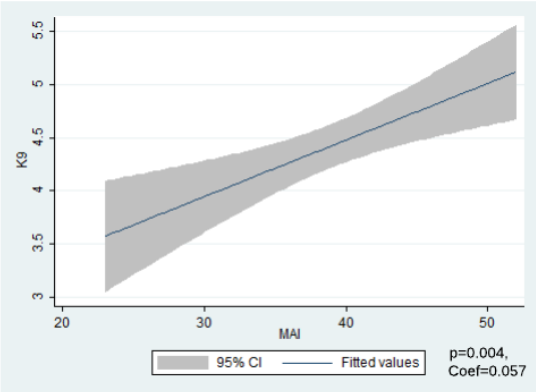


Figure 28-9. The relationships between MAI and FKA9

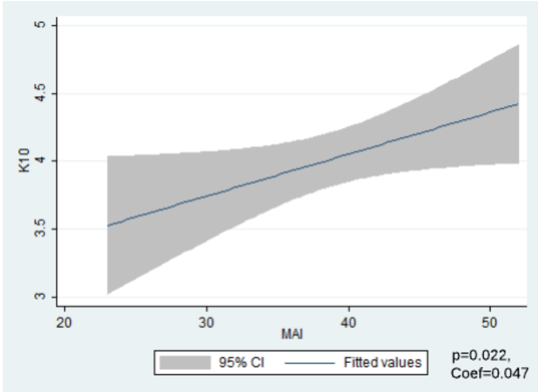


Figure 28-10. The relationships between MAI and FKA10

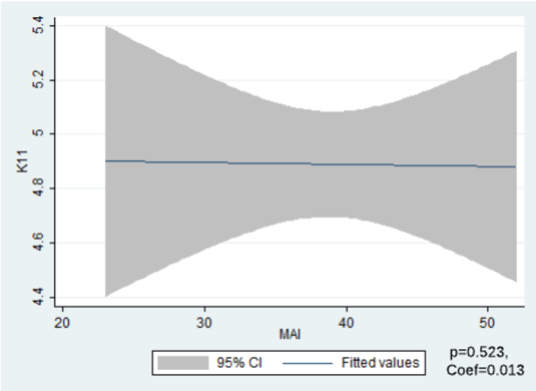


Figure 28-11. The relationships between MAI and FKA11

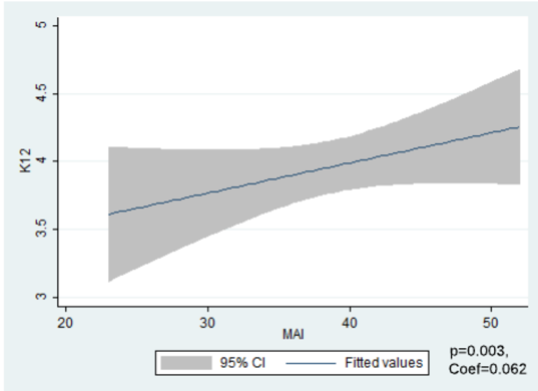


Figure 28-12. The relationships between MAI and FKA12

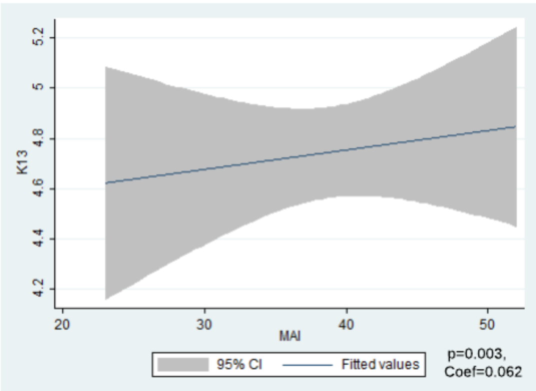


Figure 28-13. The relationships between MAI and FKA13

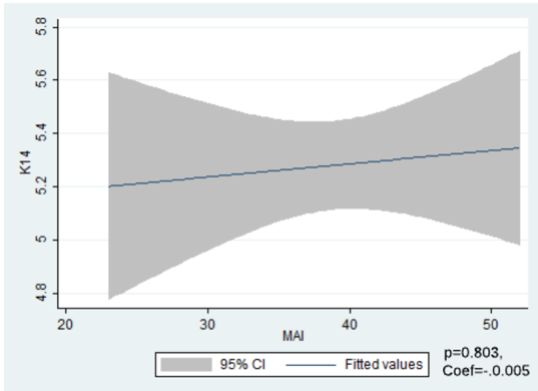


Figure 28-14. The relationships between MAI and FKA14

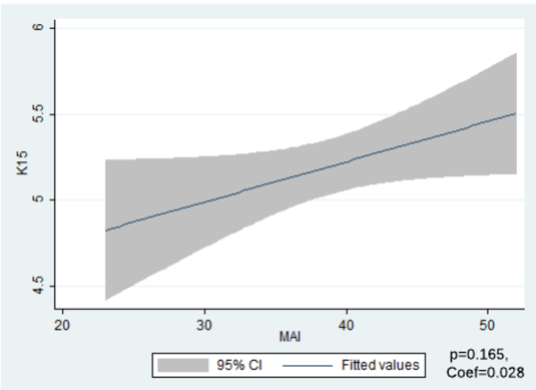


Figure 28-15. The relationships between MAI and FKA15

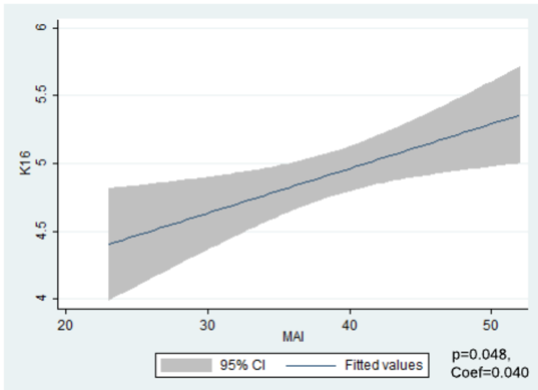


Figure 28-16. The relationships between MAI and FKA16

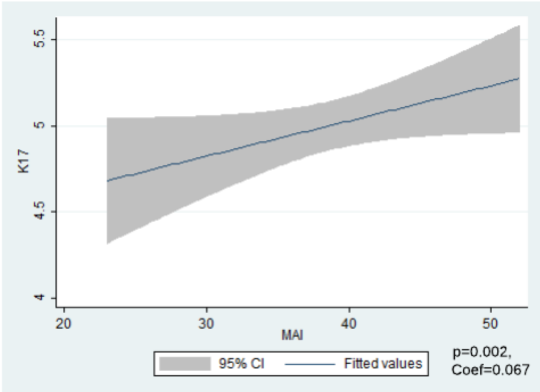


Figure 28-17. The relationships between MAI and FKA17

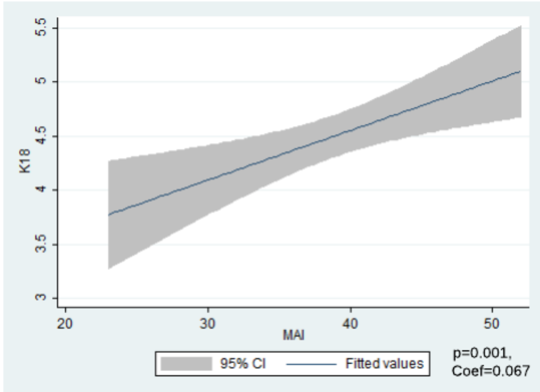


Figure 28-18. The relationships between MAI and FKA18

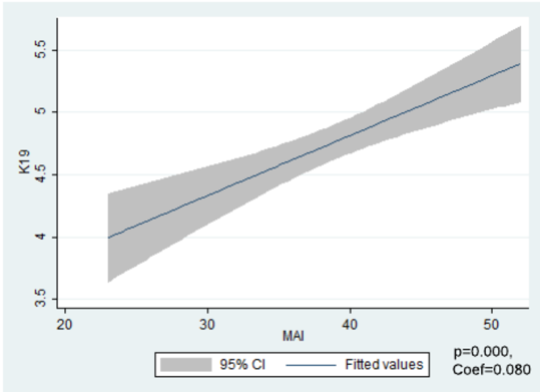


Figure 28-19. The relationships between MAI and FKA19

Figure 28. The relationships between MAI and FKA (K1–K19) (China)

In each of the graphs in Figure 28, it shows a positive relationship between the MAI and the FKA (coefficient > 0). Moreover, we can also obtain the information about the extent that metacognition exerts impact on the application of these kinds of knowledge items. The larger the coefficient value is, the larger the magnitude of the metacognition impact. For example, the coefficient of MAI against FKA19 is approximately twice as much as that of FKA2 (0.080 vs 0.039), indicating that MAI levels affect students' application of K19 to a larger extent than K2. In other words, if the respondents increased their MAI score by one, the probability of applying K19 at a higher frequency would increase by 0.080, while in the same circumstance, the respondents' probability of applying K2 at a higher frequency would only increase by 0.039 in the scale.

From a series of figures in Figure 29 (UK results, pp. 223–225), it can be observed that the coefficients of MAI on FKA2, FKA6, FKA7, FKA8, FKA9, FKA14, FKA16, FKA17, FKA18, and FKA19 are statistically significant, since their corresponding figures show that the shadow area is largely concentrated around the line ($p<0.1$). According to the degrees of their slope (also reflected by the value of the coefficient), it can be seen that these coefficients are all positive, which means the frequency of knowledge application increases as the MAI score increases. In other words, these types of knowledge are very sensitive to the metacognition level.

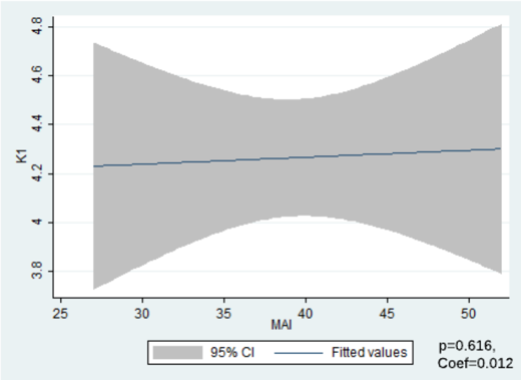


Figure 29-1. The relationships between MAI and FKA1

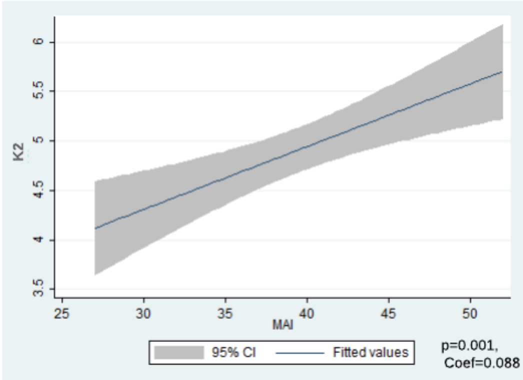


Figure 29-2. The relationships between MAI and FKA2

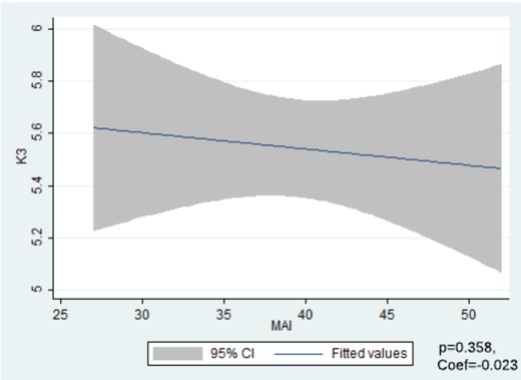


Figure 29-3. The relationships between MAI and FKA3

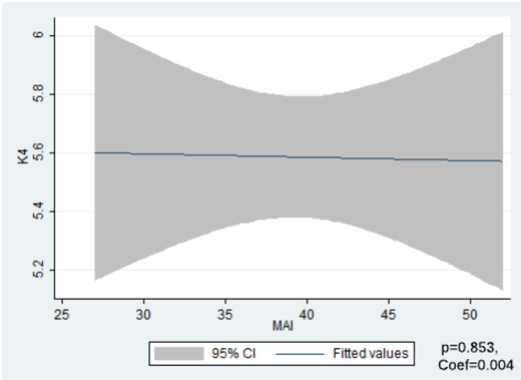


Figure 29-4. The relationships between MAI and FKA4

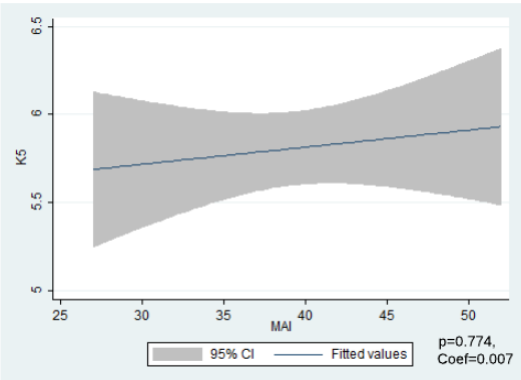


Figure 29-5. The relationships between MAI and FKA5

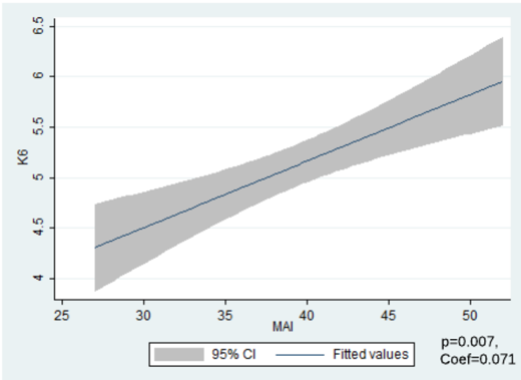


Figure 29-6. The relationships between MAI and FKA6

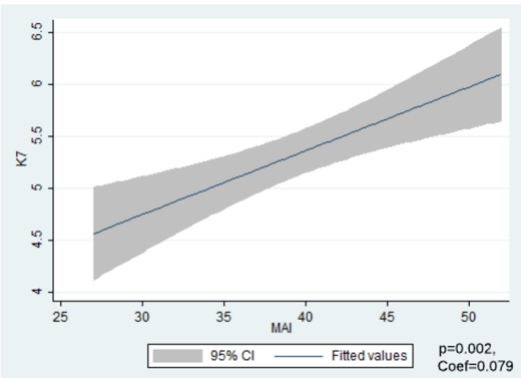


Figure 29-7. The relationships between MAI and FKA7

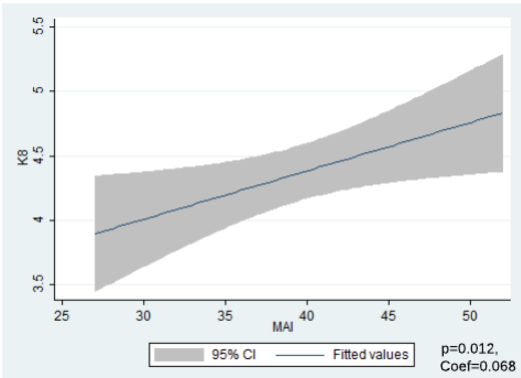


Figure 29-8. The relationships between MAI and FKA8

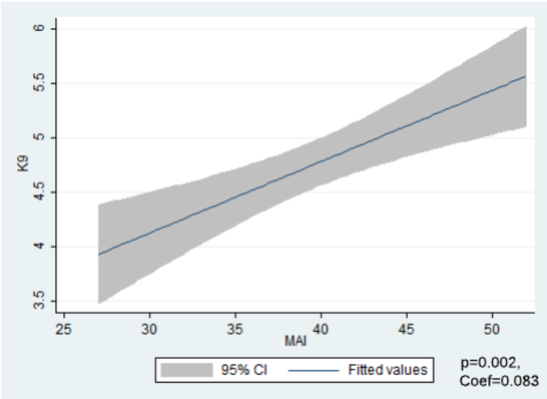


Figure 29-9. The relationships between MAI and FKA9

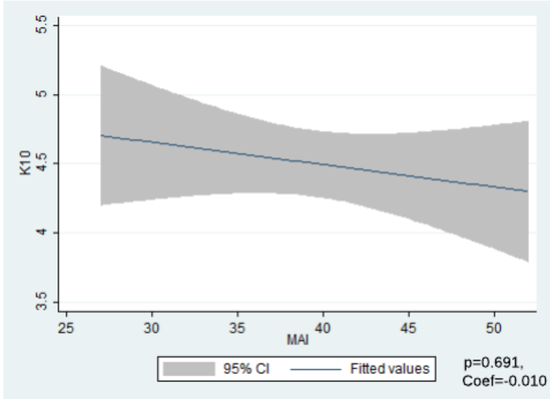


Figure 29-10. The relationships between MAI and FKA10

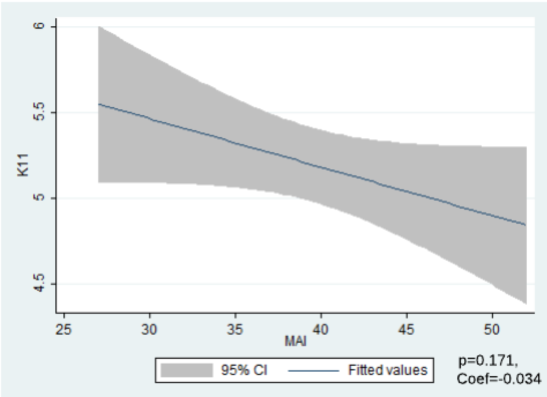


Figure 29-11. The relationships between MAI and FKA11

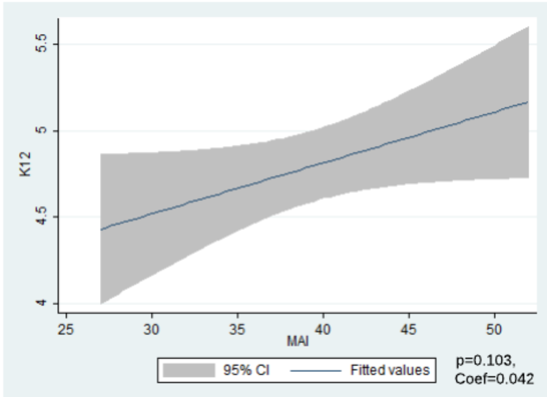


Figure 29-12. The relationships between MAI and FKA12

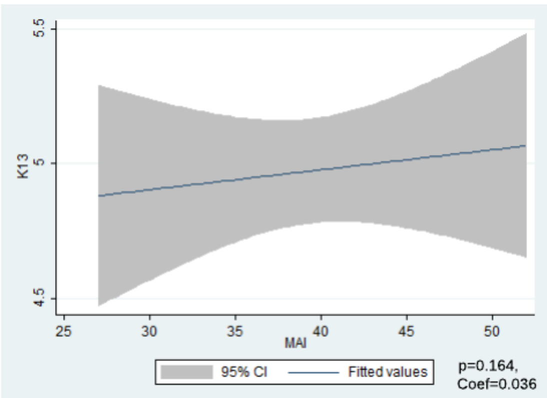


Figure 29-13. The relationships between MAI and FKA13

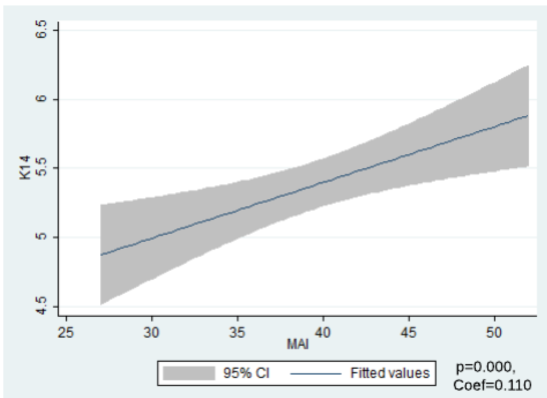


Figure 29-14. The relationships between MAI and FKA14

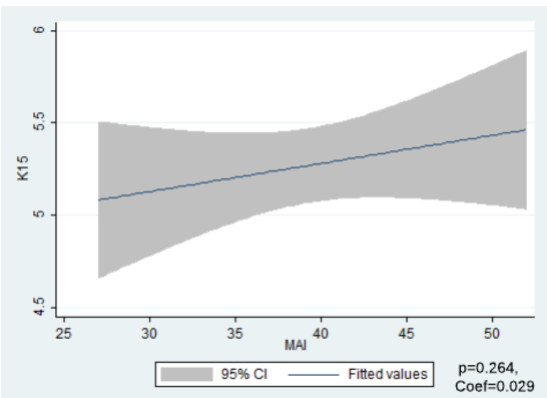


Figure 29-15. The relationships between MAI and FKA15

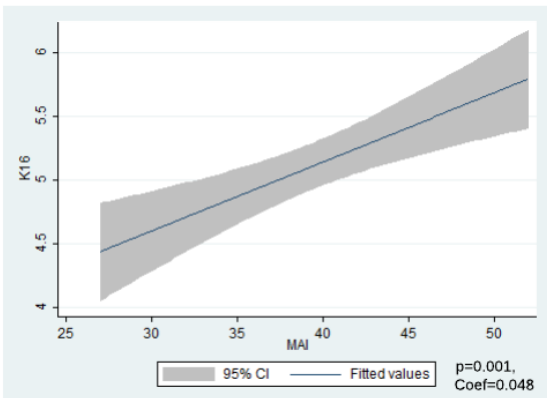


Figure 29-16. The relationships between MAI and FKA16

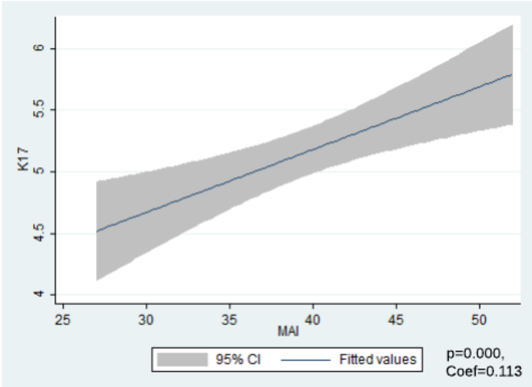


Figure 29-17. The relationships between MAI and FKA17

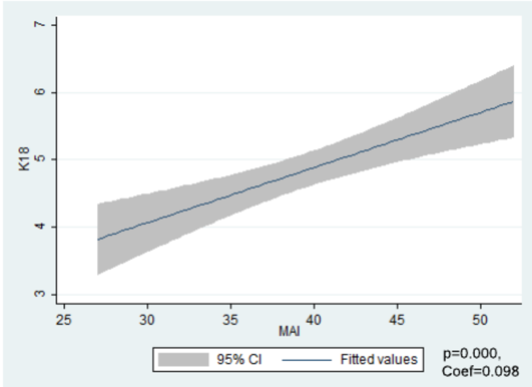


Figure 29-18. The relationships between MAI and FKA18

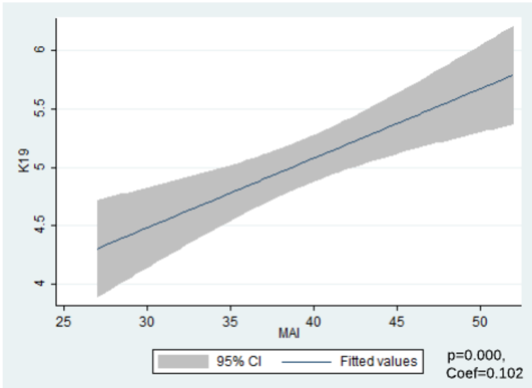


Figure 29-19. The relationships between MAI and FKA19

Figure 29. The relationships between MAI and FKA (K1–K19) (UK)

4.6.3 Main findings

According to Table 21 (in section 4.6.1, p. 217) and related Figures 28 & 29 (in section 4.6.2, pp. 219–225), main findings obtained from the results of regression generally categorise the 19 knowledge items into three groups, summarised below:

Category 1.

There are 8 items, whose applications are related to metacognition (p value<0.1) in both UK and China, and such relationships are positive (‘Coef’ >0). 4 items are from domain-specific knowledge (DSK); 1 item is from domain-general knowledge (DGK); and 3 items are from tacit knowledge (TK). They are listed below:

K2. Material: knowledge relates to specific materials to attain certain conceptual solutions. (DSK)

K6. User Trials: knowledge relates to simulations of product usage in which subjects are asked to fulfil specified tasks using a product or product simulation. (DSK)

K8. Mechanics. (DSK)

K9. Ergonomics. (DSK)

K16. Strategies: knowledge relates to motivation, plans and goals. (DGK)

K17. Knowledge of existing design solutions: the precedents of similar projects learned. (TK)

K18. Personal placement experience in design companies. (TK)

K19. Other experience in daily life: travelling, reading, events, etc. (TK)

Moreover, according to the coefficient values, the magnitude of the impact of metacognition on the application of K17, K18, and K19 is larger than that of applying K2, K6, K8, K9, and K16 in both China and the UK.

Category 2.

There are 6 items applied not being related (with p value>0.1) to metacognition. 5 items are from domain-specific knowledge (DSK), and 1 is from domain-general knowledge (DGK). They are listed below:

K1. Design history: knowledge relates to style perspectives. (DSK)

K3. Design methods: knowledge relates to the application of design research and design case studies. (DSK)

K5. Design representation: skills relate to 2D/3D drawing (effect drawing, three views). (DSK)

K11. Media technologies. (DSK)

K13. Psychology of consumer and user. (DSK)

K15. An ill-structured problem-solving process: knowledge relates to analysing situations, defining problems, finding or generating solutions. (DGK)

Category 3.

There are 5 items applied showing different results between the UK data and China data. 4 items are from domain-specific knowledge (DSK); 1 item is from domain-general knowledge DGK). They are shown below:

K4. Aesthetics: knowledge relates to colour, structure and form. (DSK)

K10. Skill to operate relevant machines. (DSK)

K12. Knowledge of organisation and marketing. (DSK)

K7. Client needs: knowledge relates to analysis of the design brief. (DSK)

K14. Knowledge of information processing: information searching and analysing. (DGK)

4.6.4 Checking the reverse-causality problem

In the regression analysis, it is assumed that MAI level affects knowledge application. However, there is a possibility that the influence may be the other way around. In other words, it is possible that knowledge application affects MAI level. This is called the reserve-causality[16] problem, and in many cases, is referred to as the endogeneity[17] problem. The General Method of Moments (GMM) model is recommended in most recent literature to handle the problems of reverse causality (Harrell, 2015). After running the GMM, an endogeneity test was then applied in this study which showed that there was no such reverse-causality problem in the data. Therefore, endogeneity was not a serious concern in the study, and the regression results in this study are reliable.

[16] In ORL, a reverse-causality problem refers either to a direction of cause-and-effect contrary to a common presumption or to a two-way causal relationship in, as it were, a loop. The reverse-causality problem is one of the endogeneity problems (Wooldridge, 2015).
[17] In OLR, an endogeneity problem occurs when an explanatory variable is correlated with the error term (Wooldridge, 2015).

Chapter Five: Discussions

5.1 Chapter overview

This chapter discusses the findings with the aim of forming a new category of subject-related knowledge which brings valuable suggestions for design students' knowledge application, which would be the major impact of this research. It analyses the relationships between metacognition and knowledge application in section 5.2. Additionally, in section 5.3 all the factors that are involved in the FYDP in relation to students' knowledge application have been further analysed. Section 5.4 highlights the impact of this study.

5.2 Discussions of the main findings

According to the p values in the OLR results, how the main findings are supporting/rejecting the null hypothesis was discussed based on three categories:

Category 1.

Metacognition's coefficients in estimating the application of 8 knowledge items (K2, K6, K8, K9, K16, K17, K18, K19) are statistically significant and positive ($p<0.1$, 'Coefficient'>0) amongst the participants both from China and UK. Therefore, these results suggest their corresponding H_as that there is a relationship between MAI and FKA2/FKA6/FKA8/FKA9/FKA16/FKA17/FKA18/FKA19, and the frequency of applying these aforementioned knowledge items increases as the MAI score increases, rejecting the null hypotheses H_0s. This finding implies that metacognition would probably exert impact on the application of aforementioned knowledge items.

Category 2.

Metacognition's coefficients against the applications of 6 knowledge items (K1, K3, K5, K11, K13, K15) are statistically insignificant ($p>0.1$) in China and the UK, indicating that metacognition had little impact on the application of these knowledge items. Therefore, the H_as that there is relationship between metacognition (MAI score) and FKA1/FKA3/FKA5/FKA11/FKA13/FKA15 cannot be suggested.

Category 3.

There are 5 items (4 from domain-specific knowledge, 1 item from domain-general knowledge) showing different results between the China data and UK data. This finding shows that the relationships between MAI and FKA4/FKA10/FKA12 are statistically significant in China ($p<0.1$ in China's column), indicating that metacognition would probably exert impact on the frequency of the application of K4, K10, and K12 only among the China's responses, but not in the UK ($p>0.1$ in the UK's column), and thus, supports the corresponding H_as only within the Chinese context. Whereas this finding implies that the metacognition exert impact on the frequency of the application of K7 and K14 only among the UK's responses, demonstrating that the relationship between metacognition (MAI score) and FKA7/FKA14 is statistically significant in the UK ($p<0.1$ in the UK's column), but not in China ($p>0.1$ in China's column), thus supports the corresponding H_as only within the UK context.

For these knowledge items as identified in category 1, the likelihood of their being more or less frequently used (on a 7-point Likert scale), can be estimated or explained by whether the corresponding participants are of higher or lower MAI. This implies that the higher the MAI of the participants, the greater chance of higher frequency in applying those kinds of knowledge in category 1. This, in turn, indicates that the category 1 knowledge items, via how frequently they are used, are related to their creativity. Metacognition in this study is a criterion for assessing creative thinking ability, and the students who attained a higher score in the MAI test are considered to have the advantage in creative thinking, and thus can be more creative. For the knowledge items in category 2, their frequency of use is not influenced by the MAI levels of the participants. For the knowledge items in category 3, the evidence found in the UK and Chinese students is contradictory, thus implying that the cultural differences may constitute another underlying factor for knowledge application. For each knowledge item, the following sections 5.2.1–5.2.3 will be used to describe results in detail ordered by Category 1, Category 2, and Category 3 of the main findings, and to discuss these results with reference to the current literature reviewed.

5.2.1 Discussion of knowledge items in Category 1.

The eight items in category 1 are provided in Table 22 (p. 232).

Table 22. Knowledge item list – the frequency of their application related to metacognition

K2. Material: knowledge relates to specific materials to attain certain conceptual solutions.
K6. User Trials: knowledge relates to simulations of product usage in which subjects are asked to fulfil specified tasks using a product or product simulation.
K8. Mechanics.
K9. Ergonomics.
K16. Strategies: knowledge relates to motivation, plans and goals.
K17. Knowledge of existing design solutions: the precedents of similar projects learned.
K18. Personal placement experience in design companies.
K19. Other experience in daily life: travelling, reading, events, etc.

Among these items, 4 items (K2, K6, K8, and K9) belong to domain-specific knowledge; 1 item (K16) is from domain-general knowledge, and 3 items (K17, K18, K19) are from tacit knowledge. The results of the OLR on these items are interpreted item by item in detail first, and then discussed with respect to the literature. The main conceptual process of this section is shown in the flowchart (Figure 30):

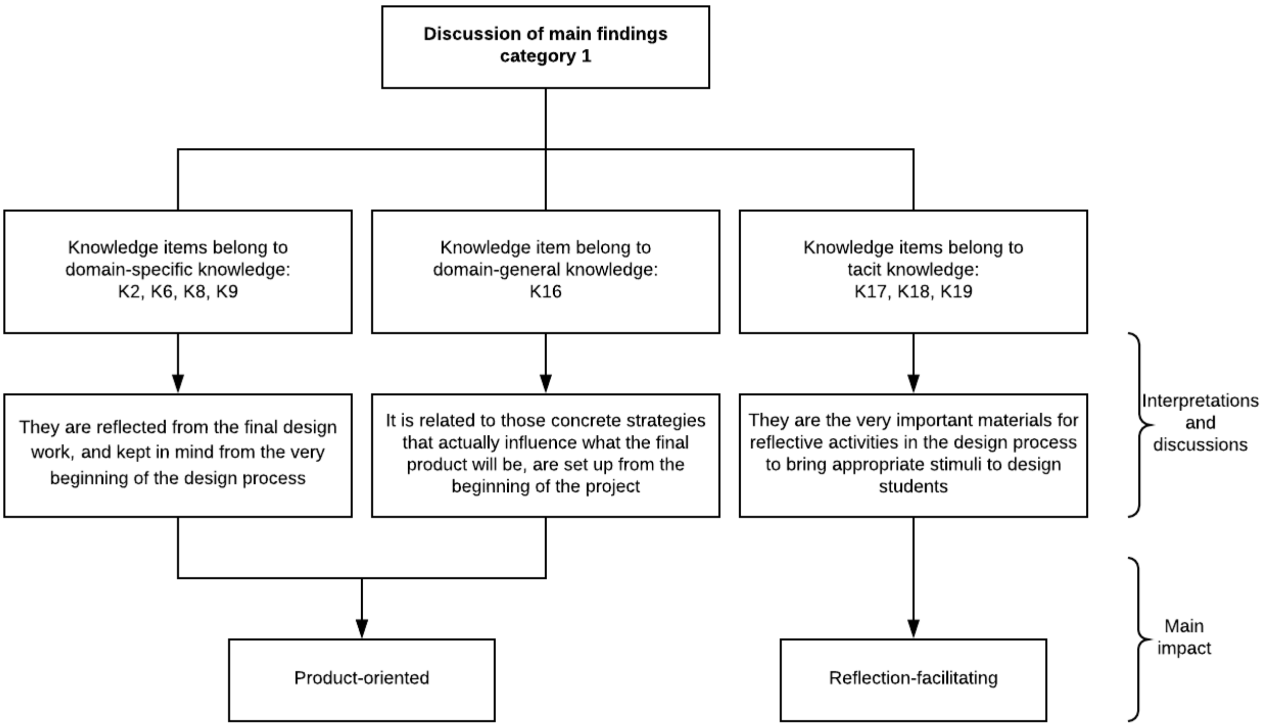


Figure 30. The conceptual process of discussion for category 1

i) K2, K6, K8, and K9

K2. Material: knowledge relates to specific materials to attain certain conceptual solutions. (Table 23)

Table 23. Regression coefficients for MAI in estimating FKA2

	Coef.		**P value**	
	China	UK	China	UK
MAI/FKA2	.0390951	.0880546	0.058*	0.001*

The p values indicate that the MAI level's impact on the application of K2 is statistically significant in the UK and in China ($p<0.1$), which implies that MAI levels of the respondents in both countries significantly influence the likelihood of their applying K2 (more or less frequently) in their FYDPs. The coefficients of MAI levels are positive in both countries (0.088 in the UK and 0.04 in China), showing that the respondents with higher MAI levels are more likely to use K2 at a higher frequency than those with lower MAI levels. The UK coefficient is approximately twice as much as the China coefficient (0.09 vs 0.04), indicating that the MAI levels of the UK respondents affect their application of K2 to a larger extent than those of the Chinese respondents. In other words, if the UK respondents increase their MAI levels by one, the probability of applying K2 at a higher frequency would increase by 0.09, while in the same circumstance, the Chinese respondents' probability of applying K2 at a higher frequency would only increase by 0.04 on the scale.

As part of the design procedure – initiated by an original product's conceptualisation and then closing with the choice of initiating an official development scheme – the 'fuzzy front end' is a specific aspect, as outlined in section 2.14.3 (pp. 109–110). As Asbjørn Sörensen et al. (2017) suggested, the general and intangible ideas regarding materials are evaluated at the fuzzy front end, with the conclusion of the design procedure seeing an aspect of the design challenge resolved through the introduction of more concrete ideas. Thus, the entire design procedure incorporates material knowledge, with development of the procedure seeing increasing adoption of such knowledge. Furthermore, as one moves from the design problem area to resolution, such evolution sees this adoption become naturally. Additionally, Ljungberg and Edwards (2003) noted that the product's appearance will be conveyed by the material, while also affecting the experience of consumers. Supporting evidence for this has suggested that affective and technical practical dynamics provide two interrelated areas of the part materials play in design (Ashby & Johnson, 2013). Consequently, as Ashby and Johnson (2013) emphasised, materials' inventive adoption has typically been linked to innovative product development.

K6. User Trials: knowledge relates to simulations of product usage in which subjects are asked to fulfil specified tasks using a product or product simulation. (Table 24)

Table 24. Regression coefficients for MAI in estimating FKA6

	Coef.		**P value**	
	China	UK	China	UK
MAI/FKA6	.042094	.0707227	0.037*	0.007*

The p value is an indication that the MAI levels' influence on the application of K6 is statistically significant in both the UK and in China ($p<0.1$), which implies that the

MAI levels of the respondents in both countries have exerted an impact on the frequency of their applications of K6 in FYDPs, and this impact is significant. Both countries' coefficients are positive at 0.07 in the UK and 0.04 in China, which demonstrates that those students with higher levels of MAI would use K6 more frequently than those with MAI levels that are lower. The MAI coefficient of the UK is higher than that of China (0.07 vs 0.04) which gives us an indication that the UK respondent's MAI levels are more greatly affected in terms of their K6 application when compared with respondents from China. Simply speaking, the likelihood of K6 being applied would increase by 0.07 for UK respondents whilst the Chinese respondents’ likelihood would only increase by 0.04, assuming the circumstances are the same.

For the knowledge regarding user trials, Lawson (2006) suggested that the extent to which an item is appealing and of practical utility for consumers may be determined by asking them to appraise the product, thus making customer trials crucial. During the design procedure, the final phase typically sees the adoption of customer trials, as outlined in section 2.14.3 (p. 116). Nevertheless, a company can identify evaluators at a preliminary stage and undertake trials at the design procedure’s outset. However, as Brown (2009) suggested, this may be challenging due to organisational strategy and the need for contemporary market data being needed, in order to identify the target consumer population that could provide evaluators.

K8. Mechanics & K9. Ergonomics (Table 25)

Table 25. Regression coefficients for MAI in estimating FKA8 & FKA9

	Coef.		**P value**	
	China	UK	China	UK
MAI/FKA8	.048247	.0679747	0.026*	0.012*
MAI/FKA9	.0570645	.0836136	0.004*	0.002*

In Table 25, the p values indicate that the MAI's impact on K8 application is statistically significant in the UK and China with both being less than the 10% significance level ($p<0.1$). This implies that MAI levels of respondents in both countries have a significant impact on the frequency of applying K8 for students in FYDPs.

When analysing the coefficients, it is noted that they are positive for both counties; 0.07 in the UK and 0.05 in China. This shows that the respondents with higher MAI levels are more likely to use K8 at a higher frequency than those with lower MAI levels. As the coefficient for the UK is higher, being 0.07 vs 0.05, this indicates that the UK respondents' MAI levels have a slightly greater effect on their K8 application, as opposed to the Chinese. Put differently, for the UK respondents who have an increase of one in their MAI levels the likelihood of applying K8 at a higher frequency would increase by 0.07, whereas the Chinese respondents would only increase by 0.05 in the scale.

When looking at the K9 application, the p values indicate the MAI levels as significant statistically, with both the UK and China being at the 1% significance level. The implication is that the MAI levels for both countries have an influence on the probability in their applications of K9 in their FYDPs. Both coefficients are positive (0.08 in the UK and 0.06 in China), and therefore it is likely that the MAI levels being higher means that K9 will be used at a higher frequency than those respondents who have a lower MAI level. The UK coefficient is higher at 0.08 vs 0.06 which infers that the application of the K9 is slightly more affected in the UK. In other words, for the UK respondents who have an increase of one score in their MAI levels, the likelihood of applying K9 at a higher frequency would increase by 0.08, whereas the Chinese respondents would only increase by 0.06 in the scale.

In terms of product design, the engineering-orientated aspects are ergonomics (K8) and mechanics (K9), as section 2.14.3 (pp. 117–118) in the literature review chapter outlined. Ergonomics knowledge comprises how well a person and product are suited as well as technological development. As Sagot et al. (2003) explained, the preliminary design stages should include a requirement assessment, while the entire design procedure must consider ergonomic dynamics in order to reduce expenditure and increase efficacy. When a product is used by a consumer, it will evoke certain emotions and fulfil a particular requirement, which is associated with ergonomics. A product's development will be influenced by ergonomic considerations, even if the product's pictures do not convey such dynamics. Essentially, as Lawson and Dorst (2009) stressed, consumers' experiences will be affected by ergonomics.

Regarding mechanical knowledge, Sagot et al. (2003) related that this concerned reflecting the actual design of an item in its physical development, alongside a devised item's actual structures, as fundamental information. Likewise, it has been argued that the design procedure must incorporate engineering-orientated understanding (Bingham et al., 2013). Additionally, Bingham et al. (2013) suggested that learners' modelling capabilities are strengthened through the considerable applied engineering-focused instruction within the FYDP module.

General discussion on K2, K6, K8, and K9

In summary, the way in which domain-specific knowledge K2, K6, K8, and K9 reflect a similar attribution in the design process has been discussed; that is, they are directly related to the final product images which will be experienced by the end-users. Although their application outcomes seem directly reflected in the designed product (the surface, the structure, the function and the performance), it is suggested that they are all supposed to be considered at the very beginning of the design process. Each knowledge item aims to address and solve a specific design problem. The solution is refined gradually during the design process, and eventually matures to be physically materialised in the final product. Therefore, the domain-specific knowledge K2, K6, K8, and K9 would logically play significant roles in the transference from the problem space to the solution space. That is, the designer's conceptual ideas become increasingly clear and are manifestly delivered and embodied as a physical product. According to Acuna and Sosa (2011), the process of transferring conceptual ideas into the form of a physical object spurs creativity. This, in turn, may explain why these participants with higher scores in the MAI test are considered to be more creative, and are more likely to apply this kind of knowledge at a higher frequency in the FYDP process. It may be that their stronger creative thinking abilities help them better understand the effects of applying this knowledge, which is highly integrated throughout the whole design process, rather than at a specific stage. The design process is solution-oriented, and the corresponding knowledge is applied thoroughly, which in turn helps to facilitate a smoother FYDP engagement process. In contrast, those students with relatively lower scores in the MAI test are considered to be less creative and are more likely to apply this knowledge at a lower frequency. This could probably be attributed to their increased attention to specific stages when using this knowledge (which may be influenced by the course module), which indicates they are relatively weak at using this knowledge at the appropriate stages. Creativity in design is known as problem-based and solution-focused and has been studied mainly via qualitative approaches based on practices (Friedman, 2003; Razzouk & Shute, 2012). The results here would probably support the viewpoint that the design process is solution-focused (Jonas, 1993; Lawson, 2006) from a quantitative perspective, because using these knowledge items is constantly shifting the focus back to the performance of the final products, which in turn helps to facilitate a smoother FYDP engagement.

ii) K16. Strategies: knowledge relates to motivation, plans and goals. (Table 26).

Table 26. Regression coefficients for MAI in estimating FKA16

	Coef.		**P value**	
	China	UK	China	UK
MAI/FKA16	.040478	.0960231	0.048*	0.001*

When analysing K16 application, the p values indicate that the impact of MAI levels on K16 application are statistically significant in both the UK and in China ($p<0.1$). This implies that the MAI levels significantly impact the probabilities of frequently applying K16 in FYDPs. Both countries MAI levels are positive with 0.10 in the UK and 0.04 in China indicating that respondents with higher levels of MAI have a higher likelihood of using K16 at a higher occurrence than those with lower MAI levels. The UK numbers are much higher than the Chinese (0.10 vs 0.04) which demonstrates the fact that MAI levels of the UK respondents affect their application of K16 to a larger extent than those of the Chinese respondents. In other words, UK respondents with an increase of one score in their MAI levels would probably apply K16 at a higher frequency (increased by 0.10), while in the same circumstance, the probability of applying K16 at a higher frequency only increase by 0.04 in the scale for the Chinese respondents.

Christiaans and Venselaar's (2005) study implied that students whose designs have a higher creativity rating would apply on average a greater amount of domain-general knowledge than other students. The results in this study indicate that not all domain-general knowledge reflects the same situation as interpreted in Christiaans and

Venselaar's study. This study indicated that only K16 from domain-general knowledge is applied more by students with higher metacognition levels in both countries.

The results show that the frequency of K16 application (domain-general knowledge) is positively influenced by students' metacognition. The strategy knowledge should be involved not only in the design process at the early stage, such as during the establishment of a range of goals and plans, but also used throughout the design process as it involves deploying different knowledge scopes (Alexander & Judy, 1988). Similarly, Christiaans and Venselaar (2005) stated that the domain-general knowledge usually guides the application of domain-specific knowledge and plays a crucial role in the design process as a 'guideline'.

It is implied here that students with a higher MAI score intend to use this knowledge (K16) at a higher frequency. The reason is probably that it is related to the management of the physical process of a design project, as it involves motivation, plans and goals. A well-managed procedure benefits the students who are considered to be more creative, whereas those students with a lower MAI score would probably ignore its 'guideline' role in the design process, and hence present a relatively lower frequency of this knowledge application. Strategy knowledge tends to influence the whole design process, and thus may also influence the application of domain-specific knowledge. Those students with a lower MAI score use K16 less frequently, indicating their limitations in proper management of the whole process. Hence, they may apply certain domain-specific knowledge less efficiently, and therefore, may face more problems in the process.

iii) K17, K18, and K19 (Table 27)

Table 27. Regression coefficients for MAI in estimating FKA (17–19)

	Coef.		**P value**	
	China	UK	China	UK
MAI/FKA17	.0671738	.1129527	0.002*	0.000*
MAI/FKA18	.0670912	.0984483	0.001*	0.000*
MAI/FKA19	.0797108	.1019051	0.000*	0.000*

- *Notes: K17. Knowledge of existing design solutions: the precedents of similar projects learned; K18. Personal placement experience in design companies; K19. Other experience in daily life: travelling, reading, events, etc.*

When analysing the application of K17, K18, and K19, the p values indicate that in the UK and China the influence of MAI levels is statistically significant ($p<0.1$), and therefore implies that the MAI levels of the respondents significantly influence the probability of their applications of K17, K18, and K19 in their FYDPs.

All MAI level coefficients are positive. For FKA17, the coefficient values are 0.11 in the UK and 0.07 in China; for FKA18, these are represented as 0.10 in the UK and 0.07 in China; and for FKA19, these are 0.10 in the UK and 0.08 in China. This highlights that it is more likely that the respondents with higher MAI levels will use K17, K18, and K19 at a higher frequency than those with lower MAI levels.

From Table 27, it can also be found that all the UK coefficient values are higher than the China coefficient (0.11 vs 0.07 for FKA17; 0.10 vs 0.07 for FKA18; and 0.10 vs 0.08 for FKA19), indicating that the MAI levels of the UK respondents affect their application of K17, K18, and K19 to a greater extent than those in China. In other words, UK respondents with an increase of one score in their MAI levels are likely to apply K17 at a higher frequency by an increase of 0.11. In the same circumstance, the Chinese respondents' probability of applying K17 at a higher frequency would only increase by 0.07. The likelihood of K18 application at a higher frequency would increase by 0.10. Using the same variables, the probability of Chinese respondents applying K18 at a higher frequency would only increase by 0.07. For the UK respondents, with an increase of one score in their MAI levels, the probability of applying K19 at a higher frequency would increase by 0.10, while in the same circumstance, the probability of Chinese respondents applying K19 at a higher frequency would only increase by 0.08 in the scale.

As opposed to a technical, fluid issue resolution procedure, the design procedure has been characterised in Dorst and Cross' (2001) seminal research as a form of mutual evolution within the problem and solution areas. Furthermore, it has been suggested that the problem and solution areas may be bridged through the designers' acuity regarding innovative awareness, rather than this constituting a divide to be jumped (Cross, 2004). The achievement of this 'bridging' would be dependent on the magnitude of the designer's reflective activities (Dorst & Cross, 2001). Designers' tacit knowledge is either related to their prior knowledge and design-related precedents (exemplars) or their previous experience of design (Oxman, 1990; Sarkar & Chakrabarti, 2011). Designers' experience is considered to be a key material in facilitating the reflective activities in such a 'co-evolution' and 'bridging' process

(Cross, 2004). Similarly, within extant education and management research, a fundamental aspect of acquiring experience-founded knowledge is considered to be appraisal of one's experience (Kolb, 1984). It is, therefore, unsurprising that creative students apply tacit knowledge more frequently, as they tend to be proficient at connecting the current situation with their experiences, or they are more reflective learners.

iv) Coefficient analysis

In addition, by separately overviewing every coefficient value in the columns of China and the UK in Table 28 (p. 246), it can be found that the coefficient values of tacit knowledge are all higher than the domain knowledge in both China and the UK. This means that tacit knowledge is more influenced by metacognition, which implies that a creative student would probably apply his/her tacit knowledge at a higher frequency than domain knowledge (considered to be significantly influenced by metacognition as well). If one of the domain-general knowledge items, K16, is regarded as guidance in applying domain-specific knowledge, then tacit knowledge would probably exert impact on each domain knowledge (including both the specific and general) with a continuous and constant influence on the whole process.

Moreover, from the horizontal comparison of coefficient values (China vs. the UK), it can be seen that the metacognition impact on each knowledge application in the UK is larger than in China (Table 28, p. 245). This means that the magnitude of metacognition impact on the applications of these knowledge items listed in Table 28 from UK students is larger than that from Chinese students.

Table 28. Values of MAI coefficient against FKAs in category 1

	MAI Coef.	
	China	UK
FKA2	.0390951	.0880546
FKA6	.042094	.0707227
FKA8	.048247	.0679747
FKA9	.0570645	.0836136
FKA16	.040478	.0960231
FKA17	.0671738	.1129527
FKA18	.0670912	.0984483
FKA19	.0797108	.1019051

The results of coefficients comparisons within one country (vertical) and between the countries (horizontal) are also shown in Figure 31:

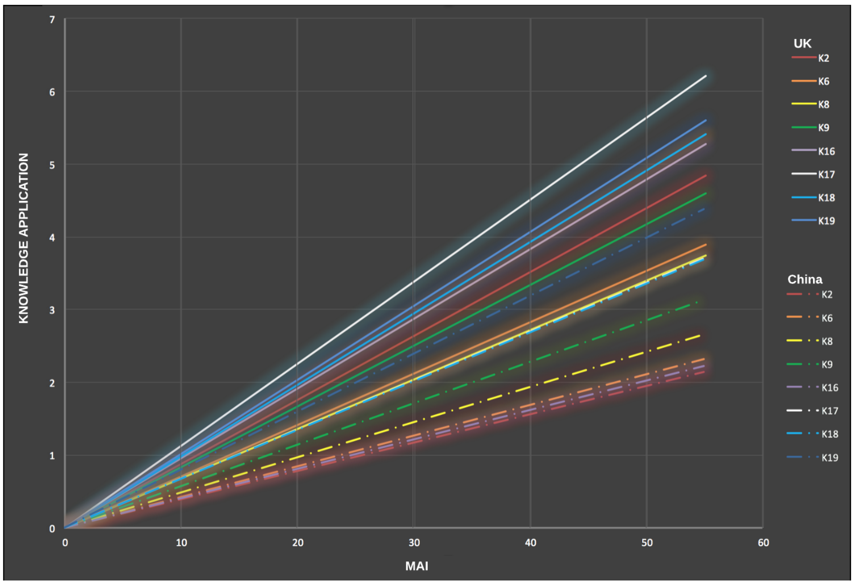


Figure 31. Linear relationships of MAI and FKA (China and the UK)

Since the values of coefficients are all positive, these linear relationships are all upward sloping. The larger the coefficient, the stronger the impact of MAI on the corresponding knowledge application. From Figure 31, it can be seen that the frequency of UK students' application of each knowledge item influenced by metacognition is larger than that of Chinese students (the slope of the active line is larger than the dotted line with the same colour). Accordingly, most psychological instruments applied in different countries would probably gain different results, which indicates that the scales of these instruments may be influenced by the socio-cultural context (Schwartz et al., 2001) and acceptable in the research. It is demonstrated that students from different cultures may show different metacognition abilities even with the same metacognition scores. Therefore, although the coefficients between the two countries are different, the tendency of metacognition to influence is represented by the consistency. Whereas this difference may not affect the results of vertical comparison, it is the natural tendency that students with higher MAI scores have higher metacognition ability than those with lower MAI scores.

From this vertical comparison, it is reasonable to believe that tacit knowledge would probably play a positive role in achieving creativity as the creative students tend to apply it to a larger degree compared to other knowledge. As reviewed in section 2.14.3, (pp. 125–126), the literature shows that investigations focusing on designers' experience are either related to designers' prior knowledge and design-related precedents (exemplars), or designers' previous experience of designing (Sarkar & Chakrabarti, 2011; Doboli & Umbarkar, 2014). It is these specific kinds of knowledge that contribute to design creativity (Dorst & Cross, 2001). Designers will search for similar solutions when they encounter design problems. Precedents or designers' designing experience provide relevant solutions or approaches to design projects.

However, in other studies it has been argued that such experiences may lead to design fixation occurring, which inhibits the creative process (Ward, 1995; see also Doboli & Umbarkar, 2014; Smith, Ward, & Schumacher, 1993, discussed in section 2.14.3, pp. 126–128). In these studies, it is suggested that knowledge or experience, which are considered as the basis of creativity by many researchers, are a double-edged sword. Designers cannot achieve creativity in a professional area without domain knowledge and experience; however, fixation may occur if they largely depend on precedents to stimulate inspiration or to look for solutions.

The results of this study may bring new insight into the relationship between designers' experience with design fixation and creativity, which indicates there is no evidence to show that being largely dependent on tacit knowledge (experience-based knowledge) may lead to design fixation, as those creative students who tend to apply this knowledge to a large degree may also improve their design process. It is then argued that it is crucial that different types of experiences are integrated in order to improve reflective activities, which are considered to be the key elements to stimulate relevant activities for achieving creativity. In addition, beside those suggestions for breaking through fixation from other studies as reviewed in section 2.14.3 (p. 127), the results of this study indicate that every experience investigated shows a positive relationship with creativity, which indicates that it may not be dependent on the precedents or prior knowledge that inhibits the creative design process. This point of view is also supported by Sio, Kotovsky, and Cagan (2015), who found that providing examples leads to more example-related generation, but surprisingly, the example-related generation is evaluated as more novel by a systematical meta-analysis. The current literature provides relevant suggestions on how to break through fixation by ignoring the essential role of prior knowledge or experience in the design process, which is the key material for reflective activities. Therefore, this study suggests that the approaches that designers consider tacit knowledge (experience-based knowledge) and how they connect their experience with current situations may be the key point to break through design fixation.

v) How do the findings answer the research questions?

In this section the knowledge items whose application is significantly influenced by students' metacognition abilities are discussed. Amongst them, K2, K6, K8, and K9, belong to domain-specific knowledge. They are applied from the beginning of the design process to the end and therefore directly lead to the performances of the final products, hence they are considered to be *product-oriented* knowledge in this process. K16 belongs to domain-general knowledge and leads the direction of the whole design process as it refers to strategic knowledge involving motivations, goals and plans, as well as focusing on the aim of solving design problems and generating the final designed product, hence it can be seen as a guideline of the design process and also regarded as *product-oriented*.

K17, K18, and K19 are specifically important as the magnitude of the metacognition impact on them is larger than on domain knowledge (both domain-specific and domain-general knowledge). They are experience-based knowledge, which is fundamental material for enabling reflective activities in the design process. Therefore, these results also suggest the importance of the role of reflective activities in this process, and K17, K18, and K19 are considered to play the role of *reflection-facilitating*.

These findings may answer the research question RQ1 (section 2.16, p. 134) that the kinds of product-oriented knowledge (K2, K6, K8, K9, and K16, see Table 22, p. 232) and reflection-facilitating knowledge (K17, K18, and K19, ibid) are applied under the impact of metacognition.

The findings also provide insight for the RQ2 (section 2.16, p. 134) that metacognition does not exert the same impact on each of the different kinds of knowledge, as the co-efficient values are all different. Moreover, by analysing these co-efficient values, this study claims that the impact of metacognition on the application of tacit knowledge does bring valuable insight into its relationship with design fixation, which is answering sub-question 4 in the RQ2 (section 2.16, p. 134). This shows that creative students tend to depend more on experience, which contradicts the findings of Ward (1995) and Doboli & Umbarkar (2014) but is consistent with Sio et al.'s (2015) perspective, as discussed.

5.2.2 Discussion of knowledge items in Category 2.

According to the OLR results in Table 21 (in section 4.6.1, p. 217), p values of the regression coefficients of MAI against on FKA1, FKA3, FKA5, FKA11, FKA13, and

FKA15 are all above 10% in both the UK and China, indicating that the MAI impacts on these knowledge applications are statistically insignificant. It means there is little difference between students with different levels of metacognition when applying these types of knowledge. The six items in category 2 are provided in Table 29.

Table 29. Knowledge item list – the frequency of their application is not related to metacognition

K1. Design history: knowledge relates to style perspectives.
K3. Design methods: knowledge relates to the application of design research and design case studies.
K5. Design representation: skills relate to 2D/3D drawing (effect drawing, three views).
K11. Media technologies.
K13. Psychology of consumer and user.
K15. An ill-structured problem-solving process: knowledge relates to analysing situations, defining problems, finding or generating solutions.

Amongst them, 5 items are from domain-specific knowledge, and 1 item is from domain-general knowledge. Although the results show that metacognition exerts little influence on the application of K1, K3, K5, K11, K13, and K15 in both the UK and China, we can still make valuable conclusions from how these kinds of knowledge are applied in the FYDP according to the mean score and standard deviation of their applied frequencies (Table 30, p. 251).

Table 30. Mean scores and standard deviations of FKAs in category 2

	Mean score	Std. Dev.	Mean score	Std. Dev.
	UK		China	
FKA1	4.3	1.45	4.2	1.35
FKA3	5.5	1.13	5.4	1.13
FKA5	5.8	1.26	5.7	1.44
FKA11	5.2	1.36	4.9	1.46
FKA13	5.0	1.18	4.7	1.37
FKA15	5.3	1.22	5.2	1.21

The mean scores of their application frequency are also shown in Figures 32 & 33, comparing the mean scores of the frequency of applying those knowledge items with significant results which have already been discussed in the previous section 5.7.1 (K2, K6, K8, K9, K16, K17, K18, and K19, see Table 22, p. 232).

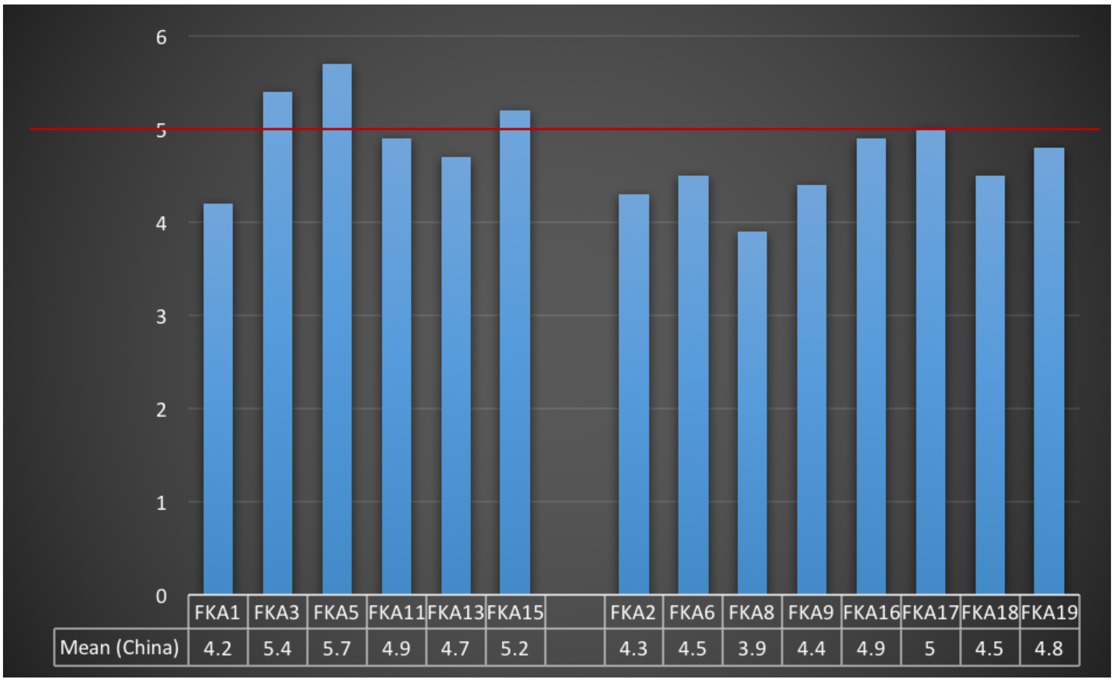


Figure 32. Comparing mean scores of knowledge application frequency in category 1. and category 2. (China)

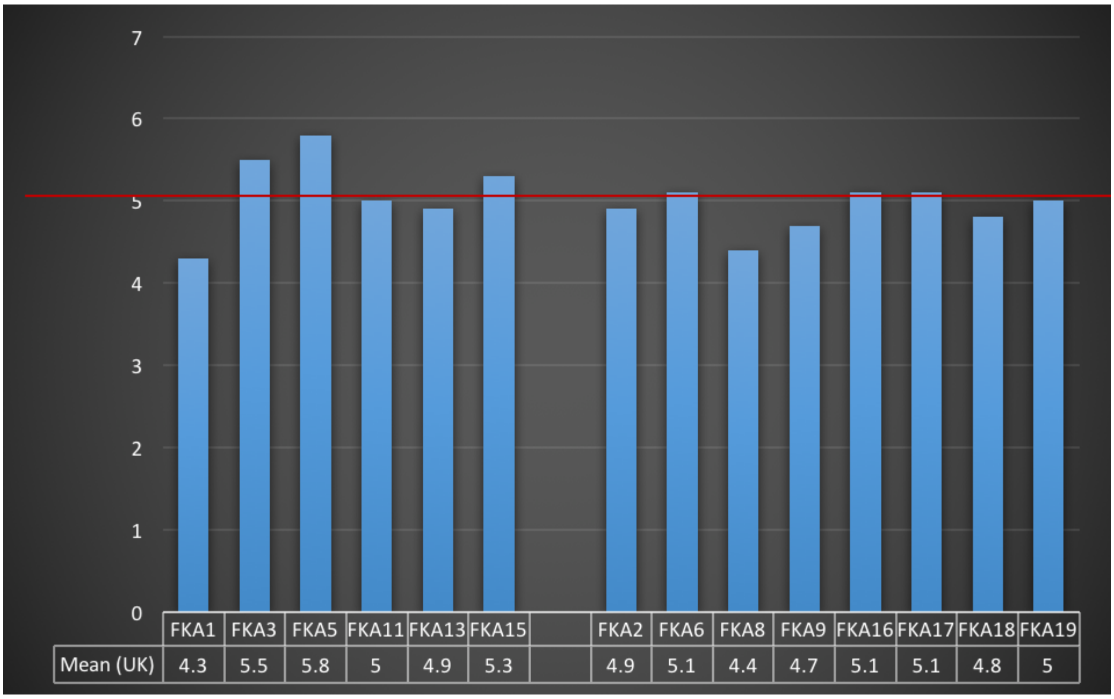


Figure 33. Comparing mean scores of knowledge application frequency in category 1. and category 2. (UK)

A cutoff point of score 5 (frequently used=5) is used here because it distinguishes the high frequency from the medium and low frequency of knowledge application. As shown in Figures 32 & 33, most of the knowledge items are applied normally in the FYDP (with the mean scores between 4 and 5) and a few knowledge items are applied frequently (i.e. K3, K5, and K15 with the mean scores above 5). It can be seen that the mean scores of the application of K3 'design methods' and K5 'design representation' from the domain-specific category, and K15 'An ill-structured problem-solving process' from the domain-general category, are much higher than that of K1, K11, and K13, with the score above 5 (7 in total for each question). This implies students would probably apply these kinds of knowledge at relatively high frequency regardless of their MAI levels. Therefore, the following paragraphs will firstly discuss the knowledge items of K3 and K5 as they represent particularly high mean scores amongst other domain-specific knowledge items, secondly, K15, as it is the only item from domain-general knowledge, and finally K1, K11, and K13. The main conceptual process of this section is shown in the flowchart (Figure 34):

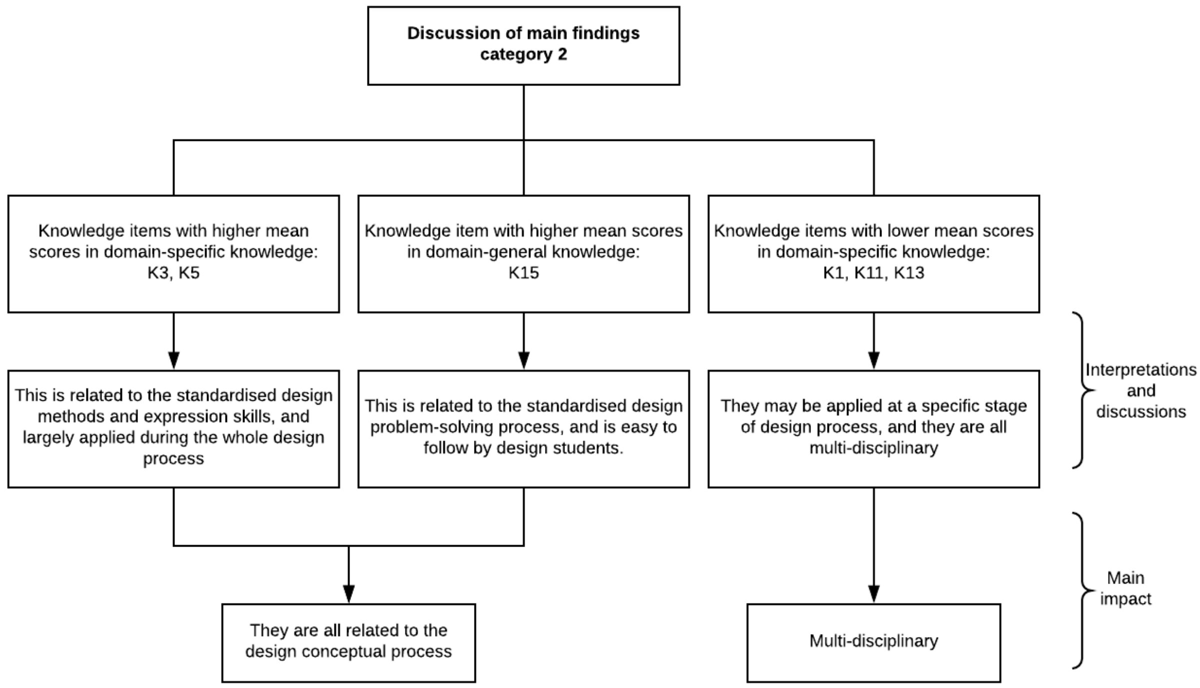


Figure 34. The conceptual process of discussion for category 2.

i) K3 and K5

K3: Design methods: knowledge relates to the application of design research and design case studies.

The means for undertaking a design project, from its initial stages to its conclusion, as well as the processes adopted during a design programme, are multifarious. Thus, the adoption of case studies to identify pertinent solutions, cognitive models and mind mapping, mood boards to formulate design ideas, alongside design research's potential limitations and issues, may all be covered, as suggested in section 2.14.3 (pp. 110–113). As a result, the application of a pertinent design approach has typically been seen to draw on a number of processes. Southee (2009) pointed to the nuanced formulation of solutions and individuals' meticulous observation and comprehension, in order to engage in the inclusive processes; Archer and Roberts (1979) noted the significance of discovery, elucidation and ongoing evaluation and re-evaluation, while Warr and O'Neill (2005) emphasised the need to explore. Thus, design procedure is associated with and shaped by the method of design.

Discussions of the results of this study

As pointed out in the literature review chapter (section 2.14.3, pp. 110–113), the new direction in design method research facilitates new models to explain the design process, which are being developed focusing on the conceptual processes (e.g. logic or rationale) between explicitly identified design processes. These include the FBS (Function, Behaviour, Structure) model explored by Gero (1990), and more recently, Chen, et al.'s (2015) development of a new conceptual design process model named the Need-Function-Principle-System (NFPS). Current literature generalises that there are different stages during a design process and identifies corresponding appropriate methods for each stage, although the individuals interviewed or surveyed vary from study to study. Based on the outcomes of the research on design methods and process, current design education mainly concentrates on delivering relevant explicit knowledge about the design process with associated methods, rather than the conceptual process which underpins the role of transfer between each design stage. This can be seen from the FYDP stages in China identified in the research problem, which conforms with the generalised design process from the design research.

This, therefore, would explain why design methods are applied with a high frequency by most participants, because they have been standardised as the basic principles of the design process. Once students begin to conduct a design project, they tend to use this kind of knowledge to a large degree. These methods (design research, case studies, brainstorming, mood boards, design scenarios, etc.) construct the framework for design conceptualization, and to some extent bring the necessary support to formulate the problem and solution space.

K5. Design representation: skills relate to 2D/3D drawing (effect drawing, three views).

As Goldschmidt (2004) described, the creation of design representations typically incorporates the entire design procedure, irrespective of whether creation, development and production of the ultimate design item has been undertaken. Golschmidt and Klevitsky (2004) noted that if design representation is absent, design will not be undertaken, because representation is considered to be the design objective by the majority of academics. Consequently, the QAA (2008) recommended that designers' education should incorporate such aspects, pointing out that visual competency has typically been stressed in the relevant fields, with interaction, appraisal, visualisation, development, hypothesising, assessment, recording and observation all underpinned by drawing skills. Therefore, as explored in section 2.14.3 (pp. 114–116), it is apparent that representation entails numerous techniques and methods in relation to design knowledge instruction. As a result, various facets of the designers' cognition may be conveyed in such representations, whether as intangible or tangible ideas. Concise notes may accompany the drawings, or rough sketches and outlines might be provided, as a means of conveying the design. Additionally, computer-aided or paper-based representations may be developed, either as two-dimensional or three-dimensional. Furthermore, the item being designed may be construed through forms that are freer, or through more established painting and illustrative styles, e.g. norms regarding perspective may be adopted. Ultimately, particular objectives will shape the dynamics of representation in the design context. Consequently, conceptual development in this context is seen to be afforded myriad options through design representation and its fluidity, with the designers' perspective also deemed important in shaping design representation proficiency, which is being stressed in design education.

Discussions of the results of this study

As reviewed in section 2.14.3 (pp. 114–116), design creativity's encouragement or attainment has been significantly associated with design representation by numerous academics. For example, rapid model-making and sketching were two design representation methods that were explored for their association with functionality and originality in Acuna and Sosa's (2011) research. They determined that conceptual development is a process that is simplified through the representative capabilities of designers, such as hand-drawn sketching and perspective. Moreover, the researchers discovered that a higher standard of solutions is achieved when model-making is pursued by designers, whereas designers facing equivalent contexts and restricted time who focused more on sketching typically produce responses with greater innovation. Consequently, Acuna and Sosa's major finding was that in terms of creativity, fulfilling functionality is more effective through representation via prototypes and accurate models, while creativity's innovation is fulfilled through sketching (ibid, p. 266). In contrast, other research has not found representation to be a variable affecting creativity, with general creativity, flexibility and fluency being the three significant variables from a set of nine, including representation-associated capability aptitude, awareness of context, satisfying design stipulations, innovation, functionality and elaboration (Demirkan & Afacan, 2012).

The results show that students apply design representation at a high frequency level regardless of their MAI scores (creative thinking). This is probably because design representation refers to technical skills, such as drawing and sketching, which are necessary and basic techniques required by any design student to express a design theme or conceptual process. For example, advanced design students who tend to apply strategic knowledge more and novice design students who tend to focus on detailed design are both using drawings/drafts to express their conceptual processes (Popovic, 2004).

When referring to the relationship between design representation and creativity, our results are consistent with Demirkan and Afacan's (2012) study. Although Acuna and Sosa's (2011) study show that design representations are related to aspects of creativity, namely, 'originality' and the 'functionality', this study indicated no differences between creative students and students who are not so creative in the frequency of using design representation. This contradiction in results implies that the creative factors' influence on knowledge application and the creative criteria that measure the final products may be different. The design presentation may help to stimulate creativity; however, from the creative thinking process viewpoint, it may not have the same effect.

To sum up, K5, a basic skill of expression within the design domain, may support designers' conceptual exploration and improve design thinking, hence influencing the whole design process. This study considered that the design methods (K3) and design representation (K5) are all important domain-specific knowledge in the FYDP and might be applied with a high frequency, and thus be considered to be essential knowledge in design. More specifically, design representation can be seen as the container that may represent how other kinds of knowledge are applied in the design process. It is believed that students with different creativity levels apply design methods and design representation to show their conceptual processes to a large degree, which is why the results show no difference between students with different metacognition levels (creativity ability) in the frequency of their application of this kind of knowledge. The differences between them would probably be the approaches, the stages, the materials, and the contents that they applied in their representations, which may determine whether they can develop relevant conceptual ideas and transfer them into an acceptable solution for the design project. This is believed to be an ability to combine with other knowledge in the design process (product-oriented knowledge

K2, K6, K8, K9, K16 and tacit knowledge K17, K18, K19, see Table 22 in section 5.2.1, p. 232).

ii) *K15. An ill-structured problem-solving process*

As Roozenburg and Eekels (1995) related, the ill-structured problem-solving procedure is a commonly accepted characterisation of the design process. The economic, political, cultural and social environment creates particular challenges which may be defined as posing an ill-structured problem (Simon, 1973). Furthermore, Kolko (2012) suggested that an inability to characterise or tackle ill-structured problems characterises them as ‘wicked problems’. As Christensen (2006) explained, an ill-structured problem can have a number of answers, and the lack of a distinct resolution strategy or answer is a characteristic of such problems, as section 2.14.3 (pp. 122–124) of the literature outlines. Consequently, the fundamental nature, means of characterisation and assessment of ill-structured problems is typically taught during design education to assist with their solution. Design procedure models typically show how a fundamental aspect of projects is the emergence of design challenges. Therefore, although ill-structured problems may be characterised variously, for example as restrictions (Lawson & Loke, 1997), tasks (Pahl & Beitz, 2013), consumer needs (Svensson, 1974; Andreasen & Hein, 1987; Hales, 1993), or requirements (Archer, 1979), the acknowledgement of such problems is a shared characteristic of design models. Based on the various characterisations, the process of design problem identification and determination, as well as solution development, definition and analysis, will vary, which makes design researchers believe that the ill-structured problem would be the key element to achieve design creativity.

Discussions on the results of this study

The description of 'ill-structured problem' indicate that K15 can be seen as knowledge referring to process-based, which is similar to K3 (Design method); specifically, K15 is more about the process of dealing with ill-structured problems. As a result, K15 is also emphasised by design educators and tutors in the teaching process. Generally speaking, the students are encouraged to practice relevant ill-structured problem-solving skills in order to improve design creativity, thus they are aware of the importance of this knowledge in the design process regardless of their MAI scores. It is implied that the 'ill-structured' or 'wicked problem' provides the preconditions which fertilise creative thinking, which reveals its internal correlation with creativity. That is not to say that creative students tend to apply relevant skills or knowledge more. The reason is similar to that of K3, which indicates that once the specific approaches or principles of this kind of knowledge have been elicited to be delivered via an educational approach, it will form a relatively fixed process for learners to apply.

Moreover, as explored in the literature review chapter (section 2.14.3, pp. 122–124), the interpretation of the correlation between design and creativity from the view of an 'ill-structured problem' stimulates a discussion on design problems, which focuses on whether design creativity will be achieved through problem definition or problem solution. The former viewpoint focuses on defining and analysing problems from new perspectives so that they can be solved; the latter, however, focuses on the belief that creativity should be achieved through seeking the creative solution of the problem, which concentrates on decision-making or selection. As Lawson (2006) has identified, there are two contrasting styles of operation, the problem-focused and the solution-focused.

Combining the results with previous conclusions from the discussion of K2, K6, K8, K9, and K16 (they are significantly influenced by metacognition, and considered to be product-oriented), this study would suggest that the creative students tend to focus on the solution-focused process. Therefore, the results show there is no difference in the knowledge application frequency between students with different metacognition levels.

General discussions on K3, K5, K15 compared with the results of knowledge in category 1. (eight items):

The results of K3, K5 and K15 show that the frequency of use of these three knowledge items has little to do with the students' MAI scores. As discussed in i)–ii) in this section (5.2.2, p. 253–261), these three knowledge items are either basic principles or skills and techniques which are inevitable and necessary during the design process, thus the design students will apply them frequently and regard them as a certain standard. More specifically, Goldschmidt (2004) indicated that designers would like to apply different kinds of representation at various stages of the design process; moreover, their representations are very flexible. Furthermore, Popovic (2004) analysed students' drawing drafts to identify how they were applying domain-specific knowledge and strategic knowledge, which suggests that the representation of design reflects how the other types of design knowledge are applied during the design process. Consistent with the literature, this study then proposed that the more creative students, defined by the MAI test, tend to take more initiatives to incorporate other kinds of knowledge (8 knowledge items in category 1) into their standard knowledge (K3, K5, K15) and apply them swiftly when appropriate in the whole process, unlike the less creative students, with lower MAI scores. Thus it is also supposed that the less creative students, due to their lack of smooth integration of different knowledge types, are more likely to come across more difficulties during the process.

To be more specific, design methods (K3) is gradually formulated based on designers' experiences of the design process (domain-specific), and the ill-structured problem-solving process (K15) is similarly formulated based on accumulated experiences. According to Christiaans (1992), K3 and K15 also belong to tacit knowledge, which is very difficult to deliver. For a long time, researchers have made a great effort to articulate these processes. With the development of cognitive research, researchers manage to investigate and theorise such experiences of processes via cognitive approaches (Cross, 2004). As a result, related models or methods have been formed and applied as guidance or principles for improving design practice. In other words, the knowledge regarding design methods and problem-solving has been theorised and standardised in order to make it easier for all the students to follow, whereas several design knowledge items discussed, e.g. K2, K6, K8, K9, K16, K17, K18, and K19 (see

Table 22, p. 232), are not standardised and the more creative students would be more capable of grasping this kind of knowledge than the less creative ones.

Furthermore, as a great deal of the literature focusing on the design conceptual process includes problem-solving and relevant methods (Dorst & Cross, 2001), K3 and K15 are thus believed to stress the conceptual process of design, and K5 plays the role of recording and expressing this conceptual process. Compared with K2, K6, K8, K9, and K16 discussed previously (section 5.2.1, pp. 233–242), which are more *product-oriented* and directly influence and facilitate the delivery of the final design product, K3, K5 and K15 are argued to be based on the *conceptual process* and are more *technique-based*.

It is then argued that the less creative students may follow the standardised procedure to master and apply K3 and K5 frequently as well as K15, but they may not be able to link the conceptual process to the delivery of design solutions. The more creative students, on the contrary, can link them well and present conceptual work in the design solutions and thus the final product. Dorst and Cross (2001) took a stand against Simon's statement of 'design is science'. They applied Schön's theory of 'reflective practice' to refute Simon's rational problem-solving for the reason that designers' experience and background plays an important role in the problem-solving process; they indicate that the problem-solving process in design could not simply be defined as a process moving from an 'ill-structured' to a 'well-structured' problem. The problem-solving process in design, from their view, is one of co-evolution, which means the design problem and solution are not fixed and keep changing during the design process as designers' reflective activities are involved. The co-evolution theory of design problems indicates that the designers' experience, in other words, tacit knowledge, plays a crucial role in the design process to achieve creativity. Therefore, the experience-based knowledge (K17, K18, and K19), as discussed in section 5.2.1 (pp. 242–248), may exert great impact on the conceptual processes of successfully transferring between each design stage via reflective activities to bring stimuli, which may reduce the design fixation that occurs in a relatively fixed design process.

Thus the students' abilities of transferring the design concept to specific design solutions or the final physical products are crucial for a design process. During the design process, students face the 'tolerance of uncertainty' (Osmond, Bull, & Tovey, 2009), a main obstacle to successful transfer. The creative students are better at accepting and tolerating these uncertainties by applying and integrating solution-oriented knowledge and tacit knowledge, so that they are able to successfully transfer their conceptual ideas into a final product, whereas those students who are less creative may not adapt to this situation, and proceed through the design process with less fluency. Therefore, these results may support the solution-focused view in a new way.

iii) K1, K11, and K13

K1. Design history: knowledge relates to style perspectives.

As the QAA (2008) have explained, as an aspect of art and design courses it is possible to also study art and design history. Its teaching may be amalgamated with different topics or taught as a stand-alone area: it may be comprehensively incorporated with major applied art and design elements or act as a single aspect of the syllabus (p. v). Ultimately, the ability of learners to undertake applied design research is the fundamental objective in studying art and design history. Indeed, a greater focus on applied knowledge may be required as part of design courses in China. It has been suggested that field-appropriate capabilities – for example aesthetic understanding – may be ably facilitated through instruction on art and design history and indeed architecture (HELPRC, 2015). As a result, in order for learners to develop and incorporate design history into their output and strengthen their knowledge, critical, theoretical and historical perspectives from the design field may be taught through an array of methods at design colleges.

K11. Media technologies

Social media is an emerging trend in contemporary life; while being characterised variously in everyday or intellectual discussion, it is what we are concerned with in relation to media technology knowledge. As Piller and Vossen (2011) observed, an array of online communication methods can be adopted by designers and design groups to disseminate knowledge of current significant data and innovative user-developed concepts in the digital context. Furthermore, HELPRC (2015) stressed how a product's demonstration and display can be facilitated through media technology.

K13. Psychology of consumer and user.

The design procedure at times necessitates psychological understanding. In this regard, product design courses and research now place greater emphasis on customer requirements, particularly the usefulness and practicality of goods. The aesthetic attraction of an item, in terms of consumers' contentment and enjoyment derived from it, is often fundamental to its performance within the market, which one may expect. Thus, consumers' emotional dynamics are typically emphasised in relation to product design's psychological knowledge. Considering such dynamics in greater depth, Khalid and Helander (2006) explained that the relationship of consumers' emotions with their conduct, the measurement of affective dynamics, and goods' sales prospects in relation to emotions are all pertinent knowledge. Furthermore, Jin et al. (2000) stressed that during the design procedure's preliminary phase, an important variable should be consumer psychology, given its effect on the entire goods development process. Moreover, such cultural dynamics as aspects of psychological knowledge are typically stressed, including to art and design students, who, it is suggested, should learn about such factors. Khalid and Helander (2004) noted that this is due to a product's appraisal by consumers as usually resting on fulfilment of their needs, which are shaped by culture.

Discussions on K1, K11, and K13

Based on current literature about these knowledge items and how they are taught in product design education, and according to the QAA report, Art and Design is a subject that embraces an overlapping and changing community of many disciplines. It is also related to many other subjects, including media and communications; the performing arts; the built environment; information technology and computing; engineering; business; and, notably, the history of art, architecture and design (QAA, 2016, p. 4). Therefore, this study argued that K1 'design history', K11 'media technology' and K13 'psychology' all reflect the multi-domain feature.

According to the mean scores of their application frequencies, they are applied less than K3 and K5 within the category of domain-specific knowledge. Therefore, it is believed that as cross-domain knowledge, they may exert an impact on specific stages in the whole design process, though they help to improve the process to some extent. Their applications are determined by certain situations, although the results of this study do not provide further evidence on the stages to which they may apply, or whether they are concentrated in a specific stage. Therefore, from this study, it is suggested that this kind of multi-domain knowledge might be appropriately applied at the right stage, which makes the design process more comprehensive and updated.

iv) How do the findings answer the research questions?

In this section those knowledge items whose applications are not influenced by metacognition statistically were discussed and it was demonstrated that there is no direct evidence of the relationship between metacognition and the degree of applying K1, K3, K5, K11, K13 and K15 (see Table 29, p. 250).

Amongst these items, K3 and K15 are process-related and technique-based. They are helping students to follow a pathway within a framework so as to improve the conceptual process of design. K3 refers to the methods that are used in the correspondent design stage, and K15 focuses on relevant knowledge about the ill-structured problem-solving process. Students are frequently applying both knowledge items during the design process, indicating their importance. Synthesising these results with the findings from K2, K6, K8, K9, K17, K18, and K19 (see Table 22, p. 232) as discussed in the previous section 5.2.1 (pp. 233–248), it was identified that the contrasts between creative and not so creative students are due to the different emphasis in the design process. The creative students may tend to focus on a solution-oriented approach as they apply knowledge items that are more product-oriented, whereas those less creative students may tend to be more problem-oriented. The knowledge item K5 is particularly applied by design students with an extremely high frequency. It is considered to be a specific tool to express designers' conceptual processes in the design domain.

In this study, it was identified that K3, K5, and K15 (see Table 29, p. 250) are more inclusive knowledge that has to be used alongside other knowledge. They are related to conceptual processes and thus construct a platform and play as a 'threshold' when students are conducting a design project. The knowledge items of K1, K11, and K13 (ibid) are discussed as well, and they are relevant contributions from other disciplines that are essential, which also supports the statement that design is a subject involving multiple disciplines. Therefore, they represent the aspect of cross-discipline in a design project.

The findings in this section would answer sub-question1 in the RQ1 (section 2.16, p. 134) that not every specific knowledge in the category of domain-specific/domain-general/tacit knowledge is applied under the impact of metacognition. Specifically, it supports a new perspective that design creativity may be more 'solution-focused' (based on the discussions of K2, K6, K8, K9, and K16, Table 22, p. 232 and the discussions of K3, K5, and K15, Table 29, p. 250), which sheds light on sub-question 2 in RQ1 (section 2.16, p. 134).

5.2.3 Discussion of knowledge items in Category 3.

Apart from the knowledge items discussed from Table 22 (p. 232), it can be seen that the regression coefficients of MAI against a few items – FKA4, FKA7, FKA10, FKA12, FKA14 – are different in the UK and China. These differences are probably due to the cultural differences between the two countries, which are considered the main factor in explaining the phenomenon in many areas (Brislin, 1993). Therefore, in the following sections these differences from the cross-cultural viewpoint will be discussed, and the different understandings of creativity in particular.

For items FKA4, FKA10, and FKA12, p values indicate a significant relationship between the MAI and these items in China, but an insignificant relationship in the UK. China's participants with a higher level of metacognition tend to apply K4, K10, and

K12 more, whereas it is not the same situation with these kinds of knowledge application in the UK. For items FKA7 and FKA14, p values indicate an insignificant relationship in China, whereas there is a significant relationship in the UK. The UK's participants with a higher level of metacognition tend to apply K7 and K14 more, whereas it is different for these kinds of knowledge application in China. The five knowledge items are represented in Table 31:

Table 31. Knowledge item list – MAI coefficients are showing different results between the UK data and China data

Regression coefficients for MAI against FKAs (knowledge items listed below) are showing statistically significant in China, whereas insignificant in the UK: K4. Aesthetics: knowledge relates to colour, structure and form. K10. Skill to operate relevant machines K12. Knowledge of organisation and marketing Regression coefficients for MAI against FKAs (knowledge items listed below) are showing statistically significant the UK, whereas insignificant in China: K7. Client needs: knowledge relates to analysis of the design brief K14. Information processing: information searching and analysis.

Moreover, the main conceptual process of this section is shown in the flowchart (Figure 35, p. 271):

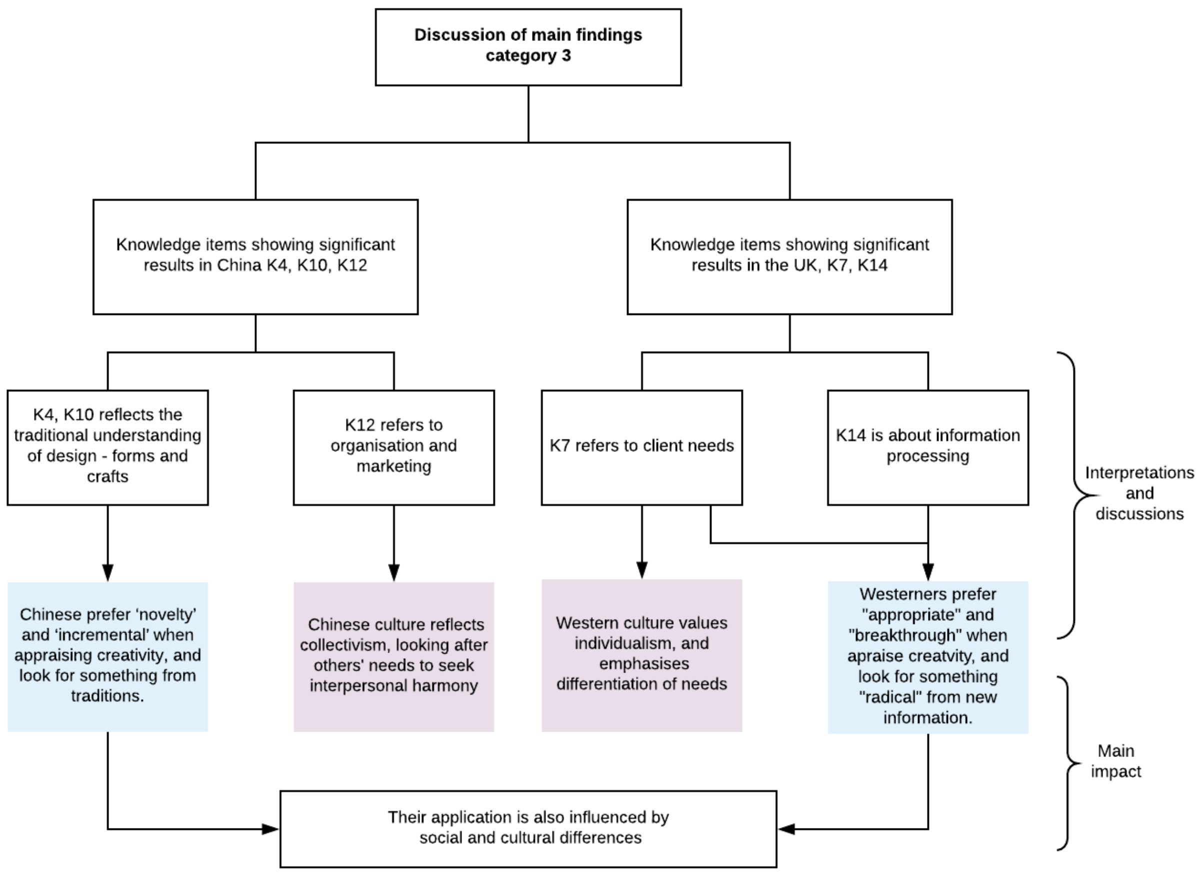


Figure 35. The conceptual process of discussion for category 3

i) K4 and K10 (Table 32)

Table 32. Regression coefficients for MAI in estimating FKA4 & FKA10

	Coef.		**P value**	
	China	UK	China	UK
MAI/FKA4	.0418545	.0048117	0.034*	0.853
MAI/FKA10	.0465495	-.0098781	0.022*	0.691

- *Notes: K4. Aesthetics: knowledge relates to colour, structure and form; K10. Skill to operate relevant machines*

The p values indicate that the impact of the MAI levels on the application of K4 and K10 are statistically significant in China ($p<0.1$), which implies that the MAI levels of the Chinese respondents significantly influence their applications of K4 and K10 in their FYDPs. The positive coefficients on both FKA4 and FKA10 show that if the Chinese respondents increased their MAI levels by one score, their probability of applying K4 and K10 at a higher frequency would increase by 0.04 (K4) and 0.05 (K10). In other words, the respondents with higher MAI levels are more likely to use K4 and K10 more frequently than those with lower MAI levels, whereas the results in the UK indicate that there is no such relationship when the UK respondents are applying K4 and K10.

K4. Knowledge of aesthetics

Brunel and Kumar (2007) emphasised that aesthetics have a distinctive importance in product design. The design field has always given great consideration to aesthetics, as Brunel and Kumar (2007) asserted that art is underpinned by aesthetics, while life crucially rests on it in a wider sense. Daily life is influenced and altered to a considerable extent by products. Therefore, as Veryzer (1995) suggested, products should provide pleasure and significance to consumers, which is possible through having design characteristics where aesthetics have been stressed, meaning that it is not just nature and art where aesthetics are significant. Overall, ensuring that the artistic, affective, forms, colour and structural variables of an item are thoroughly assessed by learners in relation to aesthetics and its associated dynamics should be one of the emphases of practical design instruction.

K10. Skill to operate relevant machines

Product creation is directly affected by such capabilities and understanding as K10. As Pevsner (2005) explained, the traditional design perspective has stressed the understanding of contemporary design's evolution as part of product design courses' inculcation of machine operation capabilities. Thus, Cabannes and Ross (2015) pointed to the importance in design history of the rejuvenation of traditional handicrafts, advocation of more basic living and strengthening of everyday items' design features that occurred with the Arts and Crafts Movement's establishment in 1880 by William Morris and John Ruskin, with its ideas rapidly disseminating across Japan, Europe and North America (p. 206). Moreover, Triggs (2014) noted that expert craftsmen who were masters in their trade, rather than ordinary teachers, provided instruction at the Bauhaus Design School – named the Weimar/Dessau between 1919 and 1933 – in the first decades of the 1900s. On this basis, the syllabi of contemporary design colleges continues to incorporate practice training in crafts.

Discussion of K4 and K10

According to the literature (section 2.14.3, p. 113; pp. 118–119), the knowledge of K4 and K10 largely reflect the 'Art and Craft' attributes of design, which are usually deemed to inspire novelty and reflect traditional understandings of design (the forms and the crafts of artifice) (Kuma, 2008). The history of modern design can be traced back to the late 18th Century since the first Industrial Revolution exploded in the UK (Margolin, 1989). It largely stemmed from the modern industry of mechanical manifestation to satisfy the requirement of qualified machines, at the same time it absorbed elements from arts and crafts. China's design education was imported from Japan and rooted in the Bauhaus system (Xi, 2000), which paid much attention to the form and decorative aspects of design (Kuma, 2008). Accordingly, China's design is still focused on the forms and crafts today, which play crucial roles in achieving design creativity (Wu, 2001), whereas Western culture (the UK) pays more attention to social topics and the living environment and puts design into other, broader discourses (Johnson, Wilson, Markopoulos, & Pycock, 1993). This would probably be further explained by the differences between the Western and Eastern culture and how they perceive creativity.

As the socio-cultural issue of creativity has already been discussed in section 2.5 (pp. 39–46), Paletz and Peng's (2008) study investigated evaluations of Chinese students and other students from Western countries (e.g. the U.S.) of the products from the view of 'novelty' and 'appropriateness', and they found that the Chinese were largely influenced by novelty rather than appropriateness. In contrast, the Western students were more influenced by appropriateness and less by novelty. This finding is consistent with Lan and Kaufman's (2012) point of view that what the Chinese emphasise as creativity is 'novelty'. Moreover, Yue (2004) stated that to achieve creativity, the Chinese pay the most attention to traditional methods and skills, so that they stress creativity from social aspects, and tend to consider those products satisfying traditions, rituals and social norms as creative ones (Ng, 2001; Sternberg, 1985; Westwood & Low, 2003). As a result, Chinese designers would prefer to accept 'incremental' creativity (Gilson & Madjar, 2011). However, the situation is different for Western countries. They emphasise 'appropriateness' and 'groundbreaking' more when evaluating a creative product (Paletz & Peng, 2008), and therefore they may respond to 'radical' creativity. This understanding of creativity derived from socio-culture would probably influence design students in the two countries.

As a result, China's creative students tend to apply K4 and K10 with a higher frequency, as these two items help to achieve relevant abilities or outcomes that conform to social understanding and evaluation in design and creativity in Chinese culture, whereas there is no such tendency in the UK, since these two items contribute more to 'incremental' creativity than 'radical' creativity.

The viewpoint that Westerners place more emphasis on 'appropriateness' and 'groundbreaking' in particular may also explain why creative students in the UK, defined by the MAI test, tend more to apply the knowledge of 'client needs' (K7) and 'information processing' (K14), which are discussed in the following paragraphs.

ii) K7 and K14 (Table 33)

Table 33. Regression coefficients for MAI in estimating FKA7 & FKA14

	Coef.		**P value**	
	China	UK	China	UK
MAI/FKA7	.0135135	.0790986	0.474	0.002*
MAI/FKA14	-.0049528	.1101319	0.803	0.000*

- *Notes: K7. Client needs: knowledge relates to analysis of the design brief; K14. Information processing: information searching and analysis.*

As evidenced in Table 33, the p values indicate that the MAI level's impact on the application of K7 and K14 is statistically significant in the UK ($p<0.1$). This implies that MAI levels of UK respondents significantly influence the application of K7 and K14 in their FYDPs. The coefficient values show that the MAI level's impact on FKA7 and FKA14 is positive, which indicates that when the UK's respondents increase one score in their MAI levels, it is more likely that they will apply K7 and K14 more frequently, and the probability will increase by 0.08 and 0.11 respectively. Therefore, it is likely that respondents with higher MAI levels will use K7 and K14 at a higher frequency than those with lower MAI levels. The results from China indicate that there is little difference between the students with different levels of metacognition when they apply K7 and K14.

K7: Client needs

A design initiative will always have a design brief, with the assessment that it contains ideally providing information regarding customer requirements, as section 2.14.3 (p. 117) explained. A firm may have a design group who communicates with the customer, or a sole designer may undertake an engagement in order to produce the design brief. On this basis, appropriate objectives will be established and communicated while the customer and designers' bonds and interaction will be established. Phillips (2004) also noted that all pertinent data that may facilitate or undermine a project, such as budget, schedule and item requirements, should be incorporated within the design project brief. Consequently, as Ryd (2004) emphasised, at the preliminary design phase the identification of design challenges should be facilitated through the design brief, as essential and varied knowledge should be included within it. Nevertheless, Phillips (2004) stressed that the brief is also crucial throughout the design procedure, enabling changes to be made in terms of staying within budget and on schedule, and to scrutinise and appraise the ultimate product; thus it should not be consigned to preliminary stages. In turn, as the design project develops, alterations and amendments may be made to the design brief itself, which should be considered a fluid structure for guiding the design process.

K14: Information processing

During the design procedure, it is essential to become proficient in the analysis of information, as the literature review emphasised (section 2.14.3, p. 121). Through contrasting original information with their established understanding, shortcomings in understanding may be overcome by designers when faced with difficulties and ambiguity if they are able to identify relevant knowledge through effective techniques. As Love and Roper (2009) emphasised, ambiguity will be diminished if original design understanding can be gained through a rigorous research and assessment procedure, which Cousins et al. (2011) explained can then enable business and designers' requirements to be fulfilled.

On this basis, Cousins et al. (2011) noted that both knowledge acquisition and evaluation are associated with information analysis. Lynn et al. (1999) demonstrated how the categorisation of original information, alongside its gathering, recording and appraisal, make up the acquisition process. The manner in which the design procedure incorporates data-acquisition processes and adoption of data sources was explored by Aurisicchio et al. (2013). They found that product and engineering designers particularly benefit from information analysis: specifically, design's preliminary phases are crucially affected by it. Consequently, the entire design programme may be strengthened if ambiguous and challenging circumstances are tackled through responses that draw on obtaining and analysing data with strong pertinence to the context.

Discussion of K7 and K14

To sum up, applying the knowledge of K7 and K14 focuses on the rationale underlying every step/activity taken during the design process and has the aim to serve the clients' needs. The outcomes of using these knowledge items would probably help to achieve 'appropriateness' rather than 'novelty'. Furthermore, as stated by Wonder and Blake (1992), the differences between East and West in terms of creativity are initially from two types of thinking, namely, the intuitive and logical. Their study indicated that Eastern thought, an essential driving force of 'novelty', is considered to be more 'intuitive' i.e., more subjective, experiential, and non-systematic; oppositely, Western thought, a baseline of 'appropriateness', is regarded as more 'logical' i.e., more unemotional, structured, and individualistic (see section 2.5, pp. 39–46). Therefore, Westerners appreciate that everything fits together following logic or according to principles, driven by their cultural emphasis on logic and appropriateness. In contrast, Easterners tend to re-arrange the pattern depending on the existing 'database' culture, rather than push the creative process through integrating new information (Wonder & Blake, 1992). This coincides with the Chinese cultural emphasis on 'intuitiveness' which relies mostly on existing experience. This idea is also supported by other studies (e.g. Rudowicz, 2003).

Therefore, the UK's creative students tend to apply K7 and K14 with a higher frequency, as they play an important role in achieving the 'appropriateness' of the outcomes emphasised in the Western countries when evaluating creativity, whereas there is no such tendency in the application of K7 and K14 among design students with different levels of creativity in China.

iii) K12 Knowledge of organisation and marketing (Table 34)

Table 34. Regression coefficients for MAI in estimating FKA12

	Coef.		**P value**	
	China	UK	China	UK
MAI/FKA12	.0620578	.0423462	0.003*	0.103

The p values also indicate that the MAI level's impact on the application of K12 is statistically significant in China (at the 1% significance level), which implies that the MAI levels of the respondents in China significantly influence the application of K12 in their FYDPs. The coefficient of the MAI against FKA12 is positive as well, showing that the respondents with higher MAI levels are more likely to use K12 at a higher frequency than those with lower MAI levels. In other words, when there is an increase of one score in their MAI level, Chinese respondents' probability of applying K12 at a higher frequency would increase by 0.04. The results of the UK indicate that there is little difference between students with different levels of metacognition when applying K12.

The knowledge of organisation and marketing (K12) generally includes knowledge of the structure, culture and behaviours of firms, and more specifically, the relevant information and methods about market research e.g. market surveys, interviews, and focus groups. Accordingly, both K12 and K7 refer to design management which includes the integration of design and business (Best, 2006) and new requests for designers (Barnett, 2000). In fact, the emphasis of their application in design education is reflecting the blueprint of the design industry in the future. However, the results of the two knowledge items (K12 and K7) are different in the two countries. This may also be explained by the cross-cultural perspective. Due to the difference in the social-cultural backgrounds in the UK and China, the social values cherished or promoted in these two countries are different as well, which will also affect design education. For example, the UK and China may have different standards or systems to determine what is desirable or undesirable, and this may lead to bias when people are asked to criticise creative products with a certain internal standard (Erez & Nouri, 2010; Lan & Kaufman, 2012).

Discussion of K12 and K7

In China's design education more attention is paid to delivering the course 'organisation and marketing' during these years, as the concepts of 'designing for all' and 'design industry' have been gradually formulated and shown (Pan, 2007). Furthermore, it may also be related to the understanding of creativity within the Chinese background as the Chinese are more likely to perceive creativity from a socially-related perspective. As the socio-cultural issue of creativity has been discussed in section 2.5 (pp. 39–46), Li (2007) interpreted that creative goods include those products or services which represent social and cultural meanings as well as symbolic values. Creative products are mainly generated within the conditions of intellectual property rights, which have been created in the light of the demands of individuals' and society's creativity (Li, 2007). Chinese culture reflects collectivism, which indicates that all people are socially interrelated (Lau, Hui, & Ng, 2004), and therefore, as Hsieh and Scammon (1993) stated, people in such cultures tend to look after others' needs and preserve their feelings to achieve interpersonal harmony. Moreover, in Aaker & Schmitt's (2001) study, Chinese participants show more favour towards assimilation needs. In comparison, Westerners emphasise the diversity of needs, and the reason would probably be, as Zha, Walczyk, Griffith, Tobacyk and Walczyk (2006) explained, that individualism has been commonly recognised as a defining characteristic of Western culture, thus in Western countries, independence is highly appreciated, and an individual is perceived as a separate entity. It is more likely that the Chinese will aim for a plan to satisfy and try to meet the general demands of society overall, but Westerners pay more attention to particular customers, and customise their service to the specific needs of the targeted customers. That is why Chinese designers focus more on the mass market, whereas Westerners pay more attention to their clients.

This socially-related perspective is also reflected in the emphasis of design education in particular, which may further explain why creative students in the UK tend to apply K7 (client needs) more than K12 (organisation and marketing). It is observed that design schools in the UK are placing more emphasis on this, indicated by the relationships established with companies and brands. For example, the Bachelor's

Product Design programme in Central Saint Martin's College extends product design students' skills by locating them in professional contexts in their second year; this is done through external design briefs provided by industry. Similarly, UWE Bristol provides product design students with a range of studio projects from real companies including Brabantia, Dremel, Bloodhound and Piper Moto. The Design School at Loughborough University provides final-year product design students with a module which covers two live design projects with briefs set by leading companies. The aim in all these modules is to mimic the activities of design consultancy, where the initial responses to client briefs need to be generated rapidly, so that they are able to experience such a process in an educational context. The situation in China's universities is not the same. Students are encouraged to focus on the mass market to develop potential needs. They have less opportunities to touch such 'real projects' from companies within the context of education. Instead, they will go to the company to experience a real working environment.

Therefore, the different emphasis of design education between China and the UK may explain why creative students in the UK tend to apply K7 more, which indicates that the design brief plays a significant role in helping students to form a design problem during the design process, whereas in China there is no difference because either creative or non-creative students may grasp a basic knowledge of a design brief, rather than understanding it deeply enough to apply it. This is because of the different needs and directions of design industries in the two countries, which influences the emphasis and related approaches in education.

iv) How do the findings answer the research questions?

To sum up, the Chinese evaluate creativity from the viewpoint of 'novelty'; moreover, they perceive creativity as an 'intuitive' and 'incremental' process during which all social elements continually accumulate (e.g. civilisation). These views represented in the design domain lead the Chinese to focus on the traditional understanding of design and place more emphasis on 'aesthetics' and 'craft'. Alternatively, Westerners evaluate creativity from the view of 'appropriateness', so they pay more attention to the rationales of the process and reasonable activities, and stress the importance of new 'information seeking'. Therefore, they tend to accept a more 'radical' perspective on creativity. Furthermore, the differences of regime (collectivism vs. individualism) and economic system (capitalism vs. socialism) lead to differences between design students in the UK and China in the application of relevant knowledge in design management. Where UK creative students prefer to apply more knowledge of the 'client's needs', Chinese creative students prefer to apply more knowledge of 'organisation and mass marketing'. Therefore, the students with relatively higher scores in the MAI in both countries tend to apply knowledge in different ways, influenced by their respective understandings of the market and the current trend of technology, due to social and cultural differences. These results further support the socio-cultural viewpoint in the study of creativity from a new perspective.

The findings in category 3 indicate that creative students are more sensitive to relevant knowledge relating to social trends, and they tend to apply relevant knowledge correspondingly. In China, creative design students tend to apply knowledge of K4, K10 and K12, while in the UK, creative design students tend to apply knowledge of K7 and K14. Though there is difference, they share a common ground in that the knowledge application conforms to the social values and cultures in each country.

The findings in this section would answer sub-question 5 in the RQ2 (section 2.16, p. 134) that metacognition does not have the same impact on the different kinds of knowledge in cultural contexts of China and the UK.

5.2.4 Summary

In the list of domain-specific knowledge, there are four knowledge items (K2, K6, K8, and K9, see Table 4, p. 108) that are shown to be influenced by metacognition. These items are believed to be related to the final products. In other words, the application of these kinds of knowledge will be reflected directly in the final products. This finding supports the perspective that design is a solution or product-directed process. There may be particular connections between applications of these product-oriented knowledge items and creativity, because the results indicate that creative students tend to apply product-oriented knowledge with a higher frequency: the more creative, the higher the frequency. Besides, there are two knowledge items (K3 and K5, see Table 4, p. 108) that reflect the students' conceptual process during the design process. This study did not find any evidence regarding the relationship between their application frequency and creativity. But from the mean value of their application frequency, these knowledge items (K3 and K5) are considered to be very basic and significant in design projects. There are a few knowledge items (K1, K11, and K13, ibid) that represent the feature of being multi-domain by including history, media, and psychology. This study indicated their applications are not influenced by metacognition. In addition, there are five kinds of knowledge (K4, K7, K10, K12, and K14, ibid) where the frequency of applications is different in different cultures.

In this study, the items within the domain of general knowledge are related to process-relevant knowledge. The results indicate that the physical process of K16 (such as concrete activities directed by the plans, motivation and goals of a project, see Table 4, p. 108) that lead to a designed product is influenced by metacognition, whereas the conceptual process (K15, ibid) is not affected by it. K16 as related to physical processes is thus considered to be product-oriented as well. This study suggests that although those kinds of product-oriented knowledge are important, the students with relatively lower creative abilities have little idea about when and where and to what extent to use these kinds of knowledge. However, the conceptual process can be applied any time and at any moment, even when there is no clear direction or plan. In addition, the application of K14 (ibid) represents the difference in cultures.

This study involved another type of knowledge – tacit knowledge (including K17, K18, and K19, see Table 4, p. 108), which is not often mentioned. It is first defined by Polanyi (1966; 2009), in his book *Tacit Dimension*. The main reason is that this type of knowledge cannot be described in detail as people are not always aware of it when it is being acquired and applied. Moreover, it cannot be delivered directly in education, but is usually learned by activities and training following the current and relevant design process. This study embraced several kinds of experiences that comprise tacit knowledge involved in the FYDP process, although they were categorised roughly as there are very limited studies on this topic. They mainly refer to the design precedents, the experiences of design projects, and the living experiences, which embrace both professional and personal aspects. The results show that metacognition influences the application of this type of knowledge.

5.3 Further analysis (checking the results with sub-samples by gender, institutions and projects)

In this section, the overall sample was divided into sub-samples by gender, institutions and projects. Each sub-sample was further divided into two sub-groups labelled as high MAI and low MAI. Those who have above-mean MAI scores were categorised into the high MAI group and those with below-mean MAI scores were in the low MAI group. For example, for the sub-samples of females and males, there were four sub-groups, high MAI (female), low MAI (female), high MAI (male) and low MAI (male) respectively. It is interesting to see whether female participants with high MAI scores apply knowledge differently to those male participants with high MAI scores. As mentioned in section 3.5.1, (part ii Inferential statistics, pp. 184–185), if a researcher needs to examine the difference between samples in two or more groups, the T-test, F-test, likelihood ratio test, and Chi-square can be employed (Preacher, 2001). To select an appropriate tool, the scale of measurement (see section 3.5.1, part iii, Scales of measurement, pp. 185–186) is the important aspect that needs to be considered.

Accordingly, Chi-square was recommended to deal with categorical data (Preacher, 2001). Therefore, as the variables were intended to be divided into groups by several categories, a Chi-square test was conducted to compare differences between groups (divided according to gender, institutes, and project) in knowledge application.

5.3.1 Chi-square test procedure

i) The Chi-square equation

The equation of Chi-square is shown as below:

$$X^2 = \sum \frac{(o-e)^2}{e} \qquad \text{Equ. 5}$$

Where:

- o= the observed frequencies
- e= the expected frequencies
- $\sum$= the 'sum of'

To run the Chi-square test, the divided groups are ordered into matrices shown as the sample (Table 35):

Table 35. Sample of Chi-square variables scatter

	Group A (observed frequencies)	**Group B (observed frequencies)**	**Total**
Category 1 (observed frequencies)	10	20	30
Category 2 (observed frequencies)	10	20	30
Total	20	40	60

Then Excel was applied to calculate the 'Chi' value and the degree of freedom[18] (df), where:

- df = (# rows - 1) * (# columns - 1)
- In Table 35 sample, the value of degree of freedom is (2 - 1) * (2 - 1) = 1

The result is abstained:

- Assorted Observed and Expected values
- Chi Square = 0.000 (very close to 0)
- Degrees of freedom = 1

ii) Interpreting the results of the Chi-square test

A critical values table was then used to obtain the associated p value according to the value of the Chi Square and df, and then to work out the significance of the result. The p value in this sample can be checked in the area highlighted. Its associated p value would be 0.995 (see Table 36, p. 289). The significant level of the Chi-square test has also been set to 10% (threshold of p=0.1)

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[18] For further information of degree of freedom, see https://doi.org/10.1080/01621459.1963.10500879

Table 36. Critical values table for Chi-square test

	P										
DF	**0.995**	**0.975**	**0.20**	**0.10**	**0.05**	**0.025**	**0.02**	**0.01**	**0.005**	**0.002**	**0.001**
1	0.0000393	0.000982	1.642	2.706	3.841	5.024	5.412	6.635	7.879	9.550	10.828
2	0.0100	0.0506	3.219	4.605	5.991	7.378	7.824	9.210	10.597	12.429	13.816
…											
1000	888.564	914.257	1037.431	1057.724	1074.679	1089.531	1093.977	1106.969	1118.948	1133.579	1143.917

- *Notes: this resource is from https://www.medcalc.org/manual/chi-square-table.php*

iii) Setting up null hypotheses

The aims of conducting the Chi-square test were threefold: 1) to see whether there is a difference in knowledge items applied by males with high level MAI and females with high level MAI; 2) to see whether there is a difference in knowledge items applied by students with high level MAI between southern institutions and northern institutions; 3) to see whether there is a difference in knowledge items applied by participants with a high level MAI score who were conducting different projects. The null hypotheses are set up as below followed by Figure 36 (p. 290):

To check gender difference:

$H_0 1$: there is no difference in FKA (K1–K19) between male students with high level MAI and female students high level MAI in the UK.

$H_0 2$: there is no difference in FKA (K1–K19) between male students with high level MAI and female students high level MAI in China.

To check geography difference:

$H_0 3$: there is no difference in FKA (K1–K19) between students with high level MAI from institutions in north UK and south UK.

$H_0 4$: there is no difference in FKA (K1–K19) between students with high level MAI from institutions in north China and south China.

To check project difference:

$H_0 5$: there is no difference in FKA (K1–K19) between students with high level MAI when they are conducting different projects in the UK.

$H_0 6$: there is no difference in FKA (K1–K19) between students with high level MAI when they are conducting different projects in China.

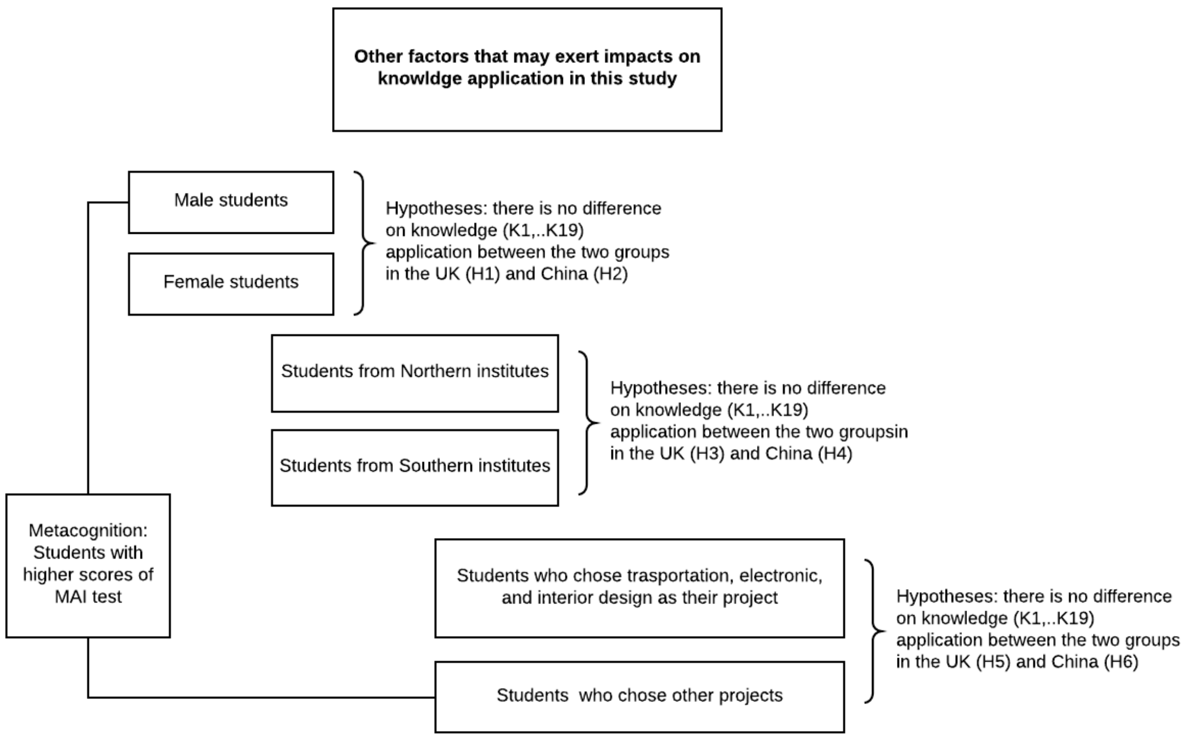

Figure 36. Null hypotheses of Chi-square test

5.3.2 Checking the influence of gender

To check the influence of gender, the focus was on two sub-groups in each country, the male students with high MAI levels (MH) and the female students with high MAI levels (FH), i.e. the students who attained higher scores than the mean score of the overall sample would be grouped into the higher level group. At the same time, each sub-group was further divided into two categories by scales in each knowledge application (from K1 to K19), the H category of relatively frequently used (from scale 5 to 7: 'frequently used' to 'always used') and the L category of relatively not frequently used (from scale 1 to 4: 'never used' to 'occasionally used'). In total, for example, there will be 2*2 matrix for each knowledge application, with two columns (MH and FH) and two rows (K_nH and K_nL, n=(1,19)). Figure groups 37 & 38 (pp. 292–297) provide the matrix for each knowledge application in each country and plot them accordingly in the bar charts (a series of figures in Figure 37 refer to Chinese results; a series of figures in Figure 38 refer to the UK results). Then the Chi-square test was conducted to examine whether the difference between FH and MH in applying each knowledge item is statistically significant or not.

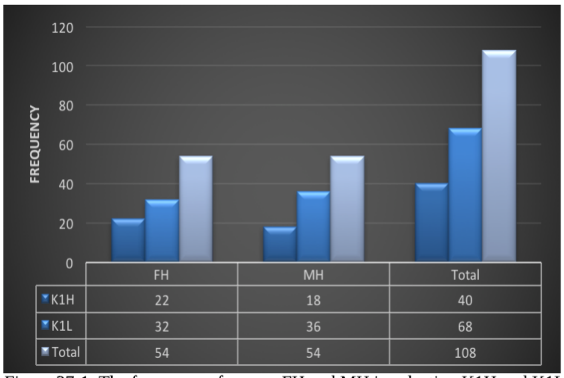

Figure 37-1. The frequency of groups FH and MH in selecting K1H and K1L

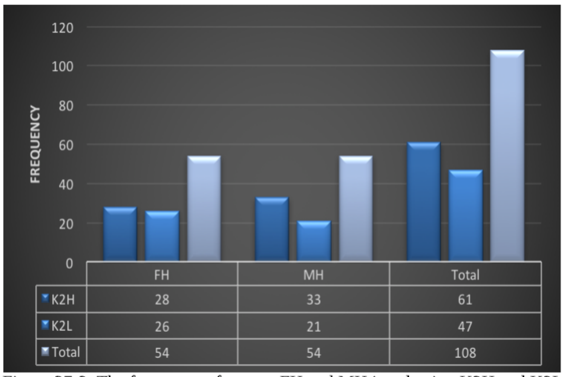

Figure 37-2. The frequency of groups FH and MH in selecting K2H and K2L

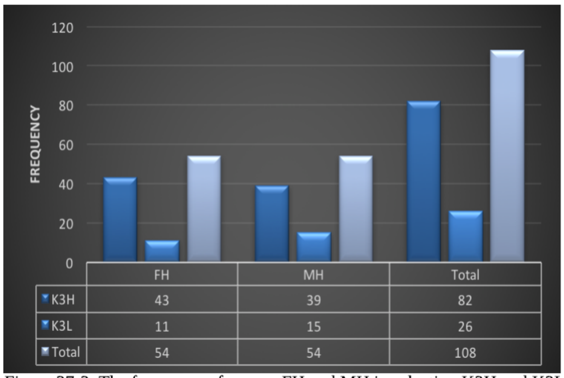

Figure 37-3. The frequency of groups FH and MH in selecting K3H and K3L

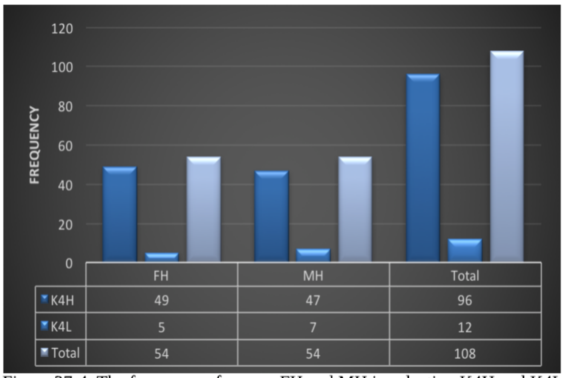

Figure 37-4. The frequency of groups FH and MH in selecting K4H and K4L

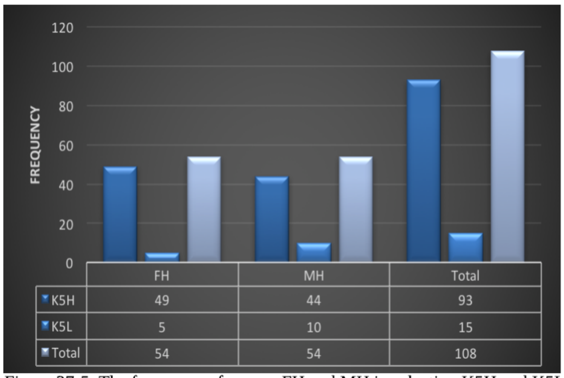

Figure 37-5. The frequency of groups FH and MH in selecting K5H and K5L

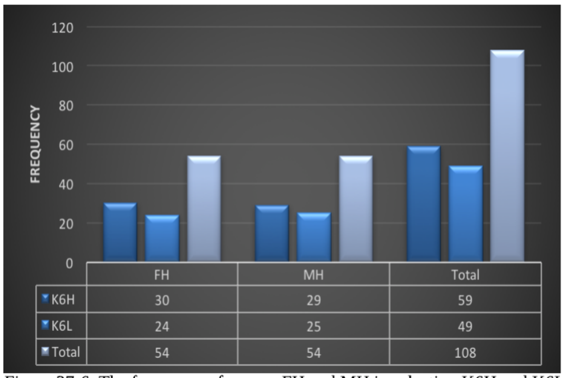

Figure 37-6. The frequency of groups FH and MH in selecting K6H and K6L

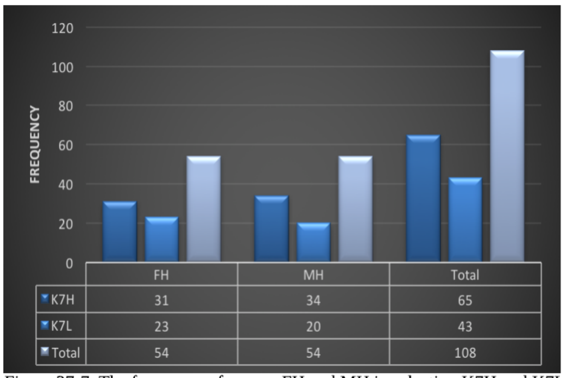

Figure 37-7. The frequency of groups FH and MH in selecting K7H and K7L

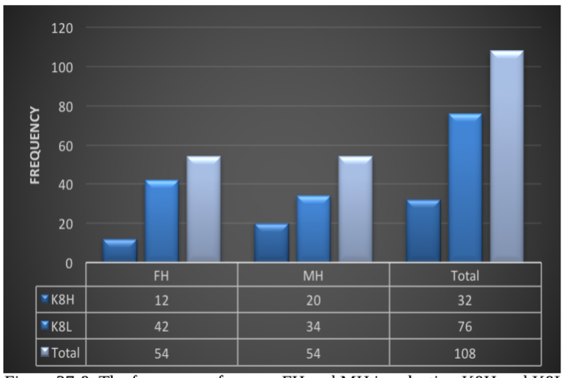

Figure 37-8. The frequency of groups FH and MH in selecting K8H and K8L

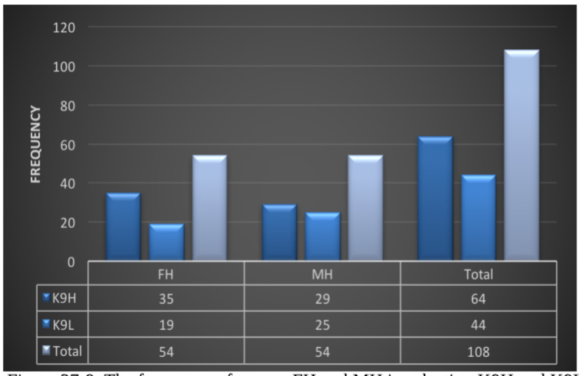

Figure 37-9. The frequency of groups FH and MH in selecting K9H and K9L

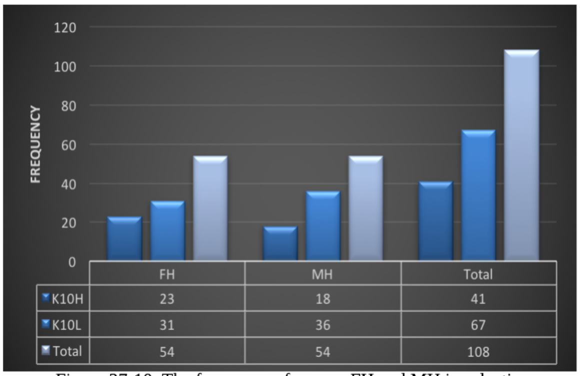

Figure 37-10. The frequency of groups FH and MH in selecting K10H and K10L

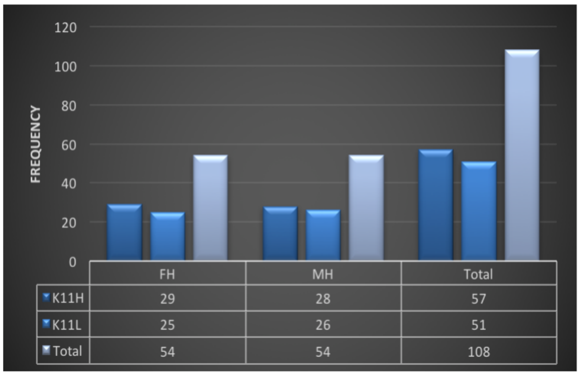

Figure 37-11. The frequency of groups FH and MH in selecting K11H and K11L

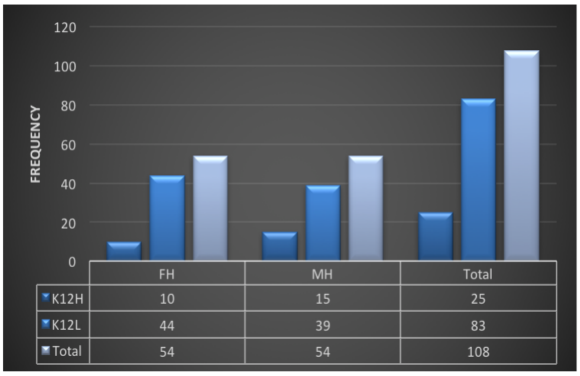

Figure 37-12. The frequency of groups FH and MH in selecting K12H and K12L

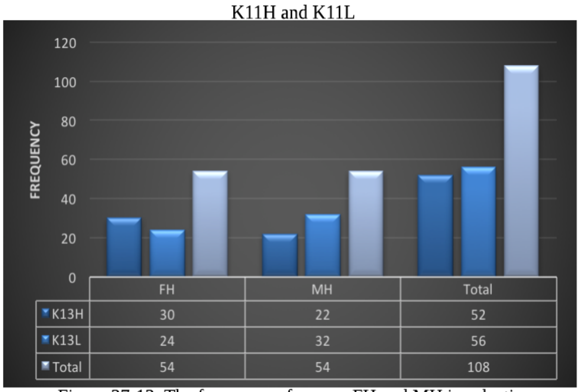

Figure 37-13. The frequency of groups FH and MH in selecting K13H and K13L

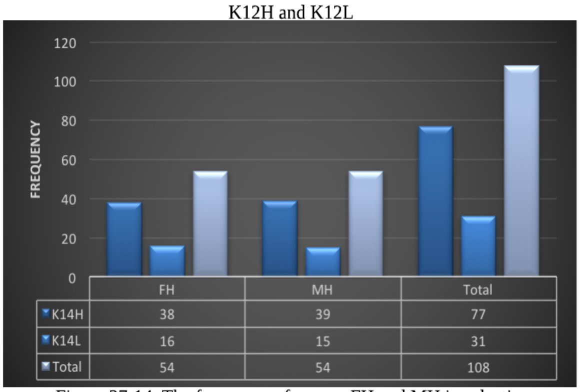

Figure 37-14. The frequency of groups FH and MH in selecting K14H and K14L

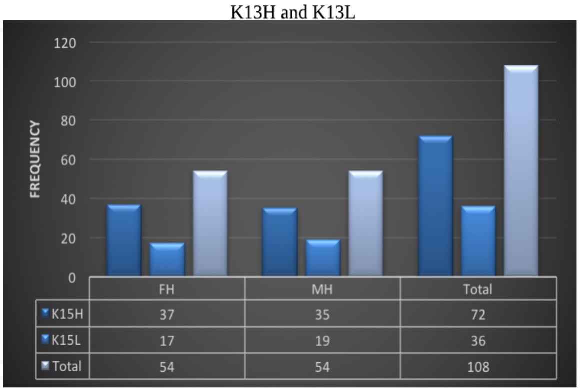

Figure 37-15. The frequency of groups FH and MH in selecting K15H and K15L

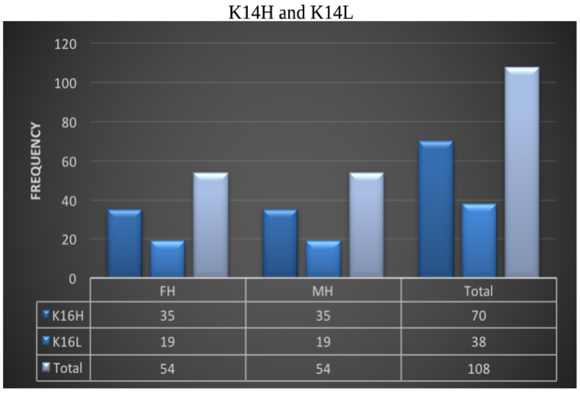

Figure 37-16. The frequency of groups FH and MH in selecting K16H and K16L

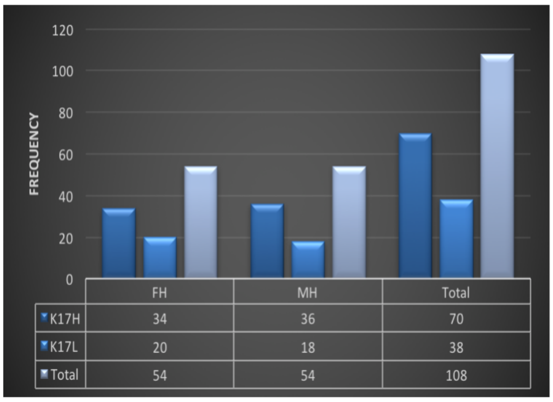

Figure 37-17. The frequency of groups FH and MH in selecting K17H and K17L

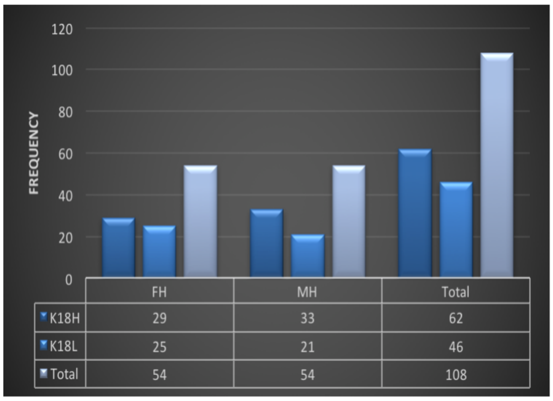

Figure 37-18. The frequency of groups FH and MH in selecting K18H and K18L

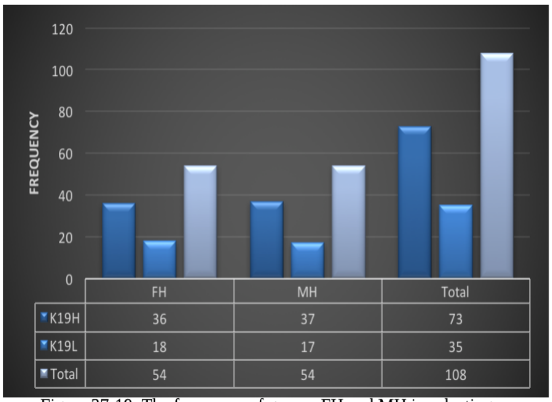

Figure 37-19. The frequency of groups FH and MH in selecting K19H and K19L

Figure 37. The frequency of groups FH and MH in selecting KH and KL (K1–K19) (China)

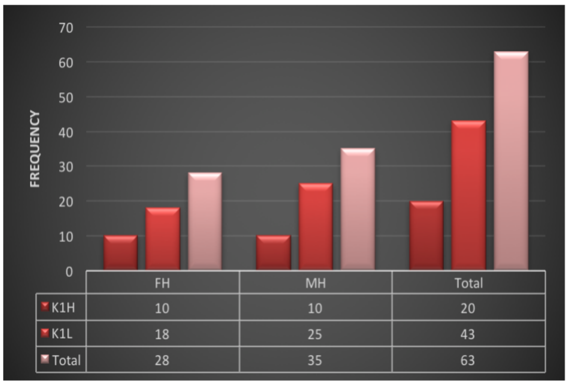

Figure 38-1. The frequency of groups FH and MH in selecting K1H and K1L

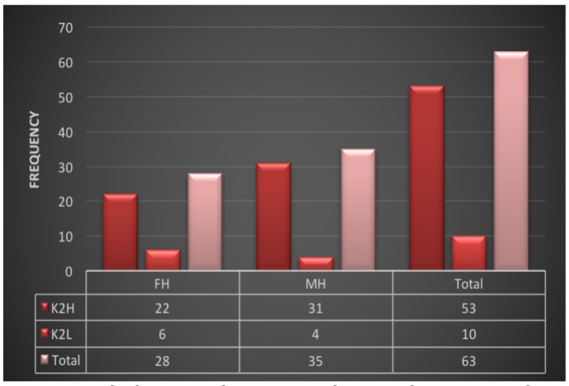

Figure 38-2. The frequency of groups FH and MH in selecting K2H and K2L

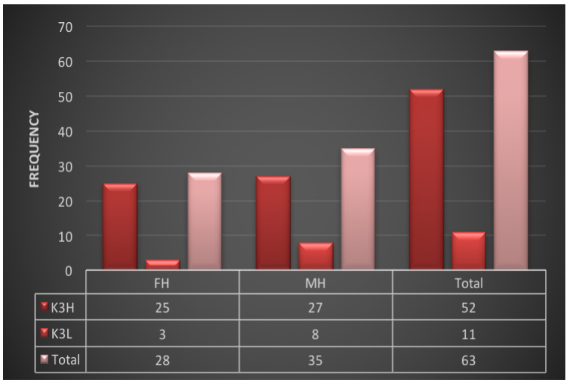

Figure 38-3. The frequency of groups FH and MH in selecting K3H and K3L

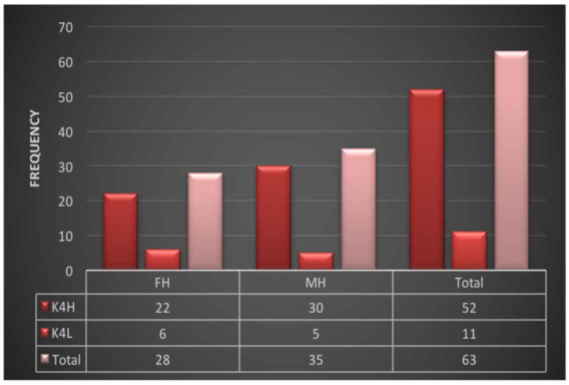

Figure 38-4. The frequency of groups FH and MH in selecting K4H and K4L

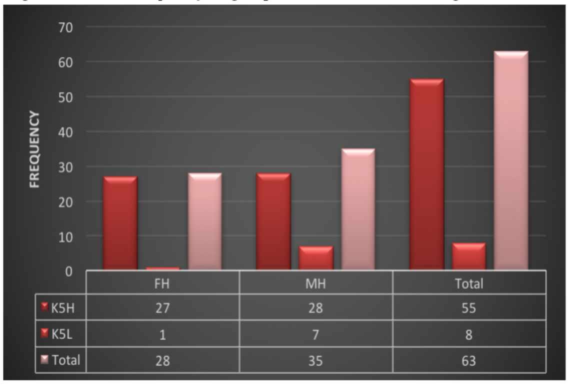

Figure 38-5. The frequency of groups FH and MH in selecting K5H and K5L

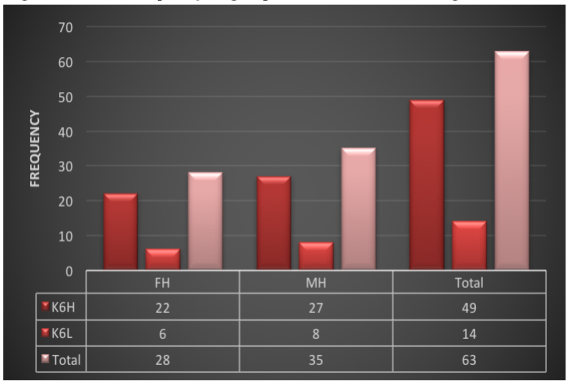

Figure 38-6. The frequency of groups FH and MH in selecting K6H and K6L

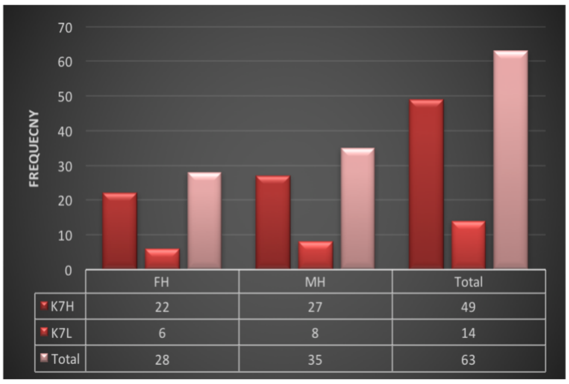

Figure 38-7. The frequency of groups FH and MH in selecting K7H and K7L

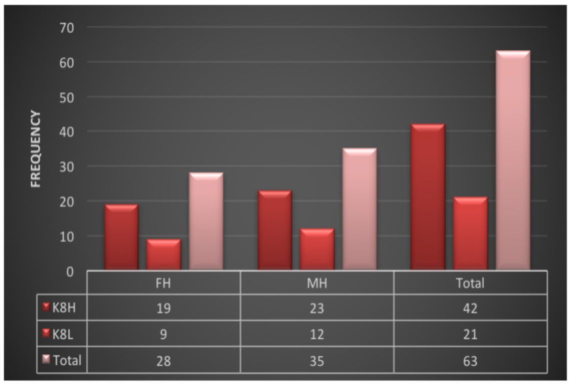

Figure 38-8. The frequency of groups FH and MH in selecting K8H and K8L

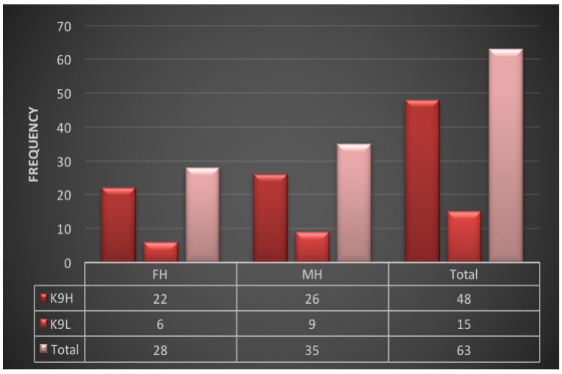

Figure 38-9. The frequency of groups FH and MH in selecting K9H and K9L

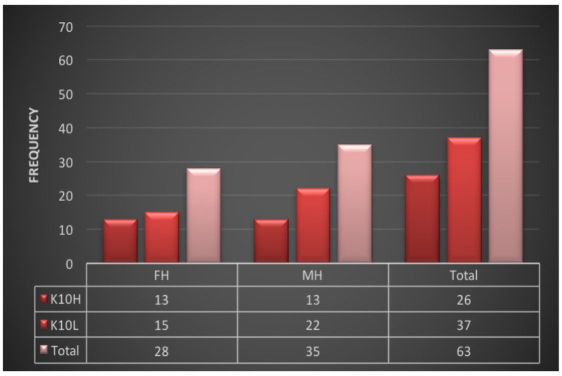

Figure 38-10. The frequency of groups FH and MH in selecting K10H and K10L

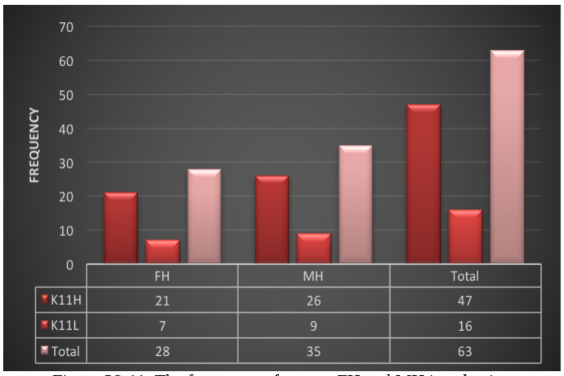

Figure 38-11. The frequency of groups FH and MH in selecting K11H and K11L

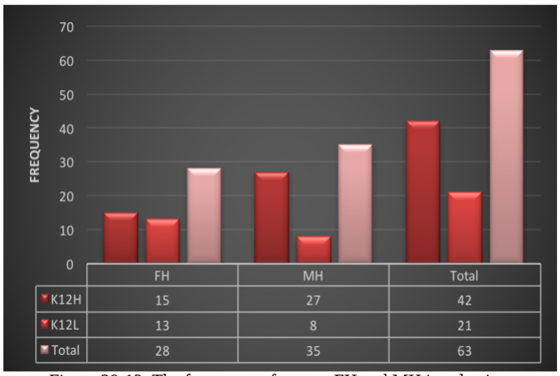

Figure 38-12. The frequency of groups FH and MH in selecting K12H and K12L

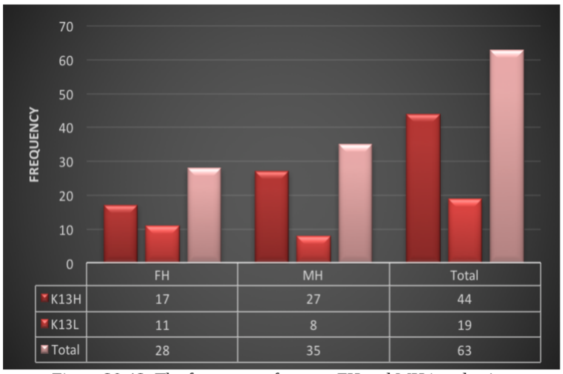

Figure 38-13. The frequency of groups FH and MH in selecting K13H and K13L

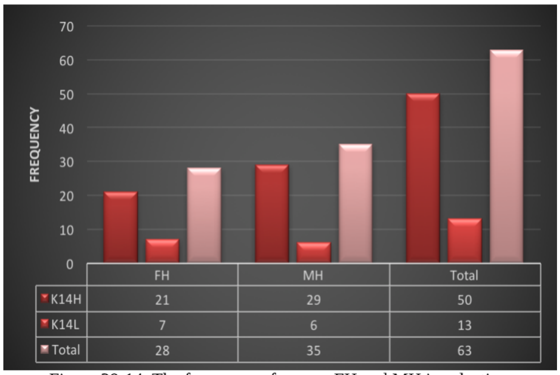

Figure 38-14. The frequency of groups FH and MH in selecting K14H and K14L

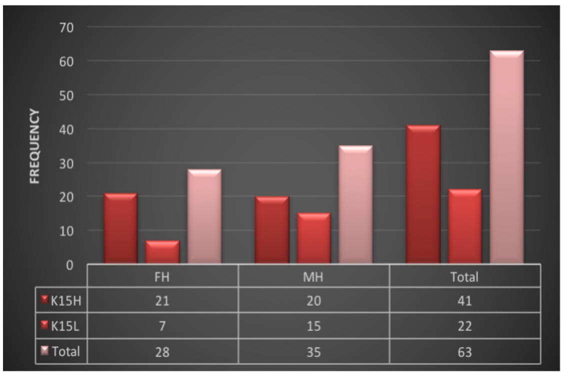

Figure 38-15. The frequency of groups FH and MH in selecting K15H and K15L

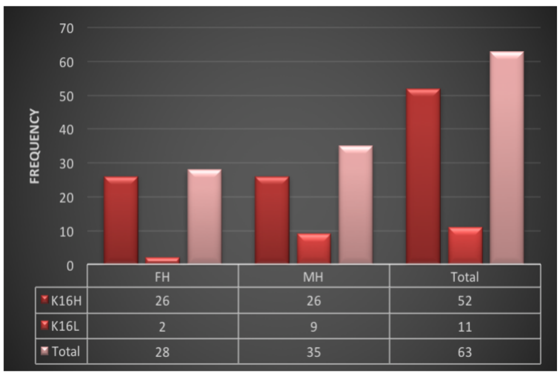

Figure 38-16. The frequency of groups FH and MH in selecting K16H and K16L

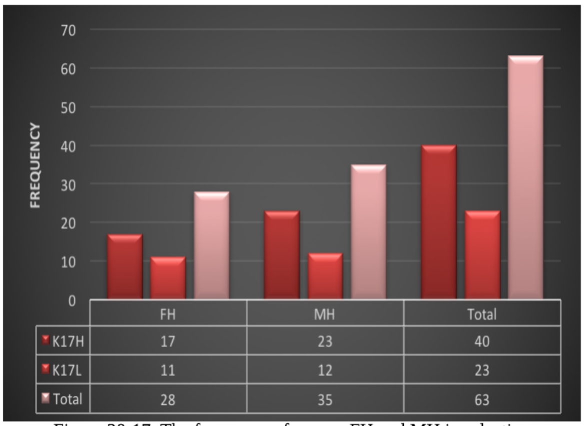

Figure 38-17. The frequency of groups FH and MH in selecting K17H and K17L

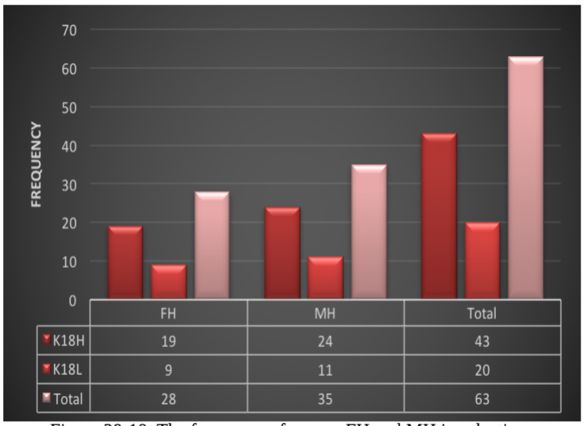

Figure 38-18. The frequency of groups FH and MH in selecting K18H and K18L

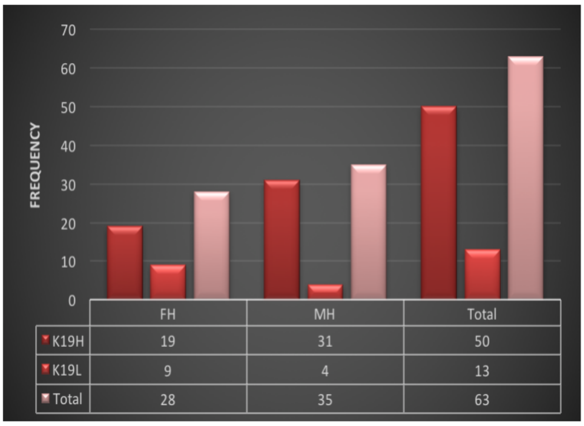

Figure 38-19. The frequency of groups FH and MH in selecting

Figure 38. The frequency of groups FH and MH in selecting KH and KL (K1–K19) (UK)

What can be seen from Figures 37 & 38 is that whether in the UK or China, there is no big difference between the groups of MH and FH when applying each kind of knowledge item. A Chi-square test was run to check the difference from a statistical perspective. The results are shown in Table 37 (p. 298).

From these results shown in Table 37 (p. 296), it can be seen the all the values of p are over 0.1, meaning the difference between groups (FH and MH) on the categories (KH and KL) are statistically insignificant. The H_01 and H_02 failed to be rejected. There is no difference in knowledge (K1,..K19) application between male students with a higher level MAI and female students with a higher level MAI in both countries.

Table 37. The results of the Chi-square test on groups divided by gender difference (UK and China)

	Chi SQ (UK)	p value (UK)	Chi SQ (China)	p value (China)
K1	0.545	>0.10	0.425	>0.10
K2	0.280	>0.10	0.332	>0.10
K3	0.207	>0.10	0.368	>0.10
K4	0.458	>0.10	0.540	>0.10
K5	0.052	>0.10	0.164	>0.10
K6	0.892	>0.10	0.847	>0.10
K7	0.892	>0.10	0.555	>0.10
K8	0.858	>0.10	0.092	>0.10
K9	0.691	>0.10	0.240	>0.10
K10	0.457	>0.10	0.321	>0.10
K11	0.948	>0.10	0.847	>0.10
K12	0.049	>0.10	0.254	>0.10
K13	0.158	>0.10	0.123	>0.10
K14	0.444	>0.10	0.832	>0.10
K15	0.140	>0.10	0.683	>0.10
K16	0.054	>0.10	1	>0.10
K17	0.682	>0.10	0.687	>0.10
K18	0.952	>0.10	0.436	>0.10
K19	0.044	>0.10	0.837	>0.10

5.3.3 Checking the influence by institutional (geographic) difference

To check the influence by institutional (geographic) difference, this study also focused on two sub-groups in each country. In the UK, the capital city London is a southern city with abundant education resources (colleges and universities); in China, there are two educational centres – the north centre represented by Beijing (the capital city) and the south centre represented by Nanjing. It is assumed that the educational environment around the same educational centre would be relatively similar. As a result, the north and south would be considered as the geographical criterion. Based on this geographical criterion, two sub-groups were formed in each country – the students from southern institutions with a high MAI level (SH) and the students from northern institutions with a high MAI level (NH), i.e. the students who obtained higher scores than the mean score of the overall sample would be grouped into the high level group. At the same time, each sub-group was further divided into two categories by scales in each knowledge application (from K1 to K19), the H category of relatively frequently used (from scale 5 to 7: 'frequently used' to 'always used') and the L category of relatively not frequently used (from scale 1 to 4: 'never used' to 'occasionally used'). In total, there will be 2*2 matrix for each knowledge application, with two columns (SH and NH) and two rows (K_nH and K_nL, n=(1,19)). Figure groups 39 & 40 (pp. 300–305) provide the matrix for each knowledge application in each country and plot them accordingly in the bar charts (Figure 39 refers to China's results; Figure 40 refers to the UK results). A Chi-square test was conducted to examine whether the difference between SH and NH is statistically significant or not.

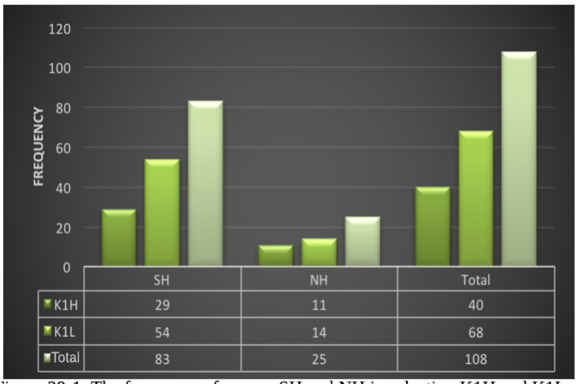

Figure 39-1. The frequency of groups SH and NH in selecting K1H and K1L

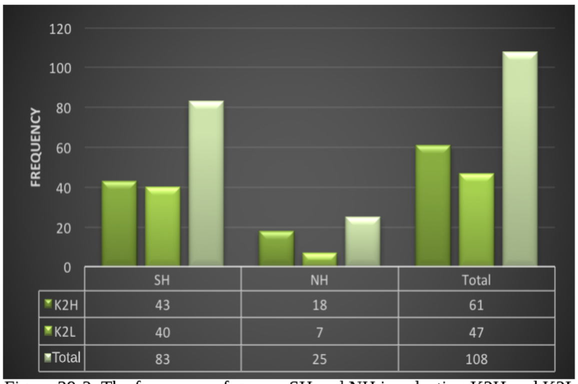

Figure 39-2. The frequency of groups SH and NH in selecting K2H and K2L

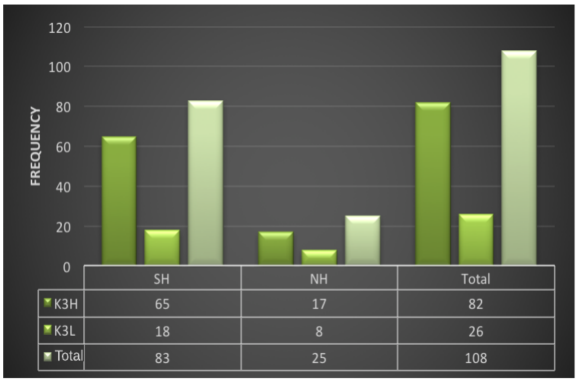

Figure 39-3. The frequency of groups SH and NH in selecting K3H and K3L

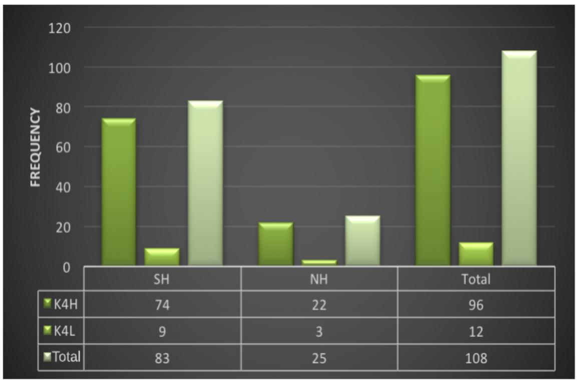

Figure 39-4. The frequency of groups SH and NH in selecting K4H and K4L

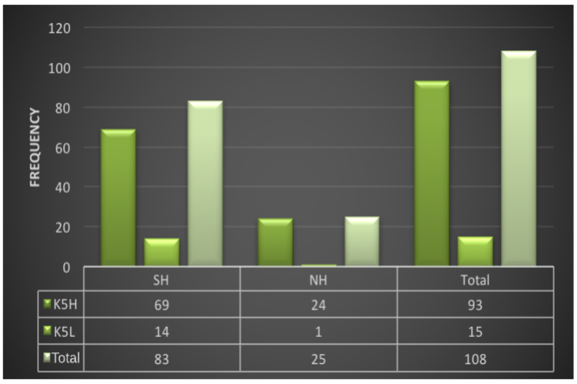

Figure 39-5. The frequency of groups SH and NH in selecting K5H and K5L

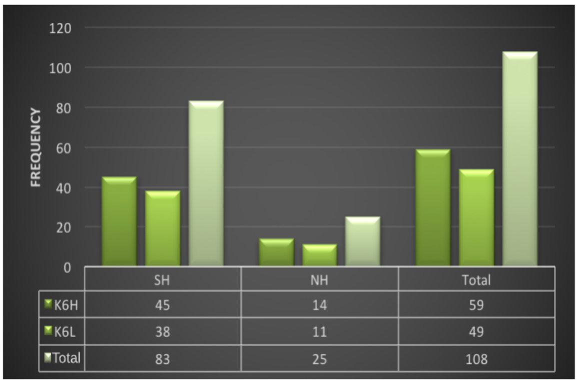

Figure 39-6. The frequency of groups SH and NH in selecting K6H and K6L

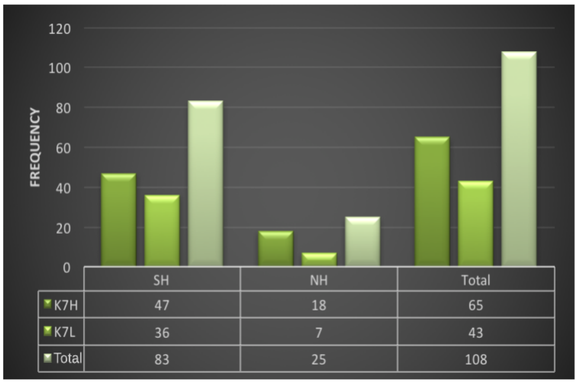

Figure 39-7. The frequency of groups SH and NH in selecting K7H and K7L

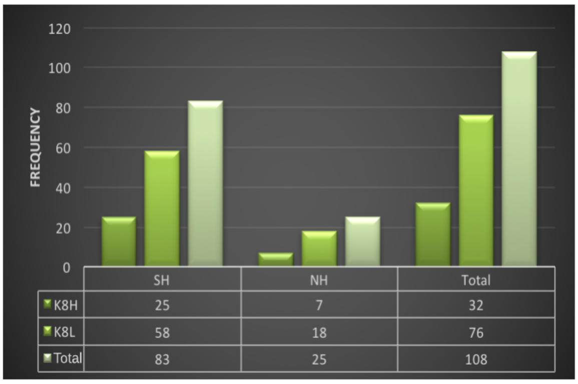

Figure 39-8. The frequency of groups SH and NH in selecting K8H and K8L

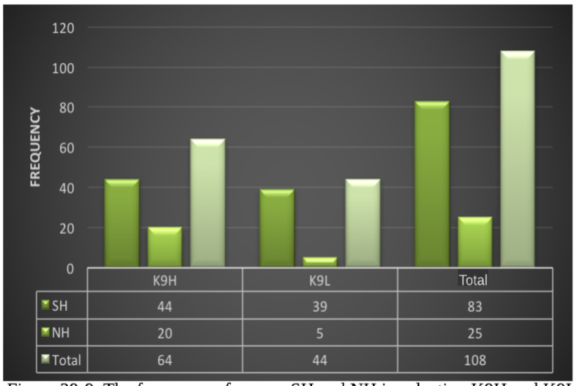

Figure 39-9. The frequency of groups SH and NH in selecting K9H and K9L

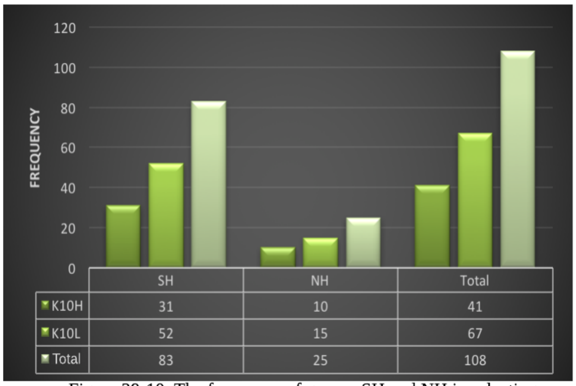

Figure 39-10. The frequency of groups SH and NH in selecting K10H and K10L

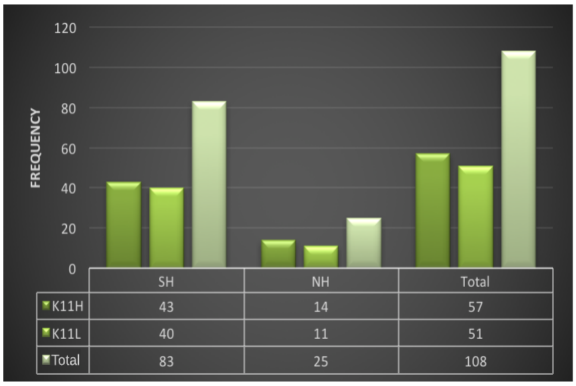

Figure 39-11. The frequency of groups SH and NH in selecting K11H and K11L

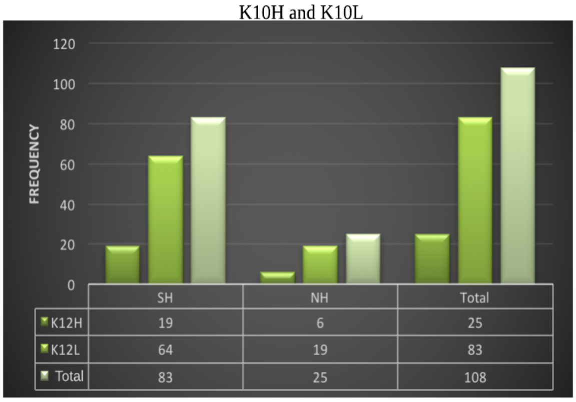

Figure 39-12. The frequency of groups SH and NH in selecting K12H and K12L

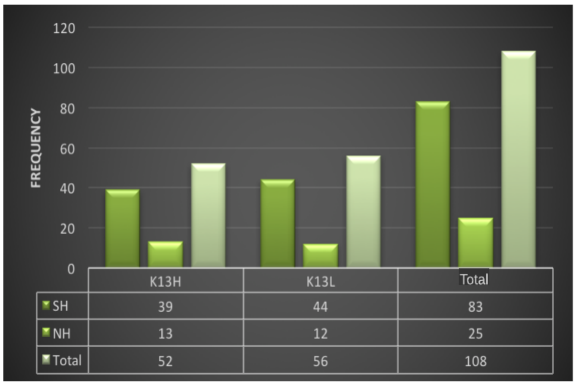

Figure 39-13. The frequency of groups SH and NH in selecting K13H and K13L

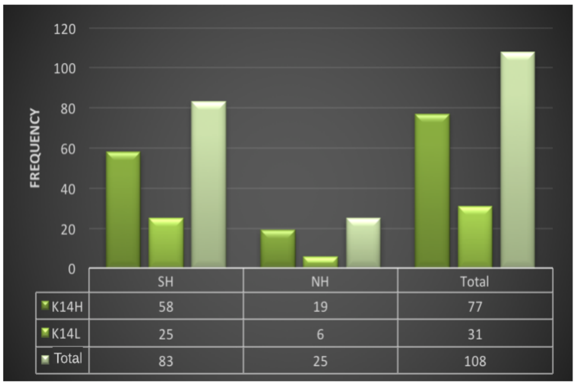

Figure 39-14. The frequency of groups SH and NH in selecting K14H and K14L

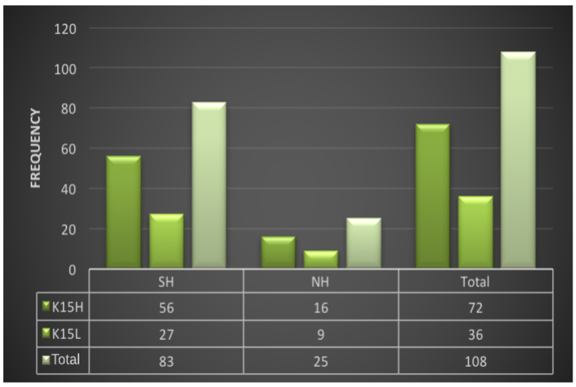

Figure 39-15. The frequency of groups SH and NH in selecting K15H and K15L

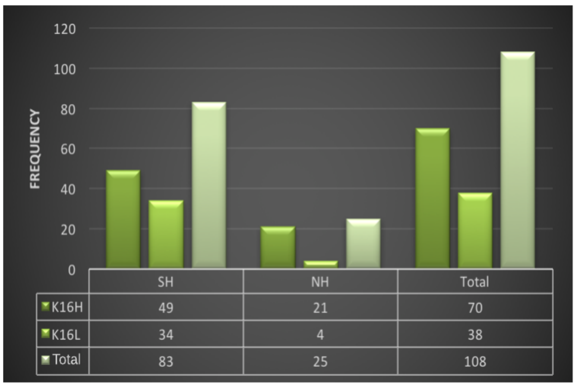

Figure 39-16. The frequency of groups SH and NH in selecting K16H and K16L

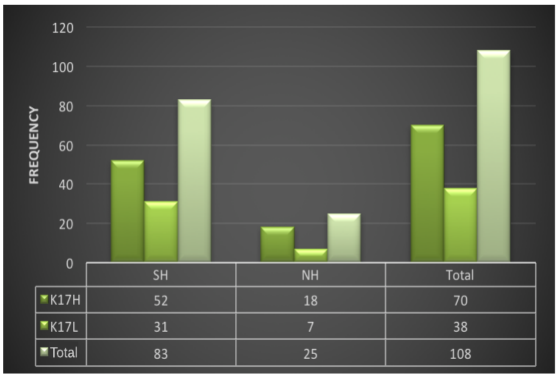

Figure 39-17. The frequency of groups SH and NH in selecting K17H and K17L

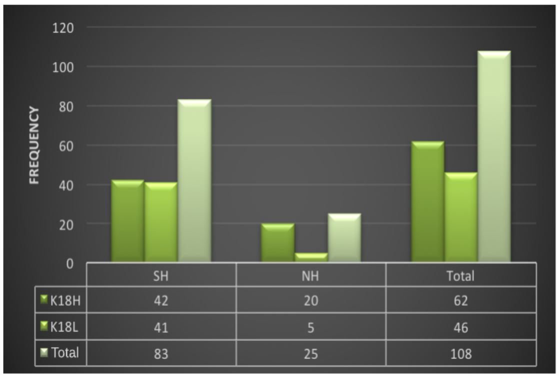

Figure 39-18. The frequency of groups SH and NH in selecting K18H and K18L

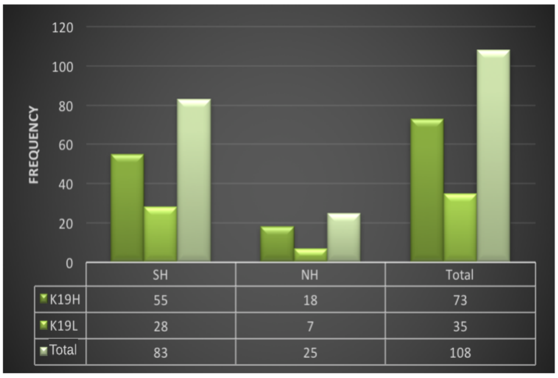

Figure 39-19. The frequency of groups SH and NH in selecting K19H and K19L

Figure 39. The frequency of groups SH and NH in selecting KH and KL (K11–K19) (China)

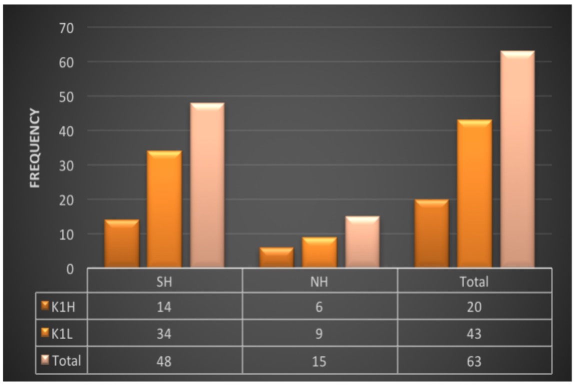

Figure 40-1. The frequency of groups SH and NH in selecting K1H and K1L

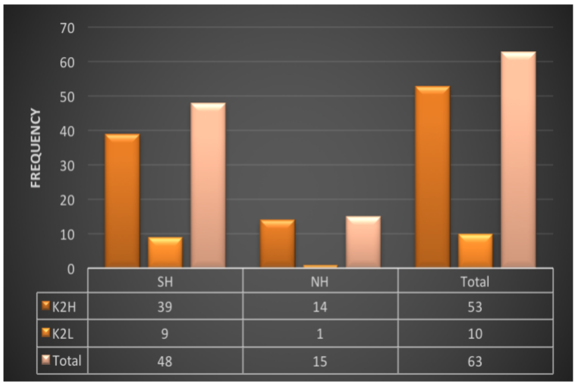

Figure 40-2. The frequency of groups SH and NH in selecting K2H and K2L

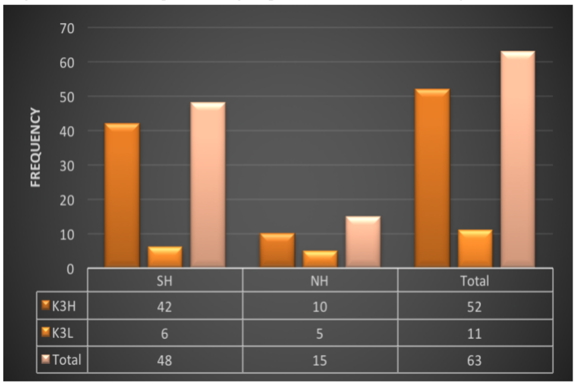

Figure 40-3. The frequency of groups SH and NH in selecting K3H and K3L

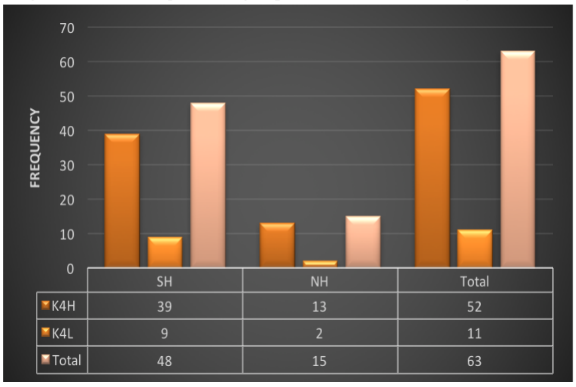

Figure 40-4. The frequency of groups SH and NH in selecting K4H and K4L

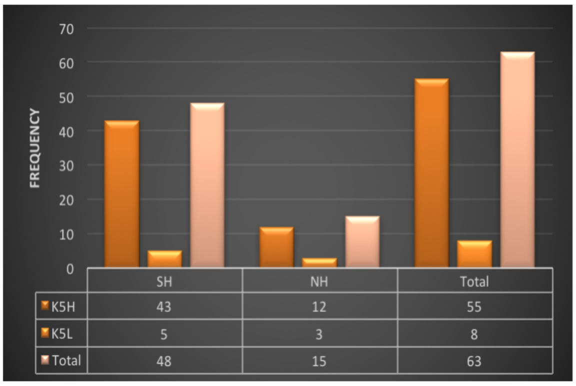

Figure 40-5. The frequency of groups SH and NH in selecting K5H and K5L

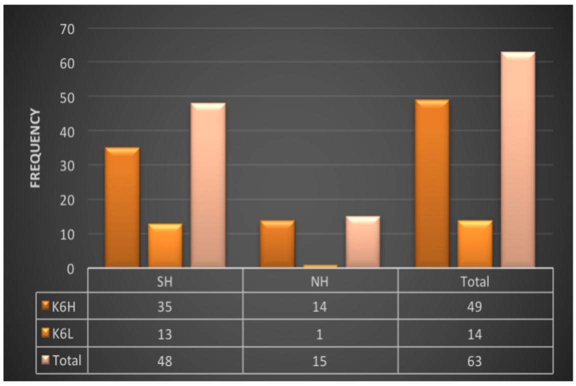

Figure 40-6. The frequency of groups SH and NH in selecting K6H and K6L

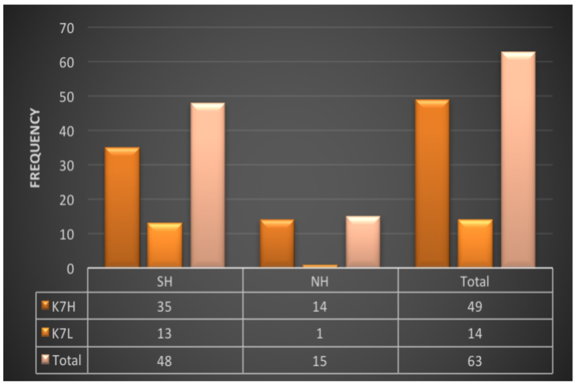

Figure 40-7. The frequency of groups SH and NH in selecting K7H and K7L

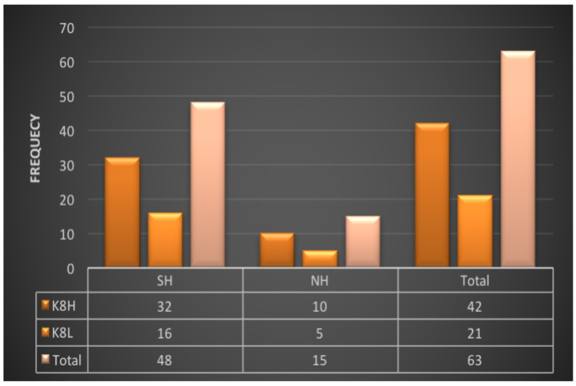

Figure 40-8. The frequency of groups SH and NH in selecting K8H and K8L

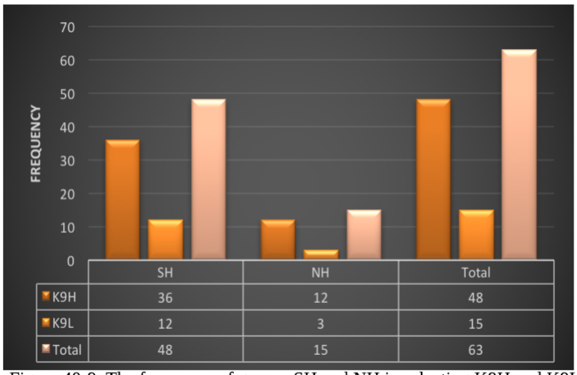

Figure 40-9. The frequency of groups SH and NH in selecting K9H and K9L

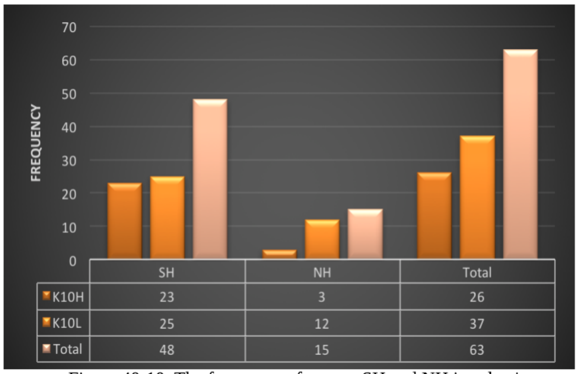

Figure 40-10. The frequency of groups SH and NH in selecting K10H and K10L

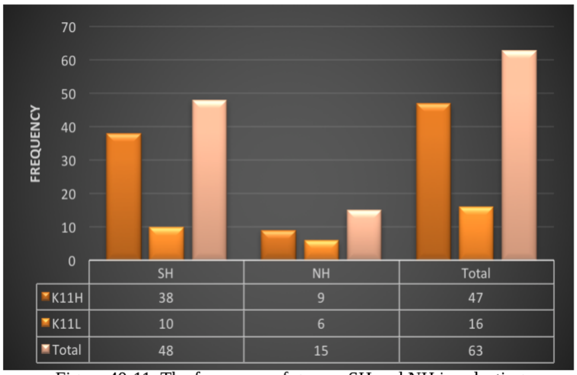

Figure 40-11. The frequency of groups SH and NH in selecting K11H and K11L

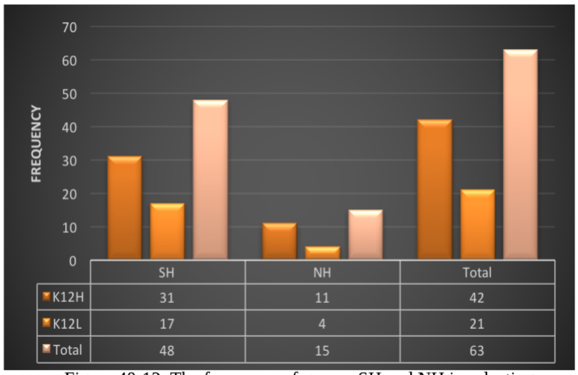

Figure 40-12. The frequency of groups SH and NH in selecting K12H and K12L

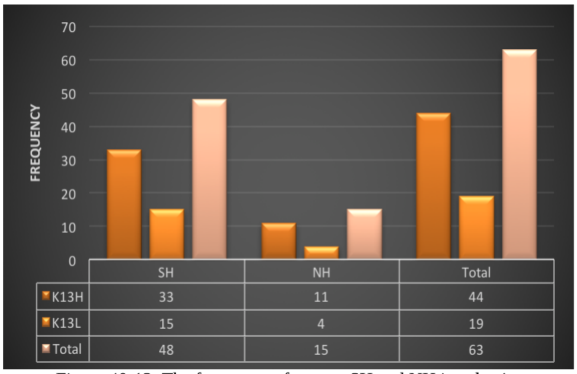

Figure 40-13. The frequency of groups SH and NH in selecting K13H and K13L

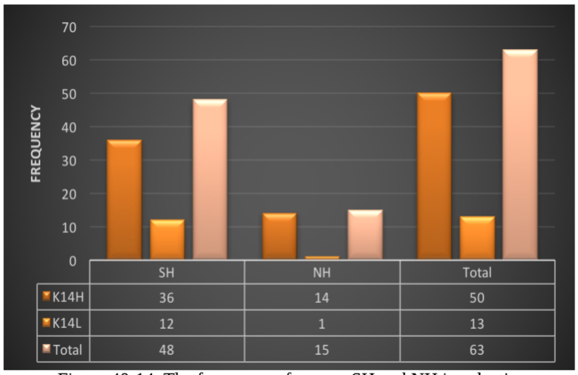

Figure 40-14. The frequency of groups SH and NH in selecting K14H and K14L

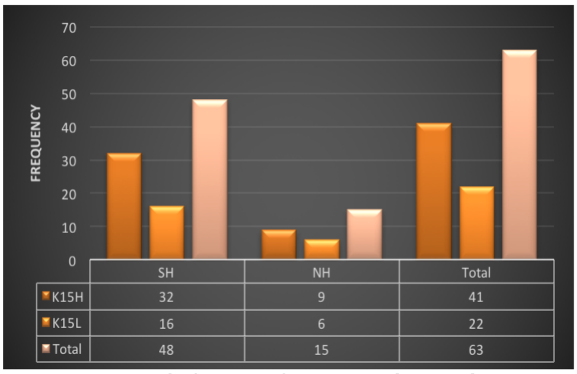

Figure 40-15. The frequency of groups SH and NH in selecting

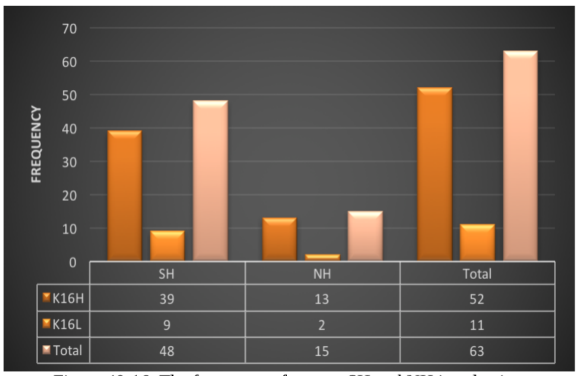

Figure 40-16. The frequency of groups SH and NH in selecting

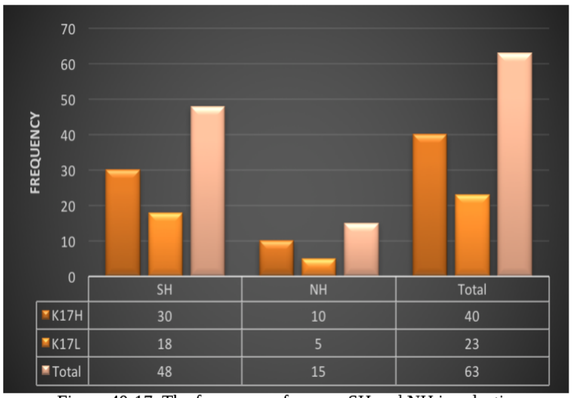

Figure 40-17. The frequency of groups SH and NH in selecting K17H and K17L

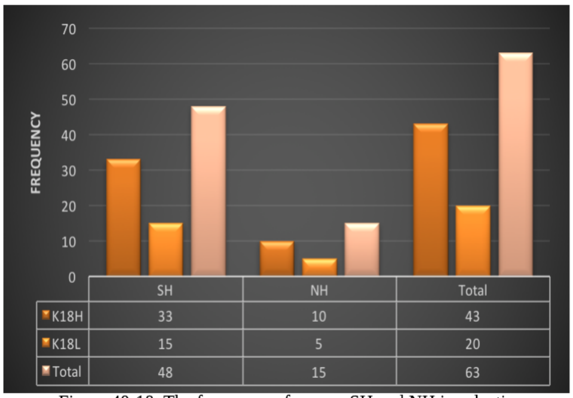

Figure 40-18. The frequency of groups SH and NH in selecting K18H and K18L

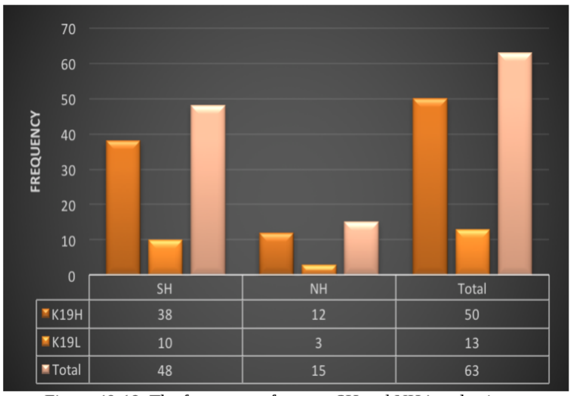

Figure 40-19. The frequency of groups SH and NH in selecting

Figure 40. The frequency of groups SH and NH in selecting KH and KL (K11–K19) (UK)

Figures 39 & 40 reveal that whether in the UK or China, there is little difference between the groups of SH and NH when applying each knowledge item. Then the Chi-square test was run to check the difference from a statistical perspective. The results are shown in Table 38 (p. 306). From Table 38, it is observed that all the values of p are over 0.1, which means the difference between groups (SH and NH) in the categories (KH and KL) are statistically insignificant. The H_03 and H_04 failed to be rejected. The results confirm that there is no difference in knowledge (K1,..K19) application between students with a high level MAI from institutions in the north of the UK and south of the UK; and there is no difference in knowledge (K1,..K19) application between students with a high level MAI from institutions in northern China and southern China as well.

Table 38. The results of the Chi square test on groups divided by geographical difference (UK and China)

	Chi SQ (UK)	p value (UK)	Chi SQ (China)	p value (China)
K1	0.431	>0.10	0.411	>0.10
K2	0.264	>0.10	0.074	>0.10
K3	0.064	>0.10	0.290	>0.10
K4	0.630	>0.10	0.872	>0.10
K5	0.331	>0.10	0.103	>0.10
K6	0.097	>0.10	0.875	>0.10
K7	0.097	>0.10	0.169	>0.10
K8	1	>0.10	0.839	>0.10
K9	0.691	>0.10	0.016	>0.10
K10	0.055	>0.10	0.811	>0.10
K11	0.137	>0.10	0.713	>0.10
K12	0.530	>0.10	0.908	>0.10
K13	0.736	>0.10	0.660	>0.10
K14	0.126	>0.10	0.553	>0.10
K15	0.636	>0.10	0.747	>0.10
K16	0.630	>0.10	0.022	>0.10
K17	0.770	>0.10	0.391	>0.10
K18	0.880	>0.10	0.009	>0.10
K19	0.945	>0.10	0.591	>0.10

5.3.4 Checking the influence by project difference

To check the influence by project difference, the focus was put on two sub-groups in each country as well. According to the represented descriptive data of the circumstances of project types selected by students (see Figures 20 & 21 in section 4.5.1, pp. 204–205), it is found that the top three project topics were selected by nearly half of the participants in both the UK and China. Therefore, the two sub-groups were formed – the students with a high MAI level whose projects belong to the top three choices (T3H) and the students with a high MAI level whose projects belong to the remaining choices (OH), i.e. the students who had scores higher than the mean score of the overall sample would be grouped into the high level group. Each sub-group was further divided into two categories by scales in each knowledge application (from K1 to K19), the H category of relatively frequently used (from scale 5 to 7: ‘frequently used’ to ‘always used’) and the L category of relatively not frequently used (from scale 1 to 4: ‘never used’ to ‘occasionally used’). There will be 2*2 matrix for each knowledge application, with two columns (T3H and OH) and two rows (K_nH and K_nL, n=(1,19)). Figures 41 & 42 (pp. 308–313) provide the matrix for each knowledge application in each country and plot them accordingly in the bar charts (Figures 41 refers to China’s results; Figures 42 refers to the UK results). Then the Chi-square test was conducted to examine whether the difference between T3H and OH is statistically significant or not.

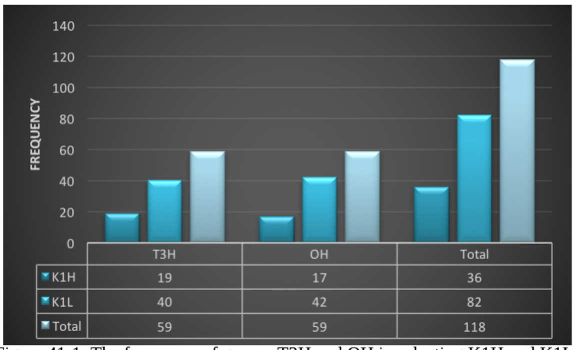

Figure 41-1. The frequency of groups T3H and OH in selecting K1H and K1L

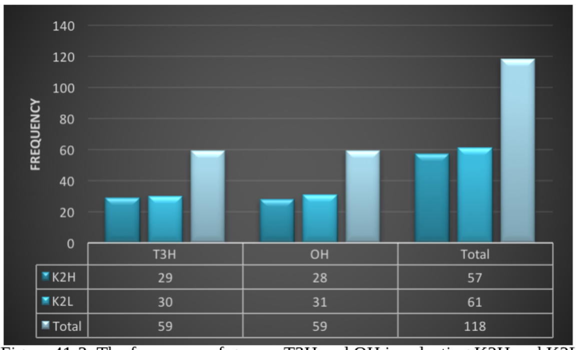

Figure 41-2. The frequency of groups T3H and OH in selecting K2H and K2L

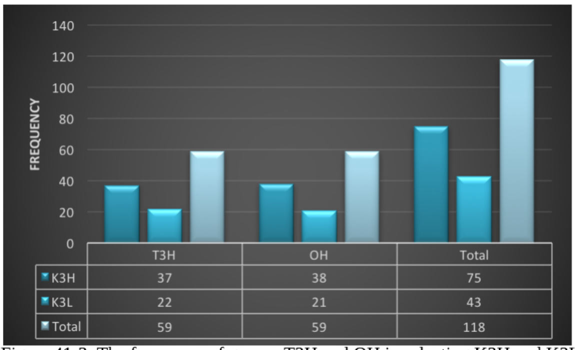

Figure 41-3. The frequency of groups T3H and OH in selecting K3H and K3L

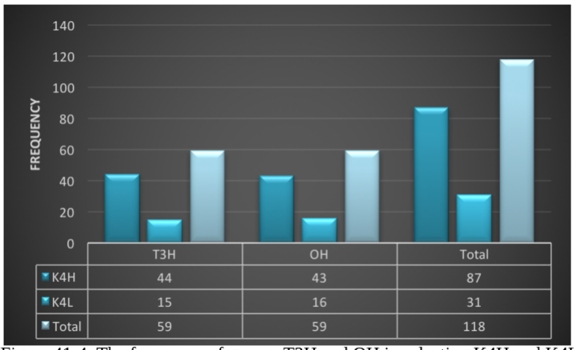

Figure 41-4. The frequency of groups T3H and OH in selecting K4H and K4L

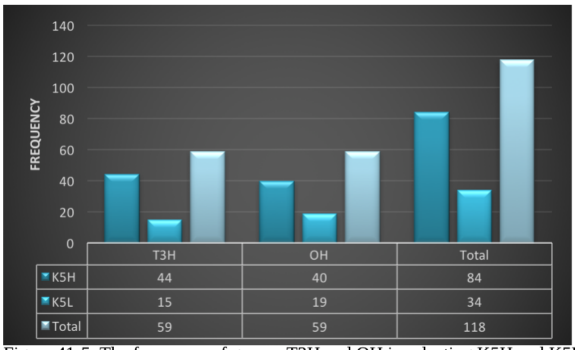

Figure 41-5. The frequency of groups T3H and OH in selecting K5H and K5L

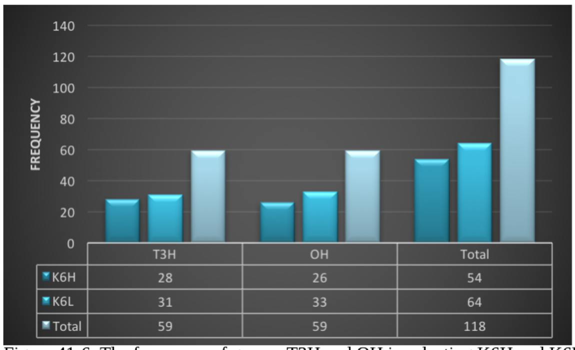

Figure 41-6. The frequency of groups T3H and OH in selecting K6H and K6L

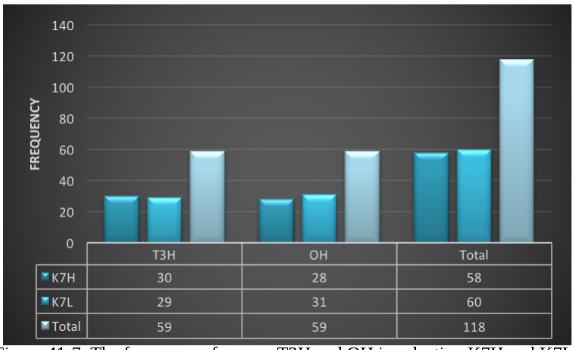

Figure 41-7. The frequency of groups T3H and OH in selecting K7H and K7L

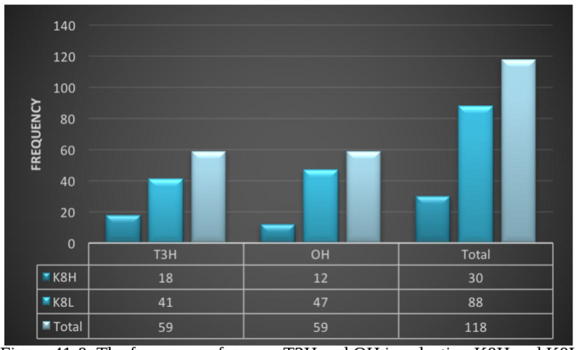

Figure 41-8. The frequency of groups T3H and OH in selecting K8H and K8L

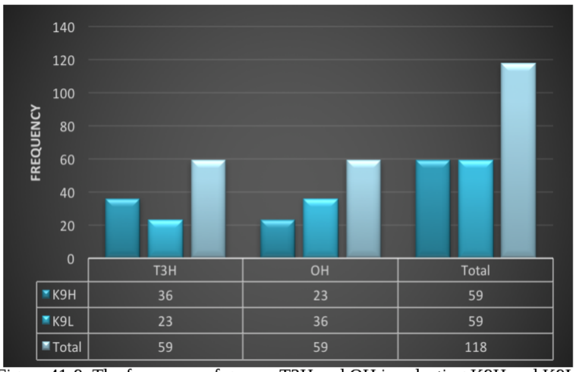

Figure 41-9. The frequency of groups T3H and OH in selecting K9H and K9L

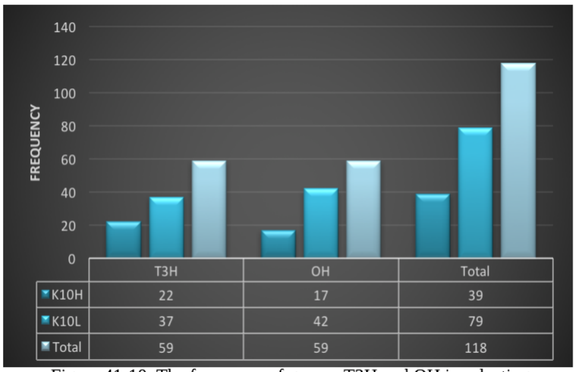

Figure 41-10. The frequency of groups T3H and OH in selecting K10H and K10L

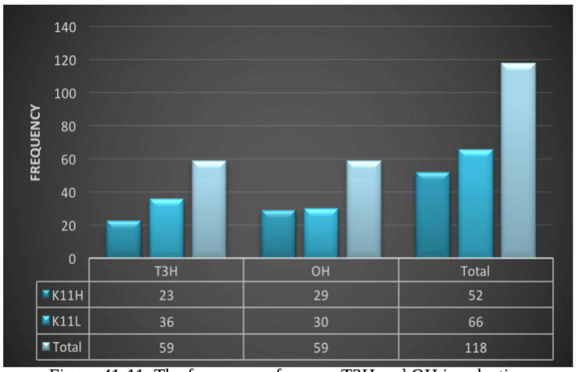

Figure 41-11. The frequency of groups T3H and OH in selecting K11H and K11L

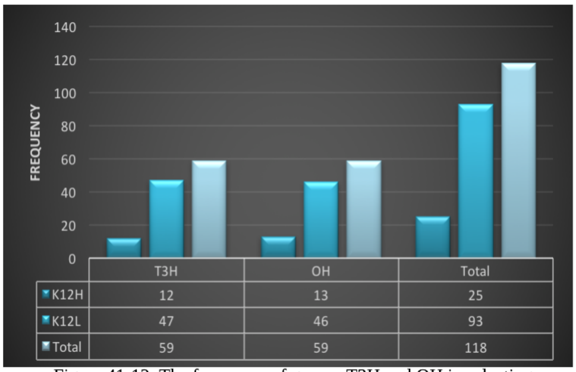

Figure 41-12. The frequency of groups T3H and OH in selecting K12H and K12L

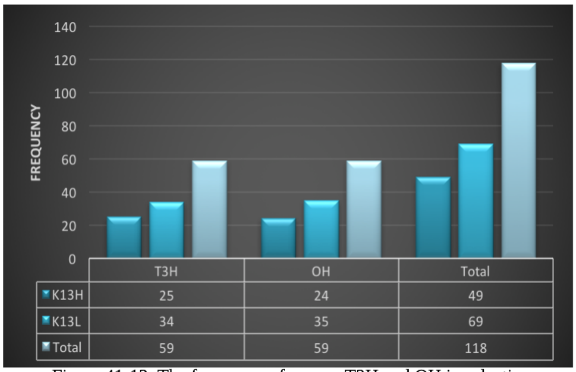

Figure 41-13. The frequency of groups T3H and OH in selecting K13H and K13L

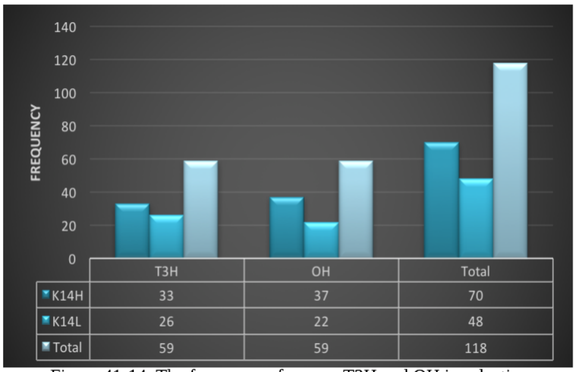

Figure 41-14. The frequency of groups T3H and OH in selecting K14H and K14L

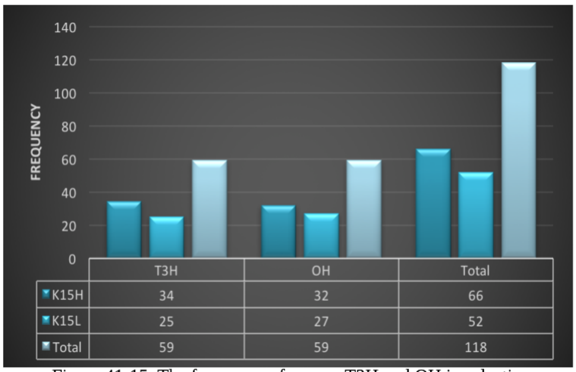

Figure 41-15. The frequency of groups T3H and OH in selecting K15H and K15L

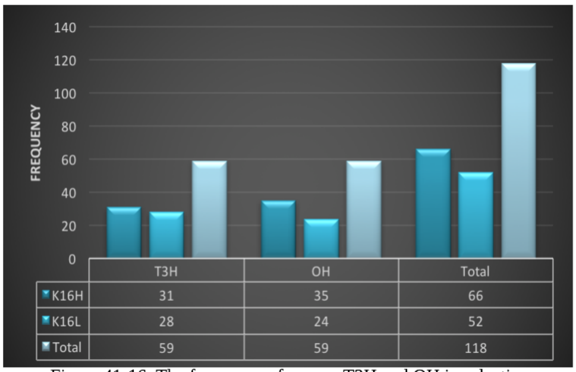

Figure 41-16. The frequency of groups T3H and OH in selecting K16H and K16L

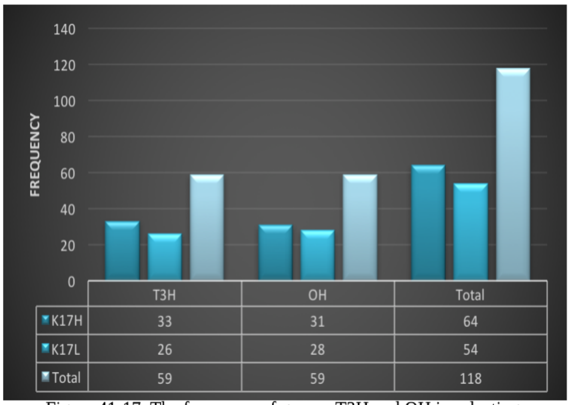

Figure 41-17. The frequency of groups T3H and OH in selecting K17H and K17L

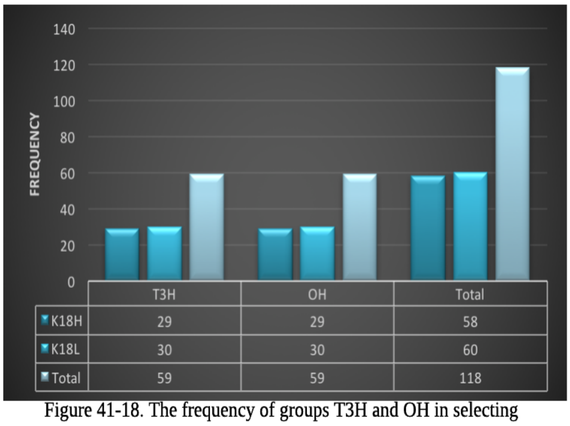

Figure 41-18. The frequency of groups T3H and OH in selecting K18H and K18L

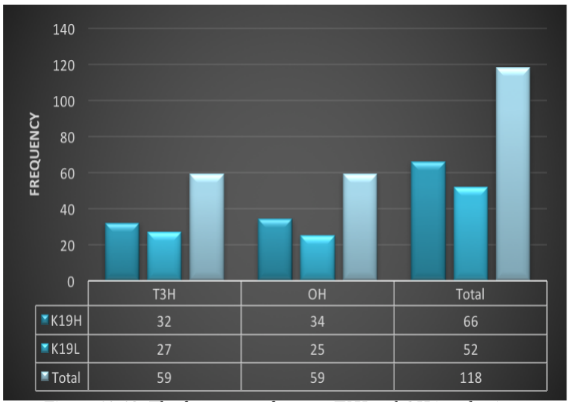

Figure 41-19. The frequency of groups T3H and OH in selecting K19H and K19L

Figure 41. The frequency of groups T3H and OH in selecting KH and KL (K11–K19) (China)

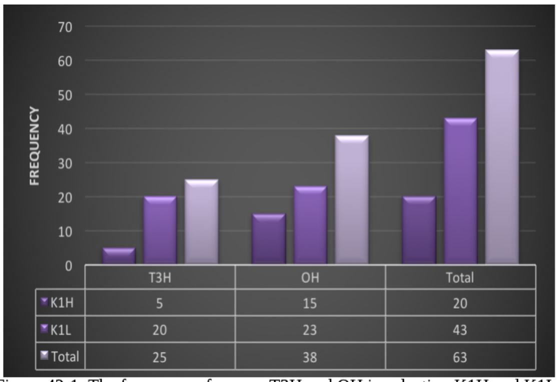

Figure 42-1. The frequency of groups T3H and OH in selecting K1H and K1L

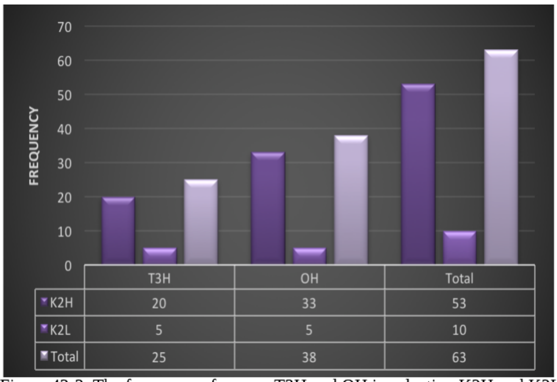

Figure 42-2. The frequency of groups T3H and OH in selecting K2H and K2L

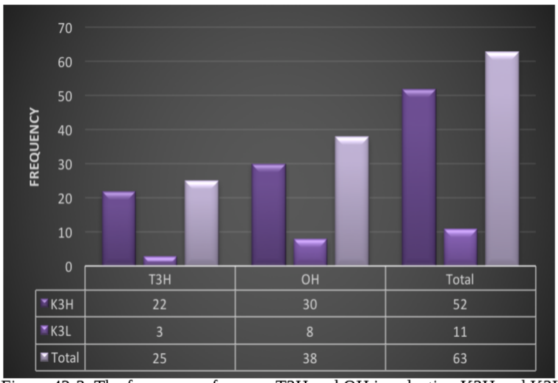

Figure 42-3. The frequency of groups T3H and OH in selecting K3H and K3L

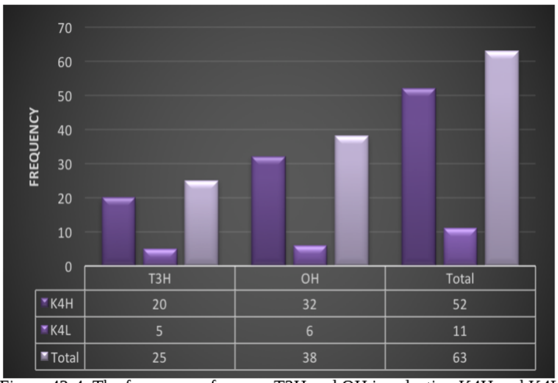

Figure 42-4. The frequency of groups T3H and OH in selecting K4H and K4L

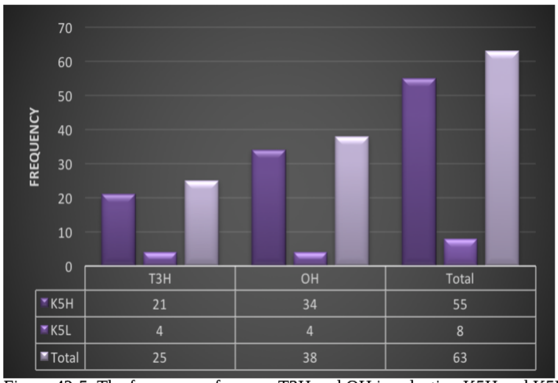

Figure 42-5. The frequency of groups T3H and OH in selecting K5H and K5L

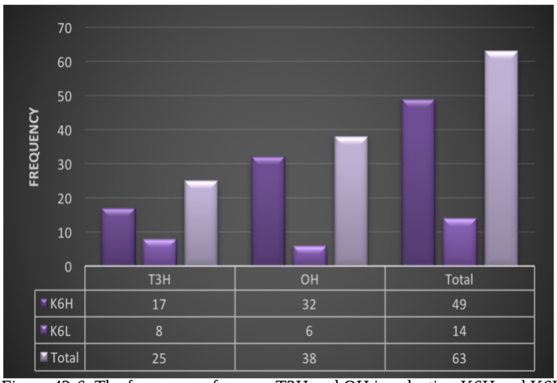

Figure 42-6. The frequency of groups T3H and OH in selecting K6H and K6L

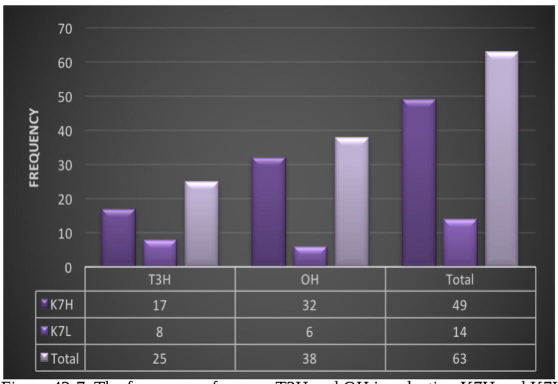

Figure 42-7. The frequency of groups T3H and OH in selecting K7H and K7L

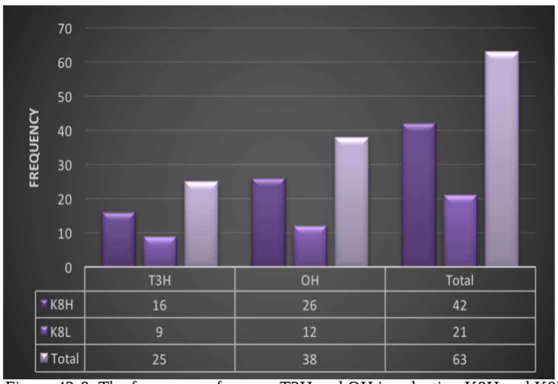

Figure 42-8. The frequency of groups T3H and OH in selecting K8H and K8L

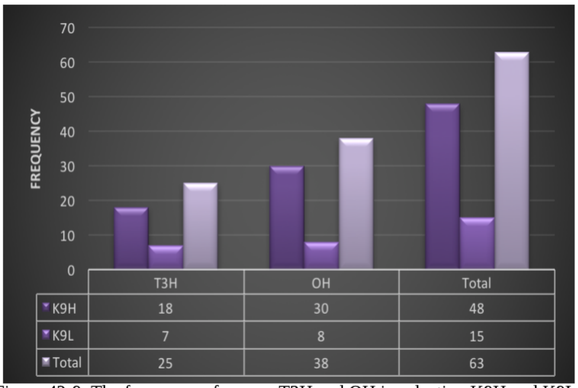

Figure 42-9. The frequency of groups T3H and OH in selecting K9H and K9L

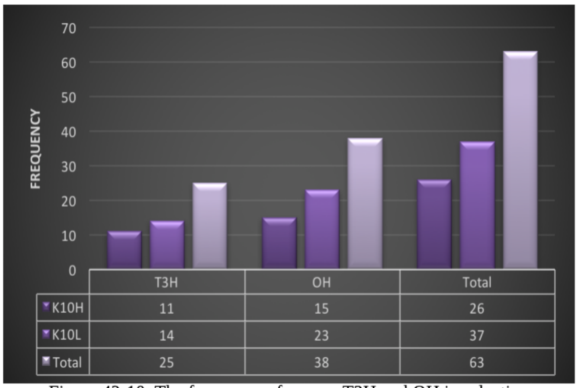

Figure 42-10. The frequency of groups T3H and OH in selecting K10H and K10L

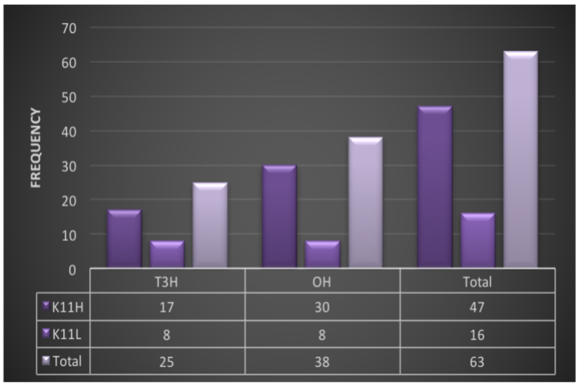

Figure 42-11. The frequency of groups T3H and OH in selecting K11H and K11L

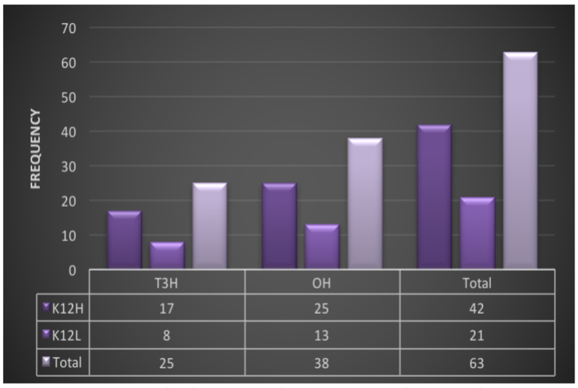

Figure 42-12. The frequency of groups T3H and OH in selecting K12H and K12L

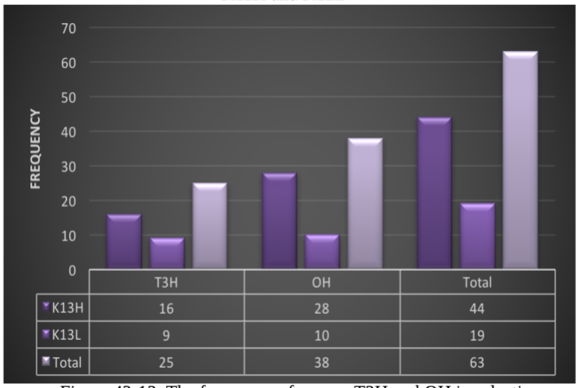

Figure 42-13. The frequency of groups T3H and OH in selecting K13H and K13L

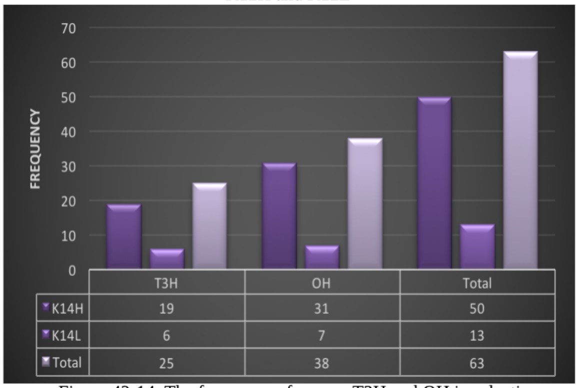

Figure 42-14. The frequency of groups T3H and OH in selecting K14H and K14L

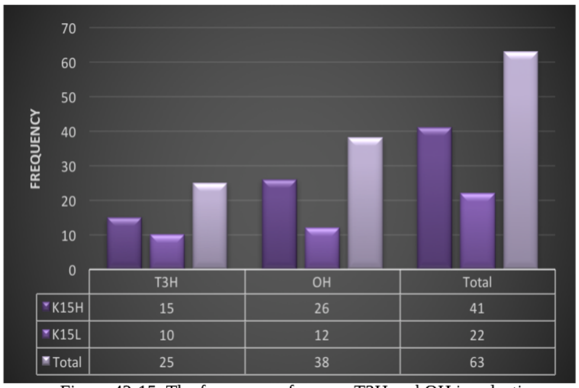

Figure 42-15. The frequency of groups T3H and OH in selecting K15H and K15L

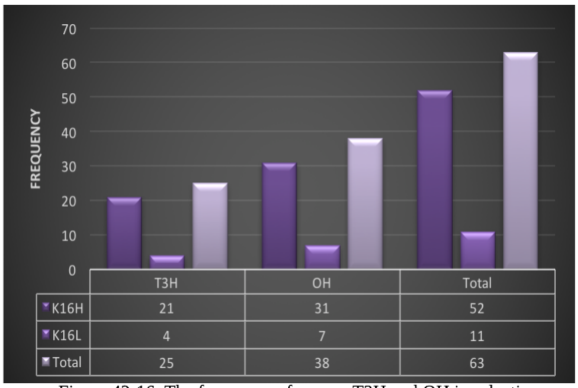

Figure 42-16. The frequency of groups T3H and OH in selecting K16H and K16L

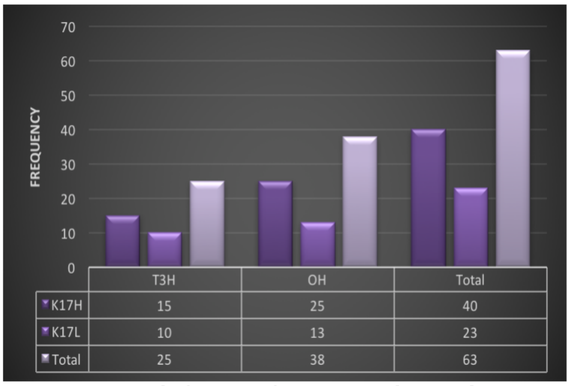

Figure 42-17. The frequency of groups T3H and OH in selecting K17H and K17L

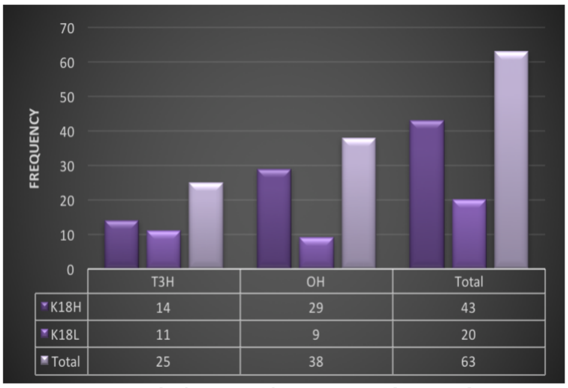

Figure 42-18. The frequency of groups T3H and OH in selecting K18H and K18L

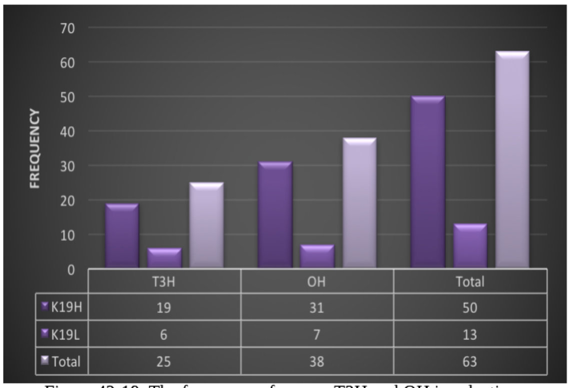

Figure 42-19. The frequency of groups T3H and OH in selecting K19H and K19L

Figure 42. The frequency of groups T3H and OH in selecting KH and KL (K11–K19) (UK)

It can be seen from Figures 41 & 42 that whether in the UK or China, there is little apparent difference between the groups of T3H and OH when applying each knowledge item. A Chi-square test was run to check the difference from a statistical perspective. The results are shown in Table 39 (p. 314).

From Table 39 (p. 314), it can be seen that all the values of p are over 0.1, which means the difference between groups (T3H and OH) in the categories (KH and KL) is statistically insignificant. The H_05 and H_06 failed to be rejected, indicating there is no difference in knowledge (K1,..K19) application between students with a high level MAI who conducted different projects in both countries.

Table 39. The results of the Chi square test on groups divided by project difference (UK and China)

	Chi SQ (UK)	p value (UK)	Chi SQ (China)	p value (China)
K1	0.104	>0.10	0.300	>0.10
K2	0.467	>0.10	0.328	>0.10
K3	0.354	>0.10	0.327	>0.10
K4	0.667	>0.10	0.326	>0.10
K5	0.523	>0.10	0.216	>0.10
K6	0.130	>0.10	0.305	>0.10
K7	0.130	>0.10	0.305	>0.10
K8	0.716	>0.10	0.121	>0.10
K9	0.526	>0.10	0.013	>0.10
K10	0.721	>0.10	0.179	>0.10
K11	0.329	>0.10	0.151	>0.10
K12	0.856	>0.10	0.324	>0.10
K13	0.412	>0.10	0.328	>0.10
K14	0.592	>0.10	0.230	>0.10
K15	0.493	>0.10	0.305	>0.10
K16	0.804	>0.10	0.232	>0.10
K17	0.641	>0.10	0.305	>0.10
K18	0.090	>0.10	0.336	>0.10
K19	0.592	>0.10	0.305	>0.10

5.3.5. In relation to the research questions

As all H_0s of the Chi-square tests are failed to be rejected, this study indicated that the factors of participants' gender, institutions and project topics do not exert significant impact on design students' knowledge application, which was consistent with the regression results. It implied that although the educational environment and topics of participants' final-year projects are diverse, these factors may not largely influence knowledge application, and the reason would be that they are all within the product design context. This finding answered sub-question 3 in RQ1 (section 2.16, p. 134) that metacognition is the main factor, to our best knowledge, that makes an impact on knowledge application.

5.4 Impact

The in-depth discussions provided the explanation for the findings obtained by comparing them with the current literature from three aspects: 1) are there any common areas in a series of knowledge items whose application is influenced by metacognition; 2) are there any reasons for the specific knowledge items whose application is not influenced by metacognition; 3) how do the main findings support/contradict the current literature regarding their relationship to creativity. Based on this discussion (section 5.2), it was possible to re-categorise 19 subject-related knowledge items and then identify their specific roles in the design process, which are summarised as:

(i) Product-oriented related knowledge

The participants with higher MAI scores are disposed to apply product-oriented knowledge more frequently, indicating that the more creative participants prefer thinking forward and concentrating more on the final products than the less creative participants. This type of knowledge includes five items identified by this study (see Table 22, p. 232, discussed in section 5.2.1, pp. 233–242).

(ii) Reflection-facilitating related knowledge

The participants with higher MAI scores are inclined to apply tacit knowledge more frequently, indicating participants who are more creative prefer reflecting on past experience in comparison to the less creative participants. This type of knowledge includes three items identified by this study (see Table 22, p. 232, discussed in section 5.2.1, pp. 242–248).

(iii) Socio-cultural environment related knowledge

The participants with higher MAI scores tend to be more sensitive to the socio-cultural environment than the less creative participants. This type of knowledge includes five items identified by this study (see Table 31, p. 270, discussed in section 5.2.3, pp. 271–282).

The findings of this study proved that the three types of knowledge listed in (i)–(iii) (13 items out of the total 19 items) are frequently applied by creative students, and therefore are crucial to good progression in the design process. This led to the suggestion that applying these kinds of knowledge may enhance the potential for improving the creative process involved in the FYDP.

(iv) Conceptual process related

All participants tend to apply K3, K5, and K15 frequently, suggesting these items are proven to be fundamental and necessary in the design process (see Table 29, p. 250, discussed in section 5.2.2, pp. 253–264).

The findings of this study could not provide further evidence to state whether these knowledge items can improve students' FYDP; however, based on the discussion, this study considers that K3, K5, and K15 are deemed more inclusive knowledge items, and that they have to work with other knowledge items in the design process. They are related to the conceptual process and thus construct a platform for incubating and developing ideas when conducting a design project.

(v) Cross-disciplinary knowledge

All participants tend to apply K1, K11, and K13 infrequently (see Table 29, p. 250, discussed in section 5.2.2, pp. 264–267).

As with conceptual process-related knowledge, this study did not provide further evidence as to whether cross-disciplinary knowledge can improve students' creativity in the FYDP. But as they are all applied with less frequency, the conclusion was drawn in this study that cross-disciplinary knowledge may have specific meaning at a certain stage of design, which is worth exploring in future studies.

In addition, in this study, my intention was measuring creativity from the view of creative thinking instead of via the creative product; therefore, my study did not further examine the relationship between students' metacognition ability and their creative outputs during the FYDP process. This means that the findings of this study may only contribute to improve the FYDP process. However, when discussing these findings, I realised that they may also indicate an improvement of creative process in design, as interpreted in section 2.11.6 (pp. 83–85), that metacognition would probably predict creative performance. Therefore, it is suggested by this study that a potential research area worth exploring would be measuring the link between design students' metacognition and their creative outputs.

To conclude, this chapter concerns the results interpretation and discussion of the findings in relation to the research hypothesis. All of the research questions (section 2.16, p. 134) were answered by the main findings of this study. These findings distinguished the application of those knowledge items largely influenced by metacognition, and the extent to which they have either been influenced or not influenced by metacognition. Plus, the difference in knowledge application between creative students and less creative students was then identified, which has fulfilled the research purpose (see section 2.17, p. 135). The main findings could be applied to design educational practices to offer suggestions for achieving research aims (section 2.6, p. 48), which will be interpreted in the next chapter.

Chapter Six: Implications, Limitations and Further Suggestions

6.1 Chapter overview

This chapter consists of five sections. Section 6.2 interprets the main knowledge contribution of this study; Section 6.3 draws the implications of the main conclusive findings of this study by interpreting how they can be applied in design education practice, focusing on the FYDP; in section 6.4 the main limitations of this study are identified; lastly, several suggestions for further studies are provided in section 6.5.

6.2 Contribution to current literature

As the hypotheses in this study were formed on the basis that there is a relationship between students' metacognition abilities and their knowledge application, the aim of conducting the survey study was to examine these hypotheses via investigating whether metacognition abilities may estimate students' application of subject-related knowledge, so as to provide valuable perspectives to answer the research questions.

In the current literature (discussed in sections 2.12 & 2.14), there is little point in paying attention to whether it is domain-specific or domain-general knowledge that contributes to creativity, as a clear 'body of knowledge' within the design context in particular is lacking (Wang & Ilhan, 2009). The focus of this study was similar to Christiaans' (1992) study, as both are interested in exploring the application of knowledge. However, because of the limitation of the methods employed by Christiaans (1992), his study focused on the general categories of domain-specific and domain-general knowledge, and there was a lack of deeper analysis of the different kinds of knowledge that are involved in the design process. As a result, his study only reached conclusions regarding a combination of knowledge categories in more general dimensions. In contrast to Christiaans' study, this research conducted an empirical study, which created the possibility of observing how different kinds of knowledge are applied by students from the perspective of application frequencies. This study obtained a comprehensive modus operandi of the extent to which students are applying subject-relevant knowledge during their FYDP processes, which then made contributions to fill the literature gaps from the following three aspects identified from the literature (section 2.16, pp. 133):

1. The prior literature measured creativity by evaluating how creative the final products are, which may be biased by tutor intervention in the process. This research therefore adopted a cognitive measurement (metacognition) which estimates how creative the participants are in the process. It is the first attempt to study metacognition's impact on knowledge application.
2. Second, the relevant existing literature categorised knowledge into domain general and domain specific but with an obscure distinction between these two types. In other words, there is no consensus on precisely which knowledge items belong to each type in design domain. In this study an attempt was made to solve this issue by actually examining a range of specific knowledge items one by one rather than investigating knowledge domains with ambiguity.

3. Third, the literature so far, to our best knowledge, most studies in the design domain were qualitative and employed protocol analysis, which has innate limitations as a research method, e.g. it can only lead to a small-scale study in a single university within one country. This research conducted an empirical study which collected data from multiple universities and also makes a comparison between China and the UK, enabling us to take a cross-cultural view, which has never been done before.

Besides the main theoretical contribution regarding understanding knowledge application under the impact of metacognition within a product design context, this study also draws other implications that bring new insight to the current study by answering a series of research questions. These are concluded as follows:

1. Compared with the current studies on design and creativity, metacognition has been explored more deeply in this study. It has been preliminarily evidenced to be a main factor that exerts an impact on the knowledge application in a design process.
2. The current study on creative design represented an argument as to whether the creative design process is problem-focused or solution-focused. The finding of this study implies that the creative design process is more likely to be solution-focused, as those knowledge items represented as product-oriented are frequently applied by creative students.
3. There is discussion on the causes that lead to the occurrence of design fixation, and one of the potential factors is that designers are highly dependent on their

prior knowledge or experiences. The findings of this study support the claim that attributing design fixation to designers' experiences is not rigorous enough, and it further suggests that designers consider tacit knowledge (experience-based knowledge) and how they integrate it with current situations as the key point to break through design fixation.

4. This study also supports the viewpoint that creativity is socio-culturally related, as the different understandings of creativity are reflected in their different emphasis on knowledge application.
5. And finally, the main findings imply that it would be more practical if we change our focus to further exploring how different kinds of knowledge are applied and integrated with each other within a design process.

6.3 Implications

In this study 19 knowledge items were further analysed, based on the in-depth discussions of the results of OLR analysis in section 5.2 (pp. 229–286), and five main conclusions were then drawn. They are elaborated below, fulfilling the research purpose (section 2.17, p. 135).

Summary of differences between the participants

1. The participants with higher MAI scores are disposed to apply K2, K6, K8, K9, and K16 (see Table 22, p. 232) more frequently, indicating that the more creative participants prefer thinking forward and concentrating on the final products in contrast to the less creative participants.

2. The participants with higher MAI scores are inclined to apply K17, K18, and K19 (see Table 22, p. 232) more frequently, indicating participants who are more creative prefer reflecting on past experience in contrast to the less creative participants.
3. The participants with higher MAI scores tend to be more sensitive to the socio-cultural environment in contrast to the less creative participants. The Chinese participants with higher MAI scores are more inclined to apply K4, K10, and K12 (see Table 31, p. 270); the UK participants with higher MAI scores are more inclined to apply K7 and K14 (ibid).

Summary of similarities between the participants

4. All participants tend to apply K3, K5, and K15 (see Table 29, p. 250) frequently, suggesting these items are basic and necessary in design education.

5. All participants tend to apply K1, K11, and K13 (see Table 29, p. 250) infrequently.

A new perspective to categorise subject-related knowledge was then proposed, based on the comprehensive understanding of design subject-related knowledge application and creativity in the design process. This is *product-oriented, reflection-facilitating, socio-cultural environment related, conceptual-process related*, and *cross-disciplinary knowledge*. It is indicated by this study that *product-oriented, reflection-*

facilitating, and socio-cultural environment related knowledge are frequently applied by creative students, and therefore are crucial to good progression in the design process.

Inspired by the five conclusions, it would be able to bring more practical and directional suggestions for product design education. The reasons are illustrated below:

Design demands creativity, as design and creativity share a similar problem-solving process involving creative thinking, which facilitates the generation of creative products. However, in the design education context, it cannot be said that all students studying design have enough creative ability to handle such a process. Therefore, design education may not only focus on those students who are creative enough, but also take care of those students with less creative ability. This might be considered as one of the aims to be achieved via design education (this has been identified in sections 2.3–2.4, pp. 14–38).

As proposed in the research problem (section 2.6, p. 48), the main reason that those students lacking in creativity-relevant abilities cannot conduct the FYDP fluently is that they may not be able to apply their knowledge in an efficient way. This was demonstrated in this study which showed that there are differences between students with different creative thinking abilities when applying specific kinds of knowledge. Creative students may handle a complex design project well (FYDP), whereas those students who are not so creative may not. Because, as Brundiers and Wiek's (2013) study (examining institutions in six countries) discovered, courses in design programmes are rarely designed to prepare students for the demands of project work. The ways of applying knowledge by design students is probably largely influenced by their previous training in relevant courses. It is possible that these standardised training courses may inhibit their comprehensive understanding of how the acquired knowledge is related to the design process in a complex design project, and therefore, those students who are not so creative may only apply knowledge well in a specific scenario, because students acquire knowledge and improve their design abilities according to the courses they are studying. Although there is no evidence to show that the more creative students are consciously applying different kinds of knowledge in a design project, the fact that they are more sensitive to several specific knowledge items (identified by this study) indicates that they do have advantages in knowledge application, which is determined by their metacognition rather than their education. This information concerning creative students' application of knowledge is worth investigating and analysing to provide valuable guidance for design educators and students, which is what this study was aiming to do and constituted the conclusion generated by the study.

Moreover, as Barnett (2000) stated, what has to be delivered in education is always from the experience of educators, which means it may (most of the time) refer to what the educators tend to teach and is what they think that students need to acquire in terms of specific knowledge. However, all these assumptions and strategies are not considered from the perspective of students, such as whether most students will adapt to a certain teaching strategy; this occurs notably in fostering creativity. Cross (1986) stated that investigating students learning activities helps design educators do better in nurturing the process. This study may also bring insight to this problem, as a deeper understanding of the nature of the design activity as performed by students was gained.

Therefore, in this section the aim is to articulate the found implications of this study for product design education, focusing on improving the FYDP process, and the ways in which these new knowledge categories (section 5.4, pp. 315–317) will be used by both design tutors and students in the FYDP are suggested.

6.3.1 Product-oriented knowledge (K2, K6, K8, K9, K16, see Table 22, p. 232)

As shown in the five conclusions (pp. 322–323), this study suggests that the more creative students will largely apply product-oriented knowledge, and the higher their creative thinking ability levels, the more they will apply this range of knowledge. This suggestion can be applied in the FYDP process for both tutors and students. As reviewed when we were identifying the research problem (sections 2.3–2.4, pp. 14–38), the design tutor plays an important role in the process of the design project, acting as a scaffold (Waks, 2001). It is suggested that they encourage students to be more active, with open minds, and try to provide a relatively 'congenial' environment for facilitating creativity, which means that within such an environment, students will enjoy more free space to make decisions on their own. However, as de Graaff and Kolmos' (2007) research found, in project work there is apparently no attempt to level out individual differences; rather it provides creative students with the opportunity to perform even better, meaning that not all students are well supported in project work.

An example of this is that most Chinese students do not like to express their opinions as they are afraid of making mistakes. As a result, once they are inspired to express their opinions in a UK classroom, they will still be hesitant compared to Western students. This situation also happens in the process of the design project. Design tutors need to encourage students to feel relaxed and positive when they are making errors, and also suggest that students think about their motivation for doing a project. However, this does not work for all students, as some may still proceed with the design project as they would have done without any extra support.

Therefore, in this study it is suggested that in the process of the FYDP, design tutors can encourage students from a new perspective, such as to apply product-oriented knowledge (K2, K6, K8, K9, K16) from the very beginning of the project, and to keep considering this in relation to the final solutions and product, making students form an idea that these kinds of knowledge may help them to be more effective when running their projects. This suggestion would probably work well for those students who are not so creative, as it provides a practical operation for them, which enables the design tutor to advise these students to approach something differently. For example, when these design students are stuck in the FYDP process, they can be encouraged to learn from their classmates by focusing on specific knowledge applied.

In terms of the students, they will receive directional guidance on what kinds of knowledge items might be emphasised before conducting the FYDP. It is also believed that students may gain a better understanding and grasp of this type of knowledge after their FYDPs.

6.3.2 Reflection-facilitating knowledge (K17, K18, K19, see Table 22, p. 232)

Like product-oriented knowledge, reflection-facilitating knowledge is also recommended for high frequency application by creative students in this study. This indicates that if design tutors suggest that students retrospectively consider their experiences when they are stuck at a certain stage of the design process, the students, if they follow the advice effectively, will be more reflective and thus manage their FYDP more smoothly.

For the design students themselves, this advice could also be used as a tip which makes them aware of the importance of accumulating design-related experience and cultivating reflection in their daily lives, so that they may progress better when conducting a long-term project similar to the FYDP.

The current students' lack of awareness is because related courses aiming to cultivate students' design experience usually provide the highest level of freedom for students, and therefore it is hard for design tutors to intervene. It is to a large degree a journey of self-learning. Students who have weak creative abilities might acquire less knowledge than the more creative students even if they engage in such a process, because they will feel they have nothing to learn without relevant guidance. The suggestion is that it is necessary to be aware of the quality of these courses, as the learning outcomes would largely influence the application of tacit knowledge in the process of the FYDP. One suggestion is to conduct a lecture before these activities for the sake of helping students set up learning goals and clarify their motivations. Moreover, setting up a feedback session at the intermediate stage, and organising several classes for students to share their experience would also be useful. All these strategies are aimed at helping students gain insights from what they have experienced, so that these can be integrated into their design projects. A well-structured 'Learner report' would be a good technique for achieving this, which provides related and professional guidance for students to check how much they have achieved. An example of applying a learner report in a design project is illustrated in Figure 43:

Learner reports

As part of the design project the student had to write his or her learning experiences at the end of each project. The instructions were:

- Learning experiences must be written in type-script, the 'house-style' of the School, on A4 format.
- For each project or project part the maximum size of the report is one page.
- The page should be subdivided into three sections:
  * An introduction into the content of the design project.
  * Learning experiences regarding the project just completed. The following standard sentences may be helpful: "I have learned that... (or) how to... (or) that it is not always true that..."
  * A beginning for consequent actions related to one or more of the learning experiences, e.g. "Next time I will (not)...".

Figure 43. Learner report contents (this example is from Christiaans, 1992, p. 65)

It is suggested that these activities would encourage the students to take advantage of tacit knowledge, referred to as reflection-facilitating materials, to improve the FYDP.

6.3.3 Socio-cultural related knowledge (K4, K7, K10, K12, K14, see Table 31, p. 270)

According to this finding, for the FYDP, it is suggested that design tutors cultivate students' awareness of these culturally-related knowledges and motivate them to apply these kinds of knowledge more fully during the FYDP process. The students would be encouraged to pay more attention to the trends of social, cultural or economic information in order to make themselves become more sensitive to these issues.

Moreover, in recent years, many courses based on studio or project work similar to the FYDP and involving students from different cultures have been developing. For example, the China School of Design at Nanjing University of the Arts teaches a course module named 'International Workshop' (involving students and tutors from the Netherlands, Germany and Belgium) to enhance the design students' competencies in communicating with different cultural backgrounds, embracing the complexity of modern society, and using their design practical skills. In Europe, a design course called 'Global Studio' (Bohemia & Harman, 2010), has been taught by several design schools, including those at Northumbria University and Edinburgh Napier University in the UK and TU Delft in the Netherlands, which aims to enhance design students' abilities in cross-cultural communication and collaboration. This would also offer opportunities to bring valuable ideas to improve the design of these courses.

A design team is likely to benefit from a diverse background of team members, but there is often a problem that the more diverse team members are, the more there will be differences or even conflicts between them. Therefore, to avoid conflicts and take advantage of the differences, team members must communicate with each other more frequently in order to understand why people are thinking in different ways. With such communication, there will be more sympathy between team members; they are more likely to cooperate more closely and make greater efforts to achieve the design goals.

In such a course, students come from all over the world, which results in different ways of thinking and different habits and behaviours. However, the tutors only have their own background, so they would not necessarily understand everyone in the class. Cultural difference in terms of knowledge application emphasis implies the necessity for design group members with different backgrounds to understand each other better from the perspective of the knowledge and skills they emphasise, so as to improve the communication between them. A good way to solve this problem and to promote better results for the students would be for the tutor to communicate more with the students, letting them share their views on the course or express their knowledge and cultural background in front of the whole class. This will enable the tutor to know more about the students and promote more effective understanding of each other.

This study also suggests setting relevant sections before studio-based courses which have a cultural mix of students; these would provide opportunities for students to know their classmates' understanding of design and their talents and gifts, which would facilitate communication in the co-operative design process. For example, in this pre-studio section, if one student finds him/herself to be good at Western-style design, while another is good at Eastern-style design, then they may be able to cooperate with each other on studio projects to provide product designs integrating both a Western and Eastern background. This mixing of culture and design style would be beneficial in inspiring students, and beneficial for better results for the whole studio class.

To sum up, looking back to the research problem identified in the early stages of the study (section 2.6, p. 48), tackling the problem that product design students fail to apply their knowledge effectively in the FYDP processes requires that these students apply more of the knowledge items shown in the aspects 1–3 of implications (pp. 322–323), which may also be improved via previous learning if appropriate changes can be made. Moreover, by stating the importance of using these kinds of knowledge students will be provided with guidance at the beginning of the FYDP, which will give them a general map of knowledge they are able to follow. Design tutors will also gain new insights for better instructing the FYDP process from the view of knowledge application.

6.3.4 Conceptual-process related knowledge (K3, K5, K15, see Table 29, p. 250)

According to the discussion in section 5.2.2 (pp. 253–264), the main body of the product design programme consists of process-based knowledge and skills. In China's Bachelor product design programmes, related courses for delivering knowledge of design methods and ill-structured problems are usually in the form of lectures and examined by paper test-based examinations, and for design representation, abundant training courses and practice are provided in the first and second years which reflect the students' application of these skills. In this study, it is claimed that these knowledge items (K3, K5, and K15) have relatively standardised procedures, follow specific principles, and play a significant role when delivering and expressing students' conceptual processes. Most importantly, this finding would suggest that when students are stuck at a certain stage of the FYDP, conducting more drafts (based on drawing or visualising) or showing related drafts to tutors for evaluation may not be a good choice to break through barriers. The focus might be shifted to paying more attention to the final product which would be improved by applying product-oriented knowledge and experiences.

6.3.5 Cross-disciplinary knowledge (K1, K11, K13, see Table 29, p. 250)

None of students apply these knowledge items very frequently. It is proposed that these cross-disciplinary knowledge items are applied at specific stages of the design process, rather than being continually used during the whole process. Therefore, depending primarily on applying this kind of knowledge may not be a useful way to better progress the FYDP process. However, as a stage-based investigation of the FYDP would cost much time and labour in a PhD programme, it is not possible to provide precise guidance, but it is proposed that there may be differences between students at the stage of applying these knowledge items which may influence their FYDP process. This is worth further exploration.

To conclude, the first three pieces of advice generate concrete suggestions for current product design education from a practical view. Although the other two pieces of advice cannot offer such concrete suggestions as the first three, they still provide reasonable proposals based on the current situation, and most importantly they create a new platform for design research on the topic of design knowledge and bring new insights and directions to design studies.

6.3.6 Other implications for China's design education and research

Additionally, this study was also able to draw implications on design education and research, particularly in China, from three aspects:

This study concentrated on the relationship between creativity and domain knowledge application, which involved 19 different subject-related knowledge items. We extracted a general idea of the roles they are playing in the holistic system of the design process to achieve creativity, and this outcome is required by China's design education. As Wang (2011) has stated, design is a relatively new subject in China with a 30-year history of development. Design syllabi were created based on the existing design syllabus in Japan, Germany, and other Western countries; however, what has been lacking is the investigation of how these subject-related knowledge items extracted from other countries serve a design task as a system. As a result, as Professor Guo (2005) pointed out, knowledge in the subject of design currently lacks systematic research and comprehensive understanding, based on which a more scientific and appropriate syllabus could be built. This study shed some light on this issue as subject-related knowledge was specifically re-categorised by identifying its different roles in relation to improving the process of the FYDP, which may also bring inspiration to design research on knowledge, as design today is developing very quickly and integrating more and more new subject knowledge (Barnett, 2000). We have to continuously think about the role of new knowledge that is involved in the design process.

Moreover, design is a subject which needs more practical training. In most of China's colleges where they deliver design programmes, the placement is usually set in the fourth year and lasts for 1–2 months. The aim is to help students obtain related experience of design projects to improve their practical capabilities, so as to prepare for the FYDP. In recent years, a few schools have extended the length of placement up to six months (e.g. CKAD, Shantou University). Our study indicates that although designers' experience is crucial, the most important thing is to integrate experience with the current situation, e.g. efficient reflective activities. For those students who lack such consciousness, neither a 2-month nor a 6-month placement would work effectively. Therefore, in this study, it is suggested that the intentions of design tutors turn to cultivating students' consciousness of the importance of reflective activities based on their experiences, rather than just obtaining related experience. For example, sharing and discussing students' experiences would be more helpful than just participating in design projects, and might be encouraged.

Finally, it is suggested that design educators might be aware of cultural differences when learning from other countries. As Chinese design educators, we have to carefully evaluate which subject-related knowledge might be embraced in our course list, and which may be less suitable in the Chinese context and therefore might not be over emphasised, e.g. the knowledge of client needs (K7) identified as one of the *socio-cultural environment related* knowledge items in this study.

6.4 Limitations

In addition to the suggestions on design education and design research, there are also several limitations to this study, which it is hoped might be addressed or refined in future studies, so as to make a bigger breakthrough than was possible in the current study. These shortcomings are summarised below:

Firstly, methodology: this study employed Likert scales, which have several innate limitations that should be noted, such as the data only suggesting relative responses, or tendency, rather than absolute responses. In addition, as a consequence of the existing shortages in current studies on this topic, this study applied the survey method to collect data from a large population group and used a statistical approach to analyse it, which also has some innate limitations. Although valuable findings were obtained from the study, these limitations should still be taken into account, including the following: statistics largely deals with averages and these averages may be made up of individual items radically different from each other; the data has been collected by participants who may have been dishonest or biased; statistics does not depict the entire story of the phenomenon as it cannot obtain individuals' in-depth information as is possible in a qualitative approach study, e.g. an in-depth interview (Ott & Longnecker, 2015)

It is also realised that although the knowledge list in the questionnaire has been preliminarily built up according to the relevant literature and has been pilot studied which is conducted by the author. However, there is a need to keep on reviewing ad updating the knowledge items, for example from an ethical and sustainable perspective. Design today is continually developing and integrating more knowledge hence from a research perspective, another study may need to investigate these aspects in addition to the list in this study (Barnett, 2000).

Moreover, this study investigated knowledge application in the FYDP process, which covers a complex cognitive activity in a long-term period, and which subsequently made this study full of challenges. I identified 13 items that were influenced by metacognition and 6 items not influenced. But unfortunately, I cannot rule out the possibility that the 6 items could be influenced by metacognition during a specific stage of the design process, if not observed for the whole process. In this study, it was impossible for me to obtain further information to look into specific stages during the design process due to the issues of time and labour. It is therefore suggested that any future study might focus on this specific issue.

Furthermore, in my preliminary outcomes, 13 knowledge items were identified as influenced by metacognition. However, this study could not provide any further evidence about whether the applications of those identified items were actually leading to creative performance in FYDPs, because currently there is no performance-based measurement for creativity (e.g. an efficient decision-making process, or a goal-setting process) (Jeon, Moon, & French, 2011; Razzouk & Shute, 2012). In this study it is not possible to make further suggestions on this issue. It is encouraged that future studies in creativity and the design domain to explore or develop a validated performance-based measurement, leading to more specific suggestions and results being generated.

6.5 Further suggestions

After exploring the impact of metacognition on design students' knowledge application in the FYDP, abundant issues have been found. These issues are worth exploring to make a greater contribution to this area, and are listed below:

First of all, relying on the constructed theoretical framework, this study conducted a preliminarily examination of the relationship between creativity and knowledge application from the view of creative thinking (via metacognition measurement) because there is lack of effective performance-based measurement tools within or across creativity and design research. Specifically, within the domain of design, there are insufficient relevant studies on the links between metacognition and creative outputs, and this needs more attention and focus. It is suggested that scholars dedicate more time to developing such measurements, which will contribute to identifying a more comprehensive picture for studies of creativity and knowledge application.

This study preliminarily categorised tacit knowledge into three aspects and found valuable results. However, the results also reveal that the list of tacit knowledge should be developed further; more detailed experiences should be added into the instruments.

If the experiences can be categorised into more types, with more details, building upon this study, then the suggestions would be more focused and directional. Therefore, a qualitative approach is suggested to explore more deeply the categories of people's experiences in forming tacit knowledge, so as to refine this instrument, and eventually generate better insight into this topic.

Additionally, in this study it is suggested that cross-disciplinary knowledge is being applied at specific stages of the design process, rather than being continually used during the whole process. It is assumed that students with different levels of creativity may apply these kinds of knowledge at different stages, which is believed to be another key point to explain how knowledge can be applied efficiently in the FYDP. It has not been identified in this study yet due to data availability. Therefore, to identify at which stage of the design process these knowledge items are emphasised is considered to be worth further exploration.

Finally, in this study data was collected from China and the UK. A global study on other countries is recommended, so as to form a comprehensive map of how design knowledge is used and how it is related to creativity in the world.

Chapter Seven: Conclusion

7.1 Chapter overview

This chapter is a conclusion of the whole study. It starts with Section 7.2, which gives a general summary of the whole research project, followed by Section 7.3, which highlights the main method, findings and implications of this study. Section 7.4 gives a summary of the contribution of the research to the body of knowledge. Finally, Section 7.5 offers a conclusion from the research.

7.2 Scope of the project

This research focused on the impact of metacognition on the application of different types of knowledge in the product design context, and in particular, the FYDP. The scope of this study included the interpretation of creativity, metacognition and knowledge, the identification of the knowledge items that are involved in the FYDP process, and discovery of the influences that metacognition had on each knowledge item. In order to obtain quantitative results, the initial assumptions of this research are proposed as below:

- Design students' creative thinking ability would be better measured through metacognition.
- Metacognition is a crucial factor that influences knowledge application.

- The application of knowledge would be a valid measure through their use frequency, which can be obtained by a student's retrospections on their FYDP process.

The aim of this research was to find out how metacognition, as a creative-related construct, influences each knowledge item applied in the FYDP through examining the differences in knowledge use between students (creative or not so creative). It is believed that creative students' ways of applying knowledge can be learned by those who are not so creative in order to improve their FYDP processes, and this can also benefit design tutors by enabling better instruction in the FYDP process. Due to the diversity of knowledge involved in the FYDP and the long period of the FYDP process, to get a comprehensive understanding of the impact of metacognition on the application of each knowledge item would be the most difficult part of this research. Therefore, a novel research strategy of a quantitative approach was used to analyse the relationship between metacognition and knowledge application. It is based on data collection work through an online questionnaire, which consisted of two main instruments. The main process is summarised in Figure 44 (p. 342).

By using this strategy, quantitative conclusions about metacognition's impact on each knowledge item were obtained through the use of statistical analysis, and other subtle characteristics of students involving their individual differences were taken into account using a quantitative statistical analysis; this was to further examine the validity of the results.

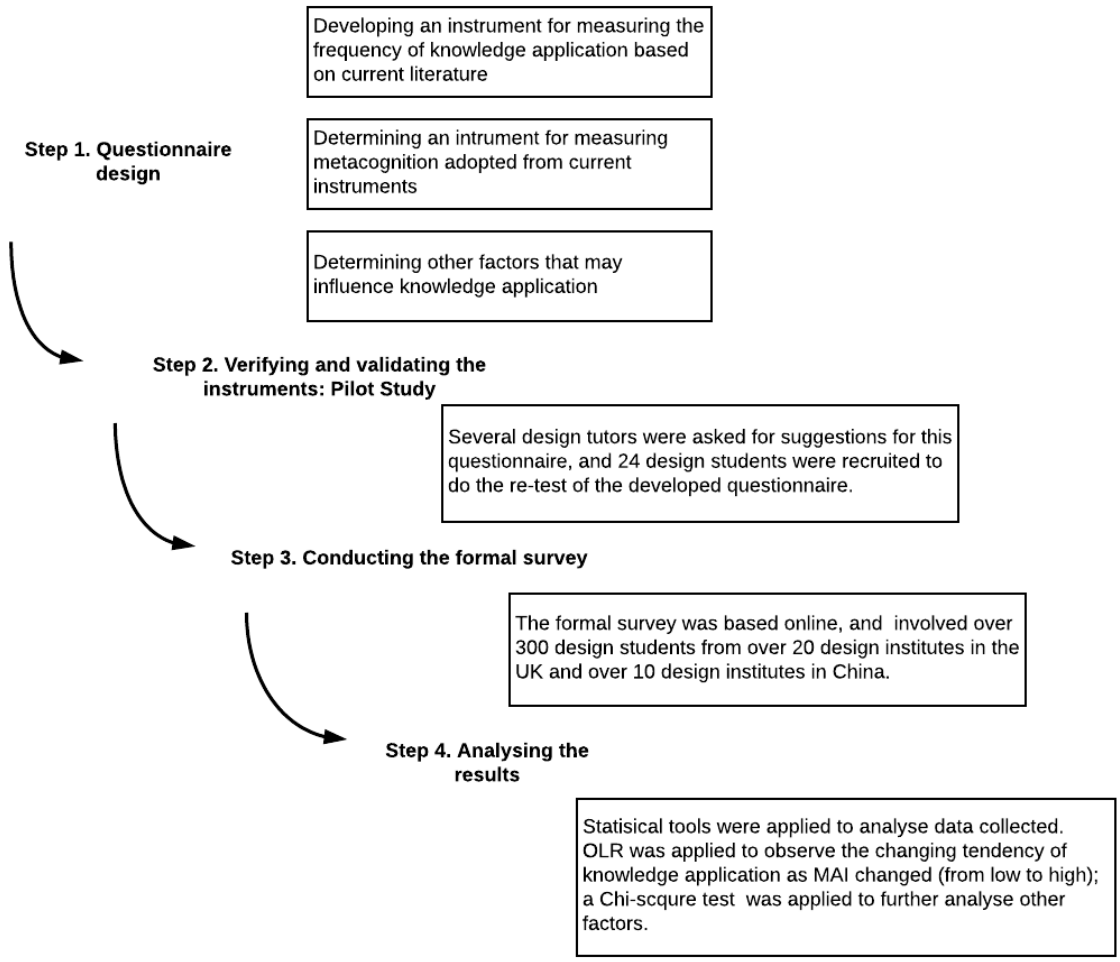

Figure 44. Summarised procedure of applying the quantitative approach

7.3 Summary of the methods, findings and implications

7.3.1 Identifying the research purpose

In the literature review in Chapter Two a lack of empirical studies on how metacognition affects cognitive activities was revealed. There is also confusion about knowledge category, and little is known about the way in which knowledge and skills within or across domains are actually used.

The literature review provided a comprehensive review of current studies of creativity and its related elements, creativity measurements, metacognition and the knowledge base. A theoretical framework was constructed through this literature review, which represents the relationship between creative relevant constructs, e.g. metacognition, creative performance and knowledge application. It proposed that knowledge application is impacted by metacognition. Moreover, metacognition measures people's creative thinking abilities from the perspective of development, so it may effectively predict people's creative performances. This literature review identified three categories of knowledge: domain-specific, domain-general, and tacit knowledge. Based on this proposed theoretical framework and the category of knowledge, moreover, as the lack of evidence concerning how different types of knowledge are applied in a design process, prompted the research purpose to identify specific knowledge applied and the extent they may be applied by product design students considered as being more creative as defined by the Metacognitive Assessment Inventory test.

7.3.2 Constructing a quantitative approach

This study involved the whole process of design students' FYDPs, which last for over three months. Thus, it is not easy to organise and manage the procedure of observing and recording activities during such a long period, and this may explain why there are few relevant studies focusing on the FYDP process. Measuring how knowledge is applied was another challenge in this study, as it also refers to a cognitive process and is difficult to describe. Therefore, to choose an appropriate research method was the biggest challenge for this study. Current studies on similar topics usually employ qualitative approaches via interviewing students and design tutors combined with protocol studies, and therefore, the scope of sample is limited with the subjects either from the same institute or comprising a few from different institutes. Therefore, the aim of this study was to obtain findings that could be generalised (which then required a sufficient sample size), rather than focusing on a specific case or phenomenon to ensure results through an investigation as a priority. Therefore, this study may not be seen as a comparative study. What is interesting for this study was not the similarities or differences of using design knowledge between the two cultures, but to identify the specific knowledge items e.g. K4. Knowledge of aesthetics, K7. Client needs. In this study, the results regarding these kinds of knowledge items (in Table 31, p. 270) rejected the null hypothesis only in a specific cultural context. As a result, it is reasonable to conclude that these kinds of knowledge items may be related to the socio-cultural attributes. These kinds of knowledge items may be not identified by analysing data collected from a single cultural context. Therefore, China and the UK data provide a more generalised result for this study than just a single country data.

This study used the perspective of post-positivism and follows the hypothetico-deductive approach, accepting the perspective of cognitivism. This was appropriate as the main objective of this study was to observe the relationship between students' metacognition and their knowledge application in FYDPs, which is largely related to design students' own internal mental processes and inner knowledge.

This study involved two cognitive relevant elements to be investigated: metacognition and the application of knowledge in a long-term process – the FYDP. Therefore, the psychometric approach was adopted for collecting data. Survey-based research does not allow for in-depth information concerning a specific topic as does an interview or case study with a limited number of interviewees. However, it can cover a wider range of issues with a much broader base of respondents, which was felt to be more appropriate for this study.

The data of participants' knowledge application and metacognition level were collected through a designed questionnaire. Based on the literature review, three categories of knowledge (domain-specific, domain-general, and tacit knowledge) were identified, and a knowledge list was created for constructing the questionnaire for the survey study. This questionnaire was verified by conducting a pilot study beforehand, and the survey study finally involved over 300 design students from over 30 institutions in the UK and China. The data was suitable for statistical analysis and, moreover, provided valuable findings from both the perspectives of product design and creativity.

7.3.3 Studying the relationship between metacognition and knowledge application by using models and experimental data

In this research the relationship between metacognition and knowledge application was studied, the results of which brought further insight to the main research questions by answering a series of sub-questions, which helped to fill in the gaps in the literature.

In the list of domain-specific knowledge, there are four knowledge items (K2, K6, K8, K9) that are proven to be influenced by metacognition. These items are believed to be related to the final products. In other words, the application of these kinds of knowledge items will be reflected directly in the final products. This finding supports the perspective that design is a solution or product-directed process. There may be particular connections between applications of this product-oriented knowledge and creativity, because the results indicated that creative students tend to apply product-oriented knowledge with a higher frequency: the more creative, the higher the frequency. There are two knowledge items (K3 and K5) that reflect the students' conceptual process during the design process. This study did not provide any evidence regarding the relationship between their application frequency and creativity, but from the mean value of their application frequency, these knowledge items (K3 and K5) are considered to be very basic and significant in design projects. There are several knowledge items (K1, K11, K13) that are multi-domain, including history, media, and psychology. This study indicated their applications are not influenced by metacognition. In addition, there are four kinds of knowledge (K4, K7, K10, K12) whose applications demonstrated the difference of cultures.

In this study, the items within domain-general knowledge are related to process-relevant knowledge. The results indicated that the physical process K16 (such as concrete activities directed by plans, motivation and goals of a project) that leads to the design product is influenced by metacognition, whereas the conceptual process (K15) is not affected by it, which is similar to the results in domain-specific knowledge. The K16 related to physical process is thus considered to be product-oriented as well. This study suggested that although such kinds of product-oriented knowledge are important, the students with relatively lower creative abilities have little idea about when, where, and to what extent to use these kinds of knowledge. However, the conceptual process can be applied any time and at any moment, even if there is no clear direction or plan. In addition, the application of K14 demonstrated differences in knowledge application in the different cultural contexts.

This study also involved another type of knowledge – tacit knowledge (including K17, K18, K19), which has had limited discussion in the literature. It is first defined by Polanyi (1966; 2009), in his book *Tacit Dimension*. The main reason is that this type of knowledge cannot often be described in detail as people are not always aware of it whilst it is being acquired and applied. Moreover, it cannot be delivered directly, but is usually learned by activity and training in the current and relevant design process. This study embraced several kinds of experiences that comprise tacit knowledge involved in the FYDP process, although they are categorised roughly as there are very few studies on this topic. They mainly refer to the design precedents, the experiences of design projects, and the living experiences, which embrace both professional and personal aspects. The results showed that metacognition does influence the application of this type of knowledge.

In addition, my results indicated that creative students are more sensitive to relevant knowledge as related to social trends. This is achieved by comparing the results of China and the UK. In China, creative design students tend to apply knowledge of K4, K10 and K12, while in the UK, creative design students tend to apply knowledge of K7 and K14. Though there is difference, they share a common ground that the knowledge application conforms to the social values and cultures in each country. Therefore, K4, K7, K10, K12, and K14 are identified as socio-cultural environment related knowledge.

7.3.4 interpreting the impact of the main findings

The in-depth discussions focused on how the identified knowledge items (influenced by metacognition) are applied by creative students, and how they are related to creativity, in comparison to the current literature. Amongst them, K2, K6, K8, and K9 belong to domain-specific knowledge. They are applied from the beginning of the design process to the end and therefore directly lead to the performances of the final products. K16, as one domain-general knowledge item, is leading the direction of the whole design process as it refers to strategic knowledge involving motivations, goals and plans, as well as focusing on the aim of solving design problems and generating the final designed product. Hence K16 can be seen as a guideline of the design process, directing all activities towards the final product. Hence, they are considered to be product-oriented related knowledge in this process.

K17, K18, K19 are specifically important as the magnitude of metacognition impact on them (the values of the coefficient) is larger than that on domain knowledge (both domain-specific and domain-general knowledge). These pieces of experience-based knowledge are fundamental material for enabling reflective activities in the design process. Therefore, this study also highlighted the important role of reflective activities in this process, as K17, K18, and K19 were largely applied by creative students. They are thus considered to play a role in reflection-facilitating.

In addition, our results indicated that creative students are more sensitive to relevant knowledge as related to social trends. In China, creative design students tend to apply knowledge of K4, K10 and K12, while in the UK, creative design students tend to apply knowledge of K7 and K14. Though there is difference, they share a common ground that the knowledge application conforms to the social values and cultures in each country. Therefore, K4, K7, K10, K12, and K14 are identified as socio-cultural environment related knowledge.

The findings of this study could not provide further evidence to state whether knowledge items K3, K5, and K15 can improve students' creativity in the FYDP; but based on the discussion, this study considered that K3, K5, and K15 are deemed more inclusive knowledge that needs to be combined with other knowledge in the design process. They are related to conceptual processes when conducting a design project.

Similarly, our findings could not provide further evidence to state whether K1, K11, and K13 can improve students' creativity in the FYDP. But as they are all applied infrequently, this study assumes that cross-disciplinary knowledge may have specific meaning in a certain stage of design. Therefore, they represent the aspect of cross-discipline in a design project.

Conclusively, this study then provided a new insight to categorise subject-related knowledge: *product-oriented, reflection-facilitating, socio-cultural environment related, conceptual-process related,* and *cross-disciplinary knowledge*, based on a comprehensive understanding of design subject-related knowledge application and creativity in the design process.

7.4 Summarising the main contributions

As concluded, the contributions of this research are three-fold:

1. From the theoretical aspect: it is the first attempt to analyse how domain knowledge applies in the design process in such detail. Moreover, it firstly tried to explore how creative thinking impacts on knowledge application. It explored identified literature gaps, and thus brought valuable suggestions to current design and creativity studies.

2. From the methodological aspect: this study employed a quantitative post-positivist approach which can easily be replicated and examined by other research in relation to similar situations, such as different cultural contexts. It also brought new insight to design education based on an empirical study rather than extracting from small-scale practices.
3. From the practical aspect: it was proposed that the main findings be applied as an instruction for the teaching in the FYDP, enhancing the students' independence in the process of the FYDP. Moreover, the findings provided more practical and specific suggestions for China's design education and research.

7.5 Conclusion

This thesis has presented empirical findings which indicate that metacognition exerts an impact on the application of a part of subject-related knowledge; it then provided a new perspective to comprehensively understand subject-related knowledge by suggesting a new way of categorising it. To the author's knowledge, this is the first step in studying how metacognition impacts on knowledge application (a cognitive process) in design education. It is also the first time that knowledge application is reported in such detail by using quantitative methods; moreover, the findings can be drawn upon as generalised findings (to a certain degree) as the data was collected from over 30 universities in two typical countries in the West and East. Initial results illustrate the importance of exploring knowledge application in future research and providing insight for improved practices within and across design educational and creative domains. Most importantly, an effort was made in this thesis to provide insights into the knowledge application in a design process. For example, suggestions and hints can be offered, based on the results, to potentially facilitate the FYDP process in design education, which is consistent with the developing trend in design education as advocated by the Chinese government.

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Appendix 1. Questionnaire
Appendix. 1-1

Loughborough University

Project Title

Improving the creative process
- Developing an effective way of applying personal knowledge in product design final year design project

Investigators Details:
Yang Zhang, Design School, Loughborough University, LE11 3TU, Y.zhang4@lboro.ac.uk, + 441509 226900

Other investigators (Supervisors):
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John McCardle, Design School, Loughborough University, LE11 3TU, J.R.Mccardle@lboro.ac.uk, +441509 222667

Section A: Information of this study

We would like to invite you to take part in our study. Before you decide we would like you to understand why the research is being done and what it would involve for you. One of our team will go through the information sheet with you and answer any questions you have. Talk to others about the study before making a decision if you wish.

What is the purpose of the study?

This research is titled 'Improving the creative process - Developing an effective way of applying personal knowledge in product design final year design project (FYDP)', which is being done by Yang Zhang from the Design School, Loughborough University. A common phenomenon reflected in the current design education is that students of Product Design programmes are observed to depend highly on their tutors' suggestions in the progression of FYDPs. Through the preliminary survey, it is proposed that some students, due to the lack of creative abilities, find it difficult to apply subject specific knowledge effectively, leading to their high dependence on their tutors' suggestions in FYDP processes. Therefore, the purpose of the study is to investigate the pattern of personal knowledge applying of individual product design student with the different level of metacognition which is defined as the criteria of the effectiveness of creative process in the FYDP. The aim is being to generate an effective way of knowledge application that improves students' creative performances in the FYDPs processes, which is expected to bring deep insight to improve the design education practice.

Who is doing this research and why?

This research is being done by Yang Zhang, from the Design School, Loughborough University. It is supervised by Erik Bohemia and John McCardle from the Design School, Loughborough University. This study is part of a Student research project supported by Loughborough University.

Are there any exclusion criteria?
You are requested to have finished your final year design project.

What will I be asked to do?

This survey is in the form of online questionnaire, which is consisted of three parts: I. Basic information; II. Self-reported Psychometric Test: How do you apply your knowledge? III. Metacognitive Awareness Inventory.

So you will be asked to complete this questionnaire via the website link highlighted in your invitation email.

Once I take part, can I change my mind?

Yes. After you have read this information and asked any questions you may have if you are happy to participate we will ask you to complete an Informed Consent Form, however if at any time, before, during or after the sessions you wish to withdraw from the study please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

However, once the results of the study are aggregated/published/dissertation has been submitted (expected to be by <01-10-2018>), it will not be possible to withdraw your individual data from the research.

Will I be required to attend any sessions and where will these be?

No.

How long will it take?

This will take you approximately 30 minutes to complete the session of survey. Including reading this information sheet (5-10 minutes) and the later session of completing the questionnaire survey (20-25 minutes). You will be left 14 days to complete this survey. You can choose any time to do this survey at your convenience during this period from 18-05-2017 to 01-06-2017.

What personal information will be required from me?

You will just need to provide your age, gender and the university that you come from.

Are there any disadvantages or risks in participating?

We believe there are no known risks associated with this research study. However, as with any online related activity the risk of a breach is always possible. Moreover, considering there are over 70 questions to be answered in total, you may feel tired or uncomfortable, but as we have mentioned you can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing. At last, please make sure that you will do this survey in a relatively safe place, such as home, classroom, etc.

Will my taking part in this study be kept confidential?

All information on participants will be treated as confidential and not identifiable unless agreed otherwise in advance, and subject to the requirements of law; storage of data comply with the Data Protection Act 1998 and the Guidance Note on 'Data Protection and Storage'. Research will not involve the sharing of data or confidential information beyond the initial consent given. The data collected during the study will be stored securely until being destroyed upon completion of the project in October 2018.

I have some more questions; who should I contact?

Any questions please do not hesitate to contact with Yang Zhang, Design School, Loughborough University, LE11 3TU, Y.zhang4@lboro.ac.uk, + 441509 226900

What will happen to the results of the study?

Your self-report will be collected for analysing, and the results will be applied to develop an effective way of applying personal knowledge in product design final year project. The data collected during the study will be stored securely until being destroyed upon completion of the project in October 2018.

What if I am not happy with how the research was conducted?

If you are not happy with how the research was conducted, please contact Ms Jackie Green, the Secretary for the University's Ethics Approvals (Human Participants) Sub-Committee:

Ms J Green, Research Office, Hazlerigg Building, Loughborough University, Epinal Way, Loughborough, LE11 3TU. Tel: 01509 222423. Email: J.A.Green@lboro.ac.uk

The University also has a policy relating to Research Misconduct and Whistle Blowing which is available online at http://www.lboro.ac.uk/committees/ethics-approvals-human-participants/additionalinformation/codesofpractice/ .

Section B: Other questions you may ask about this study

Is there anything I need to do before the sessions?

No.

Is there anything I need to bring with me?

All you will need is a device connected to the internet, such as computer, tablet device or smart mobile phone.

What type of clothing should I wear?

Any.

Who should I send the questionnaire back to?

Your response will be collected by the online questionnaire system automatically once you complete the last question, which will be collected by the investigator.

What are the possible benefits of participating?

The participants may have the information of their metacognition level statistics, which may help them know more about the learning effectiveness of themselves and the degrees of involving in the creative process.

Appendix. 1-2

Loughborough University

Improving the creative process
- Developing an effective way of applying personal knowledge in product design final year project

INFORMED CONSENT FORM

(to be completed after Participant Information Sheet has been read)

Taking Part

Please initial box

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethics Approvals (Human Participants) Sub-Committee. ☐

I have read and understood the information sheet and this consent form. ☐

I have had an opportunity to ask questions about my participation. ☐

I understand that I am under no obligation to take part in the study, have the right to withdraw from this study at any stage for any reason, and will not be required to explain my reasons for withdrawing. ☐

I agree to take part in this study. Taking part in the project will include finishing self-report in the form of questionnaire. ☐

Use of Information

I understand that all the personal information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless (under the statutory obligations of the agencies which the researchers are working with), it is judged that confidentiality will have to be breached for the safety of the participant or others or for audit by regulatory authorities. ☐

I understand that anonymised quotes may be used in publications, reports, web pages, and other research outputs. ☐

I agree for the data I provide to be securely archived at the end of the project. ☐

I agree to assign the copyright I hold in any materials related to this project to Yang Zhang ☐

Name of participant	[printed]	Signature	Date
Researcher	[printed]	Signature	Date

Appendix. 1-3 Questionnaire:

Loughborough University

Online Survey on how the metacognition level influences the pattern of knowledge application of product design students in final year projects

Dear colleague/student, you are being invited to participate in this study titled 'Developing an effective way of applying personal knowledge in product design final year project'. This research is being done by Yang Zhang from the Design School, Loughborough University. The purpose of the study is to investigate the pattern of personal knowledge applying of individual product design student with the different level of metacognition in the final year design project (FYDP). The aim being to generate an effective way of knowledge application that improves students' creative performances in the FYDPs processes. Please fill in the questionnaire form in the following pages.

This survey is consisted of three sections: I. Basic information of participant; II. Self-reported Psychometric Test: How do you apply your knowledge? III. Metacognitive Awareness Inventory.

This will take you approximately 20 minutes to complete. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any question. We believe there are no known risks associated with this research study. To the best of our ability your answers in this study will remain confidential.

Section I. Basic information of participant
Please provide appropriate information of yourself by using '√'

Your Age	Under 18	18-21	21-24	Over 24

Your Gender	Male	Female

Department:

Section II. Self-Reported Psychometric Test

How do you apply your knowledge?

Please retrospect carefully about how you applied your knowledge in the process that you implemented in your Final Year Design Project, then select the appropriate scale of each statement of the following knowledge using '√' to indicate to what extent you employed it in that project.

Before starting the following survey, please provide the information of what subject of your project is (e.g. Transportation design) in the blank area below:

____

Scale / Domain-specific Knowledge	Never used	Very rarely	Rarely	Occasionally	Frequently	Very frequently	Always used
1. Design History: knowledge relating to styling, perspectives.							
2. Material: knowledge relating to specific materials to attain certain concept solutions							
3. Design methods: knowledge relating to the application of design research, design case studies							
4. Aesthetics: knowledge relating to colour, structure and form							
5. Design representation: skills relating to 2D/3D drawing (effect drawing, three views)							
6. User Trials: knowledge relating to simulations of product usage in which subjects are asked to fulfill specified tasks using a product or product simulation.							
7. Client needs: knowledge relating to analysing the design brief							
8. Mechanics							
9. Ergonomics							
10. Skill to operate relevant machines							
11. Media technologies, such as digital imagery, digital video, and printing technology							
12. Knowledge of organization and marketing including project management and understanding organizational behaviour.							
13. Psychology regarding with the psychological stage of consumer/user							

Scale / Domain-general Knowledge	Never used	Very rarely	Rarely	Occasionally	Frequently	Very frequently	Always used
14. Knowledge of information processing: information searching and analysing							
15. Ill-structured problem solving process: knowledge relating to analysing situations, defining problems, finding or generating solutions.							
16. Strategies: knowledge relating to motivation, plan and goals.							

Scale / Tacit Knowledge	Never used	Very rarely	Rarely	Occasionally	Frequently	Very frequently	Always used
17. Knowledge of existing design solutions: the precedents of a similar project you have learned							
18. Personal placement experience in design companies							
19. Other experience in daily life: such as travelling, reading, events, etc.							

Scoring Guide:

Never used=1;
Very rarely=2;
Rarely=3;
Occasionally=4;
Frequently=5;
Very frequently=6;
Always used=7

Section III. Metacognitive Awareness Inventory

Metacognitive Awareness Inventory (MAI)

Schraw, G. & Dennison, R.S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, 19, 460-475.

Check True or False as appropriate. Use the Scoring Guide after completing the inventory.

	True	False
1. I ask myself periodically if I am meeting my goals.		
2. I consider several alternatives to a problem before I answer.		
3. I try to use strategies that have worked in the past.		
4. I pace myself while learning in order to have enough time.		
5. I understand my intellectual strengths and weaknesses.		
6. I think about what I really need to learn before I begin a task		
7. I know how well I did once I finish a test.		
8. I set specific goals before I begin a task.		
9. I slow down when I encounter important information.		
10. I know what kind of information is most important to learn.		
11. I ask myself if I have considered all options when solving a problem.		
12. I am good at organizing information.		
13. I consciously focus my attention on important information.		
14. I have a specific purpose for each strategy I use.		
15. I learn best when I know something about the topic.		
16. I know what the teacher expects me to learn.		
17. I am good at remembering information.		
18. I use different learning strategies depending on the situation.		
19. I ask myself if there was an easier way to do things after I finish a task.		
20. I have control over how well I learn.		
21. I periodically review to help me understand important relationships.		
22. I ask myself questions about the material before I begin.		
23. I think of several ways to solve a problem and choose the best one.		
24. I summarize what I've learned after I finish.		
25. I ask others for help when I don't understand something.		
26. I can motivate myself to learn when I need to		
27. I am aware of what strategies I use when I study.		
28. I find myself analyzing the usefulness of strategies while I study.		
29. I use my intellectual strengths to compensate for my weaknesses.		
30. I focus on the meaning and significance of new information.		
31. I create my own examples to make information more meaningful.		
32. I am a good judge of how well I understand something.		
33. I find myself using helpful learning strategies automatically.		
34. I find myself pausing regularly to check my comprehension.		

	True	False
35. I know when each strategy I use will be most effective.		
36. I ask myself how well I accomplish my goals once I'm finished.		
37. I draw pictures or diagrams to help me understand while learning.		
38. I ask myself if I have considered all options after I solve a problem.		
39. I try to translate new information into my own words.		
40. I change strategies when I fail to understand.		
41. I use the organizational structure of the text to help me learn.		
42. I read instructions carefully before I begin a task.		
43. I ask myself if what I'm reading is related to what I already know.		
44. I reevaluate my assumptions when I get confused.		
45. I organize my time to best accomplish my goals.		
46. I learn more when I am interested in the topic.		
47. I try to break studying down into smaller steps.		
48. I focus on overall meaning rather than specifics.		
49. I ask myself questions about how well I am doing while I am learning something new.		
50. I ask myself if I learned as much as I could have once I finish a task.		
51. I stop and go back over new information that is not clear.		
52. I stop and reread when I get confused.		

Scoring Guide: True=1, False=0

Regulation of Cognition

Planning
–Planning, goal setting, and allocating resources *prior* to learning
Information Management Strategies
–Skills and strategy sequences used to process information more efficiently (e.g., organizing, elaborating, summarizing, selective focusing)
Comprehension Monitoring
–Assessment of one's learning or strategy use
Debugging Strategies
–Strategies used to correct comprehension and performance errors
Evaluation
–Analysis of performance and strategy effectiveness after a learning episode

Planning	Score
4. I pace myself while learning in order to have enough time.	
6. I think about what I really need to learn before I begin a task.	
8. I set specific goals before I begin a task.	
22. I ask myself questions about the material before I begin.	
23. I think of several ways to solve a problem and choose the best one.	
42. I read instructions carefully before I begin a task.	
45. I organize my time to best accomplish my goals.	
Total	7

Information Management Strategies	Score
9. I slow down when I encounter important information.	
13. I consciously focus my attention on important information.	
30. I focus on the meaning and significance of new information.	
31. I create my own examples to make information more meaningful.	
37. I draw pictures or diagrams to help me understand while learning.	
39. I try to translate new information into my own words.	
41. I use the organizational structure of the text to help me learn	
43. I ask myself if what I'm reading is related to what I already know.	
47. I try to break studying down into smaller steps.	
48. I focus on overall meaning rather than specifics.	
Total	10

Comprehension Monitoring	Score
1. I ask myself periodically if I am meeting my goals.	
2. I consider several alternatives to a problem before I answer.	
11. I ask myself if I have considered all options when solving a problem.	
21. I periodically review to help me understand important relationships.	
28. I find myself analyzing the usefulness of strategies while I study.	
34. I find myself pausing regularly to check my comprehension.	
49. I ask myself questions about how well I am doing while learning something new.	
Total	7

Debugging Strategies	Score
25. I ask others for help when I don't understand something.	
40. I change strategies when I fail to understand.	
44. I re-evaluate my assumptions when I get confused.	
51. I stop and go back over new information that is not clear.	
52. I stop and reread when I get confused.	
Total	5

Evaluation	Score
7. I know how well I did once I finish a test.	
18. I ask myself if there was an easier way to do things after I finish a task.	
24. I summarize what I've learned after I finish.	
36. I ask myself how well I accomplish my goals once I'm finished.	
38. I ask myself if I have considered all options after I solve a problem.	
49. I ask myself if I learned as much as I could have once I finish a task.	
Total	6

Thank you for your time!

Appendix 2. Questionnaire for Pilot study
Appendix. 2-1

Project Title

Improving the creative process
- Developing an effective way of applying personal knowledge in product design final year design project

Investigators Details:
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Other investigators (Supervisors):
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John McCardle, Design School, Loughborough University, LE11 3TU,
J.R.Mccardle@lboro.ac.uk, +441509 222667

Section A: Information of this study

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Who is doing this research and why?

This research is being done by Yang Zhang, from the Design School, Loughborough University. It is supervised by Erik Bohemia and John McCardle from the Design School, Loughborough University. This study is part of a Student research project supported by Loughborough University.

Are there any exclusion criteria?
You are requested to have finished your final year design project.

What will I be asked to do?

This survey is in the form of questionnaire, which is consisted of three parts: I. Basic information; II. Self-reported Psychometric Test: How do you apply your knowledge? III. Metacognitive Awareness Inventory.

So you will be asked to complete this questionnaire.

Once I take part, can I change my mind?

Yes. After you have read this information and asked any questions you may have if you are happy to participate we will ask you to complete an Informed Consent Form, however if at any time, before, during or after the sessions you wish to withdraw from the study please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

However, once the results of the study are aggregated/published/dissertation has been submitted (expected to be by <01-10-2018>), it will not be possible to withdraw your individual data from the research.

Will I be required to attend any sessions and where will these be?

No.

How long will it take?

This will take you approximately 30 minutes to complete the session of survey. Including reading this information sheet (5-10 minutes) and the later session of completing the questionnaire survey (20-25 minutes).

What personal information will be required from me?

You will just need to provide your age, gender and the university that you come from.

Are there any disadvantages or risks in participating?

We believe there are no known risks associated with this research study. However, as with any online related activity the risk of a breach is always possible. Moreover, considering there are over 70 questions to be answered in total, you may feel tired or uncomfortable, but as we have mentioned you can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing. At last, please make sure that you will do this survey in a relatively safe place, such as home, classroom, etc.

Will my taking part in this study be kept confidential?

All information on participants will be treated as confidential and not identifiable unless agreed otherwise in advance, and subject to the requirements of law; storage of data comply with the Data Protection Act 1998 and the Guidance Note on ‘Data Protection and Storage’. Research will not involve the sharing of data or confidential information beyond the initial consent given. The data collected during the study will be stored securely until being destroyed upon completion of the project in October 2018.

I have some more questions; who should I contact?

Any questions please do not hesitate to contact with Yang Zhang, Design School, Loughborough University, LE11 3TU, Y.zhang4@lboro.ac.uk, + 441509 226900

What will happen to the results of the study?

Your self-report will be collected for analysing, and the results will be applied to develop an effective way of applying personal knowledge in product design final year project. The data collected during the study will be stored securely until being destroyed upon completion of the project in October 2018.

What if I am not happy with how the research was conducted?

If you are not happy with how the research was conducted, please contact Ms Jackie Green, the Secretary for the University's Ethics Approvals (Human Participants) Sub-Committee:

Ms J Green, Research Office, Hazlerigg Building, Loughborough University, Epinal Way, Loughborough, LE11 3TU. Tel: 01509 222423. Email: J.A.Green@lboro.ac.uk

The University also has a policy relating to Research Misconduct and Whistle Blowing which is available online at http://www.lboro.ac.uk/committees/ethics-approvals-human-participants/additionalinformation/codesofpractice/ .

Section B: Other questions you may ask about this study

Is there anything I need to do before the sessions?

No.

Is there anything I need to bring with me?

All you will need is a device connected to the internet, such as computer, tablet device or smart mobile phone.

What type of clothing should I wear?

Any.

Who should I send the questionnaire back to?

Your response will be collected by the online questionnaire system automatically once you complete the last question, which will be collected by the investigator.

What are the possible benefits of participating?

The participants may have the information of their metacognition level statistics, which may help them know more about the learning effectiveness of themselves and the degrees of involving in the creative process.

Appendix. 2-2

Improving the creative process
- Developing an effective way of applying personal knowledge in product design final year project

INFORMED CONSENT FORM

(to be completed after Participant Information Sheet has been read)

Taking Part

Please initial box

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethics Approvals (Human Participants) Sub-Committee. ☐

I have read and understood the information sheet and this consent form. ☐

I have had an opportunity to ask questions about my participation. ☐

I understand that I am under no obligation to take part in the study, have the right to withdraw from this study at any stage for any reason, and will not be required to explain my reasons for withdrawing. ☐

I agree to take part in this study. Taking part in the project will include finishing self-report in the form of questionnaire. ☐

Use of Information

I understand that all the personal information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless (under the statutory obligations of the agencies which the researchers are working with), it is judged that confidentiality will have to be breached for the safety of the participant or others or for audit by regulatory authorities. ☐

I understand that anonymised quotes may be used in publications, reports, web pages, and other research outputs. ☐

I agree for the data I provide to be securely archived at the end of the project. ☐
I agree to assign the copyright I hold in any materials related to this project to Yang Zhang ☐

Name of participant	[printed]	Signature	Date
Researcher	[printed]	Signature	Date

Appendix 2-3. Questionnaire:

Loughborough University

A Survey on how the metacognition level influences the pattern of knowledge application of product design students in final year projects

Dear colleague/student, you are being invited to participate in this Pilot study titled 'Developing an effective way of applying personal knowledge in product design final year project'. This research is being done by Yang Zhang from the Design School, Loughborough University. The purpose of the study is to investigate the pattern of personal knowledge applying of individual product design student with the different level of metacognition in the final year design project (FYDP). The aim being to generate an effective way of knowledge application that improves students' creative performances in the FYDPs processes. Please fill in the questionnaire form in the following pages.

This survey is consisted of three sections: I. Basic information of participant; II. Self-reported Psychometric Test: How do you apply your knowledge? III. Metacognitive Awareness Inventory.

This will take you approximately 20 minutes to complete. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any question. We believe there are no known risks associated with this research study. To the best of our ability your answers in this study will remain confidential.

Section I. Basic information of participant
Please provide appropriate information of yourself by using '√'

Your Age	Under 18	18-21	21-24	Over 24

Your Gender	Male	Female

Department:

Section II. Self-reported Psychometric Test
How do you apply your knowledge?

Please retrospect carefully about how you applied your knowledge in the process that you implemented in your Final Year Design Project, then select the appropriate scale of each statement of the following knowledge using '√' to indicate to what extent you employed it in that project.

Before starting the following survey, please provide the information of what subject of your project is (e.g. Transportation design) in the blank area below:

Scale / Domain-specific Knowledge	Never used	Very rarely	Rarely	Occasionally	Frequently	Very frequently	Always used
1. Design History: knowledge relating to styling, perspectives.							
2. Material: knowledge relating to specific materials to attain certain concept solutions							
3. Design methods: knowledge relating to the application of design research, design case studies							
4. Aesthetics: knowledge relating to colour, structure and form							
5. Design representation: skills relating to 2D/3D drawing (effect drawing, three views)							
6. User Trials: knowledge relating to simulations of product usage in which subjects are asked to fulfill specified tasks using a product or product simulation.							
7. Client needs: knowledge relating to analysing the design brief							
8. Mechanics							
9. Ergonomics							
10. Skill to operate relevant machines							
11. Media technologies, such as digital imagery, digital video, and printing technology							
12. Knowledge of organization and marketing including project management and understanding organizational behaviour.							
13. Psychology regarding with the psychological stage of consumer/user							

Please list the question number of the above questions that make no sense to you in the blank area below, and please provide your reasons for that briefly if you can.

Scale / Domain-general Knowledge	Never used	Very rarely	Rarely	Occasionally	Frequently	Very frequently	Always used
14. Knowledge of information processing: information searching and analysing							
15. Ill-structured problem solving process: knowledge relating to analysing situations, defining problems, finding or generating solutions.							
16. Strategies: knowledge relating to motivation, plan and goals.							

Please list the question number of the above questions that make no sense to you in the blank area below, and please provide your reasons for that briefly if you can.

Scale / Tacit Knowledge	Never used	Very rarely	Rarely	Occasionally	Frequently	Very frequently	Always used
17. Knowledge of existing design solutions: the precedents of similar project you have learned							
18. Personal placement experience in design companies							
19. Other experience in daily life.							

Please list the question number of the above questions that make no sense to you in the blank area below, and please provide your reasons for that briefly if you can.

Scoring Guide:

Never used=1;
Very rarely=2;
Rarely=3;
Occasionally=4;
Frequently=5;
Very frequently=6;
Always used=7

Section III. Metacognitive Awareness Inventory

Metacognitive Awareness Inventory (MAI)

Schraw, G. & Dennison, R.S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, 19, 460-475.

Check True or False as appropriate. Use the Scoring Guide after completing the inventory.

	True	False
1. I ask myself periodically if I am meeting my goals.		
2. I consider several alternatives to a problem before I answer.		
3. I try to use strategies that have worked in the past.		
4. I pace myself while learning in order to have enough time.		
5. I understand my intellectual strengths and weaknesses.		
6. I think about what I really need to learn before I begin a task		
7. I know how well I did once I finish a test.		
8. I set specific goals before I begin a task.		
9. I slow down when I encounter important information.		
10. I know what kind of information is most important to learn.		
11. I ask myself if I have considered all options when solving a problem.		
12. I am good at organizing information.		
13. I consciously focus my attention on important information.		
14. I have a specific purpose for each strategy I use.		
15. I learn best when I know something about the topic.		
16. I know what the teacher expects me to learn.		
17. I am good at remembering information.		
18. I use different learning strategies depending on the situation.		
19. I ask myself if there was an easier way to do things after I finish a task.		
20. I have control over how well I learn.		
21. I periodically review to help me understand important relationships.		
22. I ask myself questions about the material before I begin.		
23. I think of several ways to solve a problem and choose the best one.		
24. I summarize what I've learned after I finish.		
25. I ask others for help when I don't understand something.		
26. I can motivate myself to learn when I need to		
27. I am aware of what strategies I use when I study.		
28. I find myself analyzing the usefulness of strategies while I study.		
29. I use my intellectual strengths to compensate for my weaknesses.		
30. I focus on the meaning and significance of new information.		
31. I create my own examples to make information more meaningful.		
32. I am a good judge of how well I understand something.		
33. I find myself using helpful learning strategies automatically.		
34. I find myself pausing regularly to check my comprehension.		

	True	False
35. I know when each strategy I use will be most effective.		
36. I ask myself how well I accomplish my goals once I'm finished.		
37. I draw pictures or diagrams to help me understand while learning.		
38. I ask myself if I have considered all options after I solve a problem.		
39. I try to translate new information into my own words.		
40. I change strategies when I fail to understand.		
41. I use the organizational structure of the text to help me learn.		
42. I read instructions carefully before I begin a task.		
43. I ask myself if what I'm reading is related to what I already know.		
44. I reevaluate my assumptions when I get confused.		
45. I organize my time to best accomplish my goals.		
46. I learn more when I am interested in the topic.		
47. I try to break studying down into smaller steps.		
48. I focus on overall meaning rather than specifics.		
49. I ask myself questions about how well I am doing while I am learning something new.		
50. I ask myself if I learned as much as I could have once I finish a task.		
51. I stop and go back over new information that is not clear.		
52. I stop and reread when I get confused.		

Scoring Guide: True=1, False=0

Regulation of Cognition

Planning –Planning, goal setting, and allocating resources *prior* to learning **Information Management Strategies** –Skills and strategy sequences used to process information more efficiently (e.g., organizing, elaborating, summarizing, selective focusing) **Comprehension Monitoring** –Assessment of one's learning or strategy use **Debugging Strategies** –Strategies used to correct comprehension and performance errors **Evaluation** –Analysis of performance and strategy effectiveness after a learning episode		**Planning**	Score
		4. I pace myself while learning in order to have enough time.	
		6. I think about what I really need to learn before I begin a task.	
		8. I set specific goals before I begin a task.	
		22. I ask myself questions about the material before I begin.	
		23. I think of several ways to solve a problem and choose the best one.	
		42. I read instructions carefully before I begin a task.	
		45. I organize my time to best accomplish my goals.	
		Total	7

Information Management Strategies	Score	**Comprehension Monitoring**	Score
9. I slow down when I encounter important information.		1. I ask myself periodically if I am meeting my goals.	
13. I consciously focus my attention on important information.		2. I consider several alternatives to a problem before I answer.	
30. I focus on the meaning and significance of new information.		11. I ask myself if I have considered all options when solving a problem.	
31. I create my own examples to make information more meaningful.		21. I periodically review to help me understand important relationships.	
37. I draw pictures or diagrams to help me understand while learning.		28. I find myself analyzing the usefulness of strategies while I study.	
39. I try to translate new information into my own words.		34. I find myself pausing regularly to check my comprehension.	
41. I use the organizational structure of the text to help me learn		49. I ask myself questions about how well I am doing while learning something new.	
43. I ask myself if what I'm reading is related to what I already know.			
47. I try to break studying down into smaller steps.			
48. I focus on overall meaning rather than specifics.			
Total	10	Total	7

Debugging Strategies	Score	**Evaluation**	Score
25. I ask others for help when I don't understand something.		7. I know how well I did once I finish a test.	
40. I change strategies when I fail to understand.		18. I ask myself if there was an easier way to do things after I finish a task.	
44. I re-evaluate my assumptions when I get confused.		24. I summarize what I've learned after I finish.	
51. I stop and go back over new information that is not clear.		36. I ask myself how well I accomplish my goals once I'm finished.	
52. I stop and reread when I get confused.		38. I ask myself if I have considered all options after I solve a problem.	
		49. I ask myself if I learned as much as I could have once I finish a task.	
Total	5	Total	6

Thank you for your time!

Appendix 3. Recruitment material

Recruit participants for research online

Dear colleague/student, you are being invited to participate in this research study titled 'Improving the creative process - Developing an effective way of applying personal knowledge in product design final year project'. This research is being done by Yang Zhang from the Design School, Loughborough University. The purpose of the study is to investigate the pattern of personal knowledge applying of individual product design student with the different level of metacognition in the final year project, which is one part of this study. Please find more details of this study in the document attached – the 'Adult Participant Information Sheet'.

This survey is in the form of questionnaire, which is consisted of three parts: I. Basic Information about you; II. Self-reported Psychometric Test: How do you apply your knowledge? III. Metacognitive Awareness Inventory.

This will take you approximately 20 minutes to complete. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any question. We believe there are no known risks associated with this research study; however, as with any online related activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential.

If you would like to participant in this pilot study, please make sure you have read the 'Adult Participant Information Sheet', and then access to the questionnaire via the link below: https://qtrial2017q1az1.az1.qualtrics.com/jfe/form/SV_4MZFhrTY7k18TDT

Please complete the survey at your convenience before 1th June, 2017. Please do not hesitate to contact with me when you have any problem about this study via the contacts below:
Email: Y.zhang4@lboro.ac.uk
Mobile: +44 07428718877
Design School, Loughborough University

Thank you very much for your time.
Yang Zhang

Appendix 4. Ethic Approval Documents
Appendix 4-1. Signed Ethical Clearance Checklist

Loughborough University

Ethics Approvals (Human Participants) Sub-Committee

Ethical Clearance Checklist

Has the Investigator read the 'Guidance for completion of Ethical Clearance Checklist' before starting this form?	Yes

Does the study require NHS approval? *Please complete a copy of the checklist providing a brief project description in the additional information section. Please send this to the Secretary of the Ethics Approvals (HP) Sub-Committee before starting your NHS application.*	No

Project Details

1. Project Title: Improving the creative process – Developing an effective way of applying personal knowledge in product design final year design project (FYDP)

Investigator(s) Details

2. Name of Investigator 1: Erik Bohemia	10. Name of Investigator 2: Yang Zhang
3. Status: Staff	11. Status: PGR Student
4. School/Department: Design School	12. School/Department: Design School
5. Programme (if applicable): Click here to enter text.	13. Programme (if applicable): Click here to enter text.
6. Email address: E.Bohemia@lboro.ac.uk	14. Email address: Y.zhang4@lboro.ac.uk
7a. Contact address: Design School, Loughborough University, LE11 3TU	15a. Contact address: Design School, Loughborough University, LE11 3TU
7b. Telephone number: +442038051322	15b. Telephone number: + 441509 226900
8. Supervisor: Yes	16. Supervisor: No
9. Responsible Investigator: No	17. Responsible Investigator: Yes
List all other investigators (name/email address): John McCardle, J.R.Mccardle@lboro.ac.uk	

1

Ethical Clearance Checklist 2017(v1)

Participants

18. Does the project involve NHS patients from the National Centre for Sport and Exercise Medicine. *NHS approval may be required. Please complete a copy of the checklist providing a brief project description in the additional information section. Please send this to the Secretary of the Ethics Approvals (HP) Sub-Committee.*	No

Positions of Authority

19. Are investigators in a position of direct authority with regard to participants (e.g. academic staff using student participants, sports coaches using his/her athletes in training)?	No

Vulnerable groups

20. Will participants be knowingly recruited from one or more of the following vulnerable groups?	
Children under 18 years of age	No
Persons incapable of making an informed decision for themselves	No
Pregnant women	No
Prisoners/Detained persons	No
Other vulnerable group, including but not limited to, adults in care homes, adults who are vulnerable because of their social, psychological or medical circumstances. Please specify: Click here to enter text	No
If Yes to any of question 20, please answer the following questions:	
21. Will participants be chaperoned by more than one investigator at all times?	Choose an item
22. Will at least one investigator of the same sex as the participant(s) be present throughout the investigation?	Choose an item
23. Will participants be visited at home?	Choose an item

Investigator Safety

24. Will the investigator be alone with participants at any time?	No
If Yes to question 24, please answer the following questions:	
24a. Will the investigator inform anyone else of when they will be alone with participants?	Choose an item
24b. Has the investigator read the Guidance Notes on	Choose an item

'Conducting Interviews Off-Campus and Working Alone' and will abide by the recommendations within?	

Methodology and Procedures

25. Please indicate whether the proposed study:	
Involves taking bodily samples (please refer to published guidelines)	No
Involves using bodily samples previously collected with consent for further research	No
Involves transporting Human Tissue Act relevant material to or from Loughborough (a materials transfer agreement is required)	No
Involves procedures which are likely to cause physical, psychological, social or emotional distress to participants or discussion of sensitive topics (e.g. sexual activity, drug use, extreme religious or political opinions, illegal activities).	No
Is designed to be challenging **physically** or **psychologically** in any way (includes any study involving physical exercise)	No
Exposes participants to risks or distress greater than those encountered in their normal lifestyle	No
Involves collection of body secretions by invasive methods	No
Prescribes intake of compounds additional to daily diet or other dietary manipulation/supplementation	No
Involves an MRI scan	No
Involves pharmaceutical drugs/medicines	No
Involves use of radiation	No
Involves use of hazardous materials	No
Assists/alters the process of conception in any way	No
Involves methods of contraception	No
Involves genetic engineering	No

Involves testing new equipment	No
Involves testing of medical equipment or devices	No

Observation/Recording

26. Does the study involve observation and/or recording of participants?	Yes
27. **If Yes to question 26,** will those being observed and/or recorded be informed that the observation and/or recording will take place?	Yes

Informed consent

28. Will participants give informed consent freely?	Yes
29. Will participants be fully informed of the objectives of the study and all details disclosed (preferably at the start of the study but, where this would interfere with the study, at the end)?	Yes
30. Will participants be fully informed of the use of the data collected (including, where applicable, any intellectual property arising from the research)?	Yes

31. For children under the age of 18 or participants who are incapable of making an informed decision for themselves:	
a. Will consent be obtained (either in writing or by some other means)?	N/A
b. Will consent be obtained from parents or other suitable person?	N/A
c. Will they be informed that they have the right to withdraw regardless of parental/guardian consent?	N/A
d. For studies conducted in schools, will approval be gained in advance from the Head-teacher and/or the Director of Education of the appropriate Local Education Authority?	N/A
e. For detained persons, members of the armed forces, employees, students and other persons judged to be under duress, will care be taken over gaining freely informed consent?	N/A

Deception

32. Does the study involve deception of participants (i.e. withholding of information or the misleading of participants) which could potentially harm or exploit participants?	No
If Yes to question 32, please answer the following questions:	
33. Is deception an unavoidable part of the study?	Choose an item
34. Will participants be de-briefed and the true object of the research revealed at the earliest stage upon completion of the study?	Choose an item
35. Will there be an increased physical or emotional risk to participants or investigators when participants are informed of the withholding of information or deliberate deception?	Choose an item

Withdrawal

36. Will participants be informed of their right to withdraw from the investigation at any time and to require their own data to be destroyed?	Yes

Storage of Data and Confidentiality

37. Will all information on participants be treated as confidential and not identifiable unless agreed otherwise in advance, and subject to the requirements of law?	Yes
38. Will storage of data comply with the Data Protection Act 1998 and the Guidance Note on 'Data Protection and Storage'?	Yes
39. Will any transcripts and video/audio recording of participants be kept in a secure place and not released for any use by third parties?	Yes
40. Will video/audio recordings be destroyed within ten years of the completion of the investigation or securely archived if required by funder?	N/A
41. Will full details regarding the storage and disposal of any human tissue samples be communicated to the participants?	N/A
42. Will research involve the sharing of data or confidential information beyond the initial consent given?	No
43. Will the research involve administrative or secure data that requires permission from the appropriate authorities before use?	No

Incentives

44. Will incentives be offered to the investigator to conduct the study?	No
45. Will incentives by offered to potential participants as an inducement to participate in the study?	No

Work Outside of the United Kingdom

46. Is research being conducted by investigators travelling outside of the United Kingdom?	No
If Yes to question 46, please answer the following questions:	
47. Country or countries researcher will travel to for the conduct of the research:	Click here to enter text
48. Is this the investigator's home country?	Choose an item
49. Has a risk assessment been carried out to ensure the physical, emotional and cultural safety of the investigator whilst working outside of the United Kingdom?	Choose an item
50. Have you considered the appropriateness of your research in the country you are travelling to and checked the FCO	Choose an item

guidance: https://www.gov.uk/foreign-travel-advice?	
51. Is there an increased physical, emotional or cultural risk to investigators outside of the United Kingdom as a result of your research study or has the FCO issued a travel warning?	Choose an item
52. Have you obtained any necessary ethical permission needed in the country you are travelling to?	Choose an item

53. Will any of the participants be outside of the United Kingdom?	Yes
54. **If Yes to 53**, is there an increased physical, emotional or cultural risk to participants who are outside of the United Kingdom as a result of taking part in your research study?	No

Risk Assessment

55. Has a risk assessment been carried out and approved by the School, to ensure the physical, emotional and cultural safety of the investigator and participants involved in the study?	Yes

Information and Declarations

Checklist Application Only:
If you have completed the checklist to the best of your knowledge, and not selected any answers marked with an *, # or †, your investigation is deemed to conform with the ethical checkpoints. Please sign the declaration and lodge the completed checklist with your Head of Department/School or his/her nominee.

† Checklist with Additional Information to the Secretary:
If you have completed the checklist and have only selected answers which require additional information to be submitted with the checklist (indicated by a †), please ensure that all the information is provided in detail below and send this signed checklist to the Secretary of the Sub-Committee.

Checklist with Generic Protocols Included:
If you have completed the checklist and selected one or more of the answers marked with this symbol # a full Research Proposal needs to be submitted to the Ethical Approvals (Human Participants) Sub-Committee unless you, or one of the investigators on this project, are a named investigator on an existing Generic Protocol which covers the procedure. Please download the Research Proposal form from the Sub-Committee's web page. **A signed copy of this Checklist should accompany the full proposal to the Sub-Committee.**
If you, or one of the investigators on this project, are using a procedure covered by a generic protocol, please ensure the relevant individuals are on the list of approved investigators for that Generic Protocol. Include the Generic Protocol reference number and a short description of how the proposal will be used at the end of the checklist in the space provided for additional information.

The completed checklist should be lodged with your Head of Department/School or his/her nominee.

* Full Application needed:
If on completion of the checklist you have selected one or more answers which require the submission of a full proposal (indicated by a *), please download the Research Proposal form from the Sub-Committee's web page. **A signed copy of this Checklist should accompany the full Research Proposal to the Sub-Committee.**

Space for Additional Information and/or Information on Generic Proposals as requested:

Click here to enter text.

Insurance

Cover is automatic if the research is within the UK & limited to the following activities:

i. Questionnaires, interviews, focus groups, physical activity/exercise, psychological activity including CBT;
ii. Venepuncture (withdrawal of blood);
iii. Muscle biopsy;
iv. Measurements or monitoring of physiological processes including scanning;
v. Collections of body secretions by non invasive methods;
vi. Intake of foods or nutrients or variation of diet (other than administration of drugs).

All other Research involving human participants, including studies outside of the UK, should be referred to the Insurance Officer along with the completed **Insurance Questionnaire** to arrange cover - which may incur a charge. Early submission is recommended.

For completion by Supervisor

Please tick the appropriate boxes. The study should not begin until all boxes are ticked.

☑ The student has read the University's Code of Practice on investigations involving human participants

☑ The topic merits further research

☑ The student has the skills to carry out the research or is being trained in the required skills by the Supervisor

☑ The participant information sheet or leaflet is appropriate

☑ The procedures for recruitment and obtaining informed consent are appropriate

Comments from supervisor:

Click here to enter text.

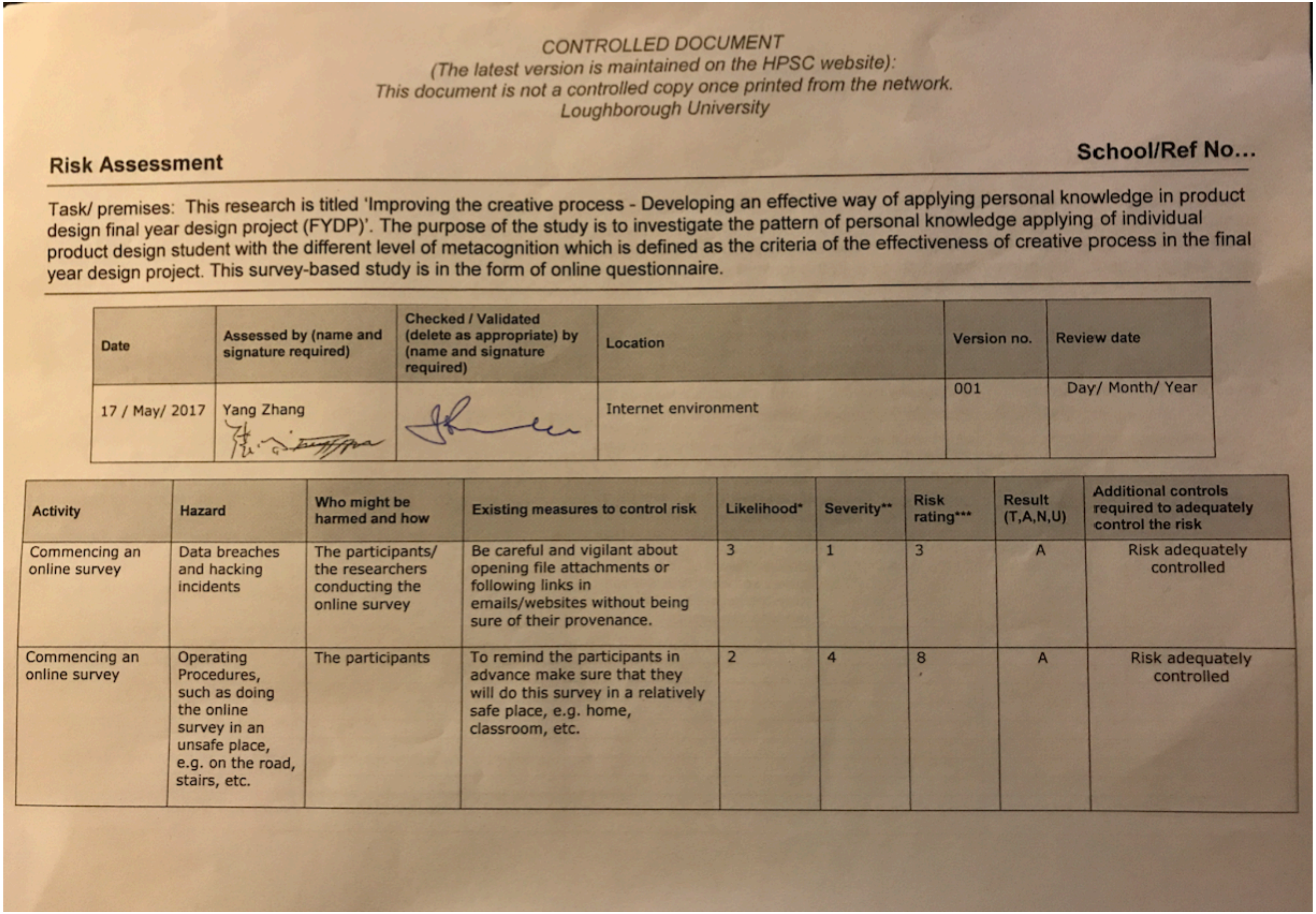
Signature of Applicant: Yang Zhang

Signature of Supervisor (if applicable): Click here to enter text.

Signature of Dean of School/Head of Department or his/her nominee: Click here to enter text.

Date: Click here to enter text. 18.05.2017

Appendix 4-2. Signed Risk Assessment



CONTROLLED DOCUMENT
(The latest version is maintained on the HPSC website):
This document is not a controlled copy once printed from the network.
Loughborough University

Risk Assessment **School/Ref No...**

Task/ premises: This research is titled 'Improving the creative process - Developing an effective way of applying personal knowledge in product design final year design project (FYDP)'. The purpose of the study is to investigate the pattern of personal knowledge applying of individual product design student with the different level of metacognition which is defined as the criteria of the effectiveness of creative process in the final year design project. This survey-based study is in the form of online questionnaire.

Date	Assessed by (name and signature required)	Checked / Validated (delete as appropriate) by (name and signature required)	Location	Version no.	Review date
17 / May/ 2017	Yang Zhang		Internet environment	001	Day/ Month/ Year

Activity	Hazard	Who might be harmed and how	Existing measures to control risk	Likelihood*	Severity**	Risk rating***	Result (T,A,N,U)	Additional controls required to adequately control the risk
Commencing an online survey	Data breaches and hacking incidents	The participants/ the researchers conducting the online survey	Be careful and vigilant about opening file attachments or following links in emails/websites without being sure of their provenance.	3	1	3	A	Risk adequately controlled
Commencing an online survey	Operating Procedures, such as doing the online survey in an unsafe place, e.g. on the road, stairs, etc.	The participants	To remind the participants in advance make sure that they will do this survey in a relatively safe place, e.g. home, classroom, etc.	2	4	8	A	Risk adequately controlled

CONTROLLED DOCUMENT
(The latest version is maintained on the HPSC website):
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Loughborough University

Risk Assessment

School/Ref No…

Task/ premises: This research is titled 'Improving the creative process - Developing an effective way of applying personal knowledge in product design final year design project (FYDP)'. The purpose of the study is to investigate the pattern of personal knowledge applying of individual product design student with the different level of metacognition which is defined as the criteria of the effectiveness of creative process in the final year design project. This survey-based study is in the form of online questionnaire.

Activity	Hazard	Who might be harmed and how	Existing measures to control risk	Likelihood*	Severity**	Risk rating***	Result (T,A,N,U)	Additional controls required to adequately control the risk
Protecting/ Dealing with data	Accidental loss/ destruction/ damage of data	The researchers conducting the online survey	Researchers should be familiar with the Guidance Note on 'Data Protection and Storage'. Researchers should note that the policies underpinning third party survey software companies differ (Survey Monkey, Qualtrics), and must make themselves aware of the policies of their chosen survey tool. Moreover, researchers must be aware of how the survey software provider will store the collated information and who can access it.	3	1	3	A	Risk adequately controlled

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Risk Assessment

School/Ref No…

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Key: T= trivial risk; **A** = adequately controlled, no further action necessary; **N** = not adequately controlled, actions required; **U** = unable to decide (further information required)

***Likelihood**

5 Very likely – risk will occur repeatedly. To be routinely expected once every 20 – 100 operations, possibly weekly or more frequently if done regularly.

4 Likely – will occur several times a year so does not surprise when it happens.

3 Possible – may occur sometimes. Likely to occur once a year.

2 Unlikely – but may occur perhaps once in every 10 to 100 years.

1 Very unlikely to occur. Likelihood approaching zero.

****Severity**

5 Fatality – death of an employee or multiple fatalities.

4 Major injury – permanent disability, serious amputation e.g. Loss of hand.

3 Medium injury e.g. Bad scald, or burn, fracture, minor amputation, temporary injury, loss of consciousness. Reportable to the HSE as a three day lost time (employee unavailable for normal work for over 3 days) or serious injury.

2 Minor injury – More severe cut, sprain, strain, burn, etc. where return to work is not possible after treatment. It may be lost time less than 3 days.

1 No injury or very low injury – scratch, bruise, knock, minor cut, needle stick etc. where the injury allows return to work after first aid treatment – no lost time.

***** Risk rating = Likelihood x Severity**

Likelihood x Severity = Risk assessment score

(LOW RISK 1-8 / MEDIUM RISK 9-15 / HIGH RISK 16-25)

Low risk - improve if possible (typically within 1 - 2 years)

Medium Risk - Introduce further controls to reduce risk further (typically 1 - 3 months)

High Risk - Possibly stop operation or immediately introduce control measures within a day or two.

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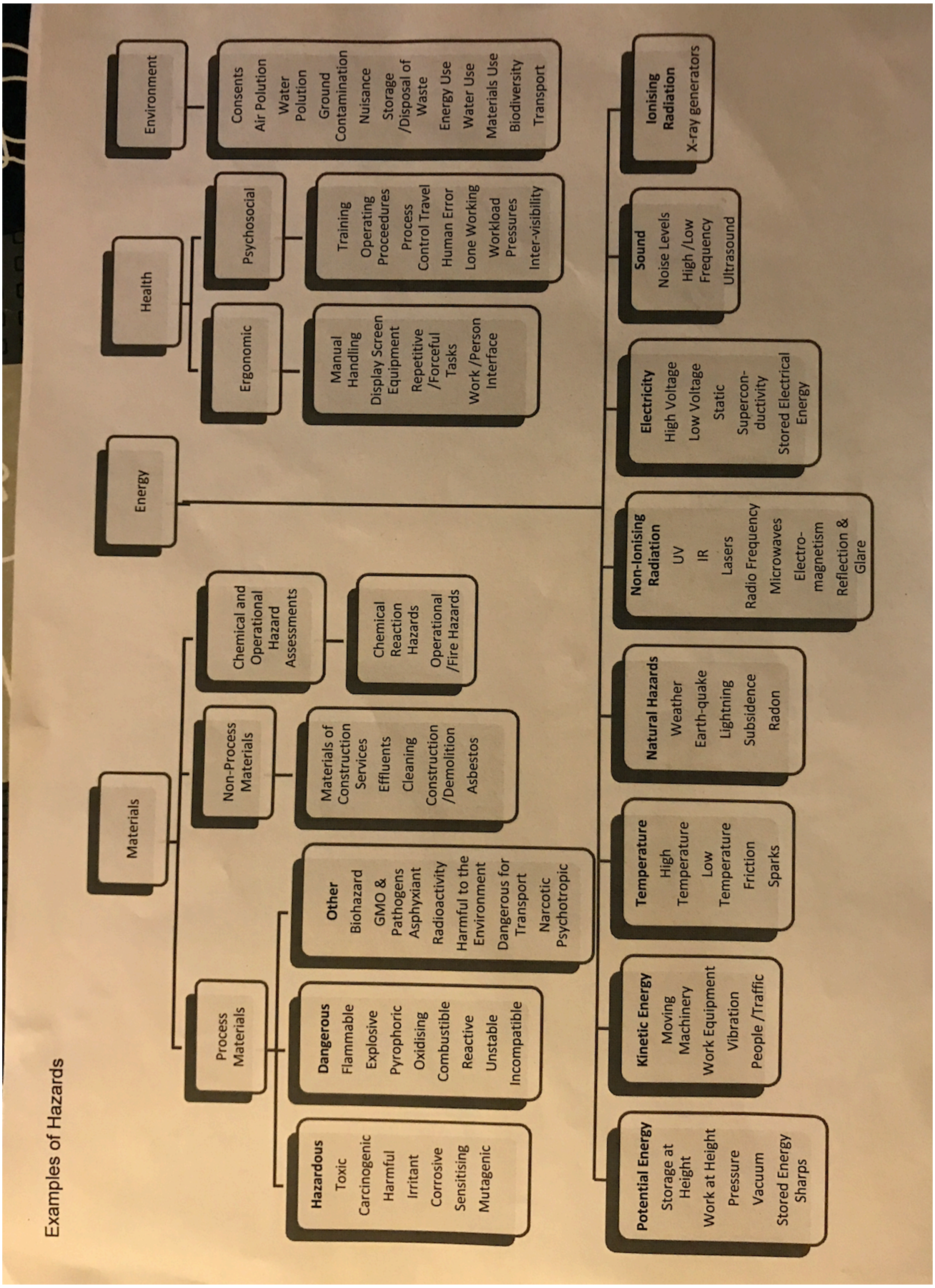
Risk Assessment **School/Ref No…**

Task/ premises: This research is titled 'Improving the creative process - Developing an effective way of applying personal knowledge in product design final year design project (FYDP)'. The purpose of the study is to investigate the pattern of personal knowledge applying of individual product design student with the different level of metacognition which is defined as the criteria of the effectiveness of creative process in the final year design project. This survey-based study is in the form of online questionnaire.

Action plan

Version no.	Further action required	Action by whom	Action by when	Done



Examples of Hazards
Materials
Process Materials
Hazardous
Toxic
Carcinogenic
Harmful
Irritant
Corrosive
Sensitising
Mutagenic
Dangerous
Flammable
Explosive
Pyrophoric
Oxidising
Combustible
Reactive
Unstable
Incompatible
Other
Biohazard
GMO & Pathogens
Asphyxiant
Radioactivity
Harmful to the Environment
Dangerous for Transport
Narcotic
Psychotropic
Non-Process Materials
Materials of Construction
Services
Effluents
Cleaning
Construction /Demolition
Asbestos
Chemical and Operational Hazard Assessments
Chemical Reaction Hazards
Operational /Fire Hazards
Energy
Potential Energy
Storage at Height
Work at Height
Pressure
Vacuum
Stored Energy
Sharps
Kinetic Energy
Moving Machinery
Work Equipment
Vibration
People /Traffic
Temperature
High Temperature
Low Temperature
Friction
Sparks
Natural Hazards
Weather
Earth-quake
Lightning
Subsidence
Radon
Non-Ionising Radiation
UV
IR
Lasers
Radio Frequency
Microwaves
Electro-magnetism
Reflection & Glare
Electricity
High Voltage
Low Voltage
Static
Supercon-ductivity
Stored Electrical Energy
Sound
Noise Levels
High /Low Frequency
Ultrasound
Ionising Radiation
X-ray generators
Health
Ergonomic
Manual Handling
Display Screen Equipment
Repetitive /Forceful Tasks
Work /Person Interface
Psychosocial
Training
Operating Proceedures
Process Control Travel
Human Error
Lone Working
Workload Pressures
Inter-visibility
Environment
Consents
Air Pollution
Water Polution
Ground Contamination
Nuisance
Storage /Disposal of Waste
Energy Use
Water Use
Materials Use
Biodiversity
Transport

Appendix 5-1. Coding of Institutions

Coding of Institutions

Data types (Institutes)		**Coding** Yes	No
China Universities	1. Tsinghua University	1	0
	2. Central Academy of Fine Art	1	0
	3. China Academy of Art	1	0
	4. Jiangnan University	1	0
	5. Nanjing University of the Arts	1	0
	6. Tongji University	1	0
	7. Donghua University	1	0
	8. Zhejiang University	1	0
	9. Communication University of China	1	0
	10. Luxun Academy of Fine Arts	1	0
	11. Soochow University	1	0
UK Universities	1. Loughborough University	1	0
	2. Northumbria University	1	0
	3. Coventry University	1	0
	4. Brunel University	1	0
	5. University of Lincoln	1	0
	6. University of Leeds	1	0
	7. University of Brighton	1	0
	8. Others	1	0

Appendix 5-2. Coding of Projects Categories

Coding of Projects Categories

Data types	Coding		Data types	Coding	
Project (China)	Yes	No	Project (UK)	Yes	No
1. Transport Design	1	0	1. Transport Design	1	0
2. Electronic Device	1	0	2. Electronic Device	1	0
3. Interior	1	0	3. Interior	1	0
4. Outdoor/Public	1	0	4. Outdoor	1	0
5. Healthcare	1	0	5. Healthcare	1	0
6. Small goods	1	0	6. Packaging	1	0
7. AI product	1	0	7. Pets	1	0
8. Age-related	1	0	8. Age-related	1	0
9. Internet/Service	1	0	9. Service	1	0
10. Product Exhibition	1	0	10. Sport	1	0
11. Others	1	0	11. Others	1	0

Appendix 6. Results of OLR
Appendix 6-1. China results

----

name: <unnamed>
log: E:\Research Plans\yangyang\16.07.2017\China 2nd attempt\regress.log
log type: text
opened on: 16 Jul 2017, 16:09:24

. ologit k1 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity
variable k1 not found
r(111);

. ologit K1 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -387.22482
Iteration 1: log likelihood = -372.80499
Iteration 2: log likelihood = -372.53735
Iteration 3: log likelihood = -372.53714
Iteration 4: log likelihood = -372.53714

Ordered logistic regression Number of obs = 228
LR chi2(24) = 29.38
Prob > chi2 = 0.2063
Log likelihood = -372.53714 Pseudo R2 = 0.0379

K1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
MAI_SUM	.0178451	.0192612	0.93	0.354	-.0199062	.0555964
Age	-.7129747	.2664752	-2.68	0.007	-1.235256	-.190693
Gender	-.4460259	.2655903	-1.68	0.093	-.9665733	.0745214
Project1	-1.054519	.6108807	-1.73	0.084	-2.251823	.1427856
Project2	-.1708661	.628067	-0.27	0.786	-1.401855	1.060123
Project3	-.5911603	.5413522	-1.09	0.275	-1.652191	.4698705
Project4	-.5542413	.6258906	-0.89	0.376	-1.780964	.6724816
Project5	-2.091906	.8799686	-2.38	0.017	-3.816613	-.3671994
Project6	-.1426005	.8027425	-0.18	0.859	-1.715947	1.430746
Project7	-1.171064	.6909847	-1.69	0.090	-2.52537	.1832408
Project8	-.8692693	.6150578	-1.41	0.158	-2.07476	.3362219
Project9	-1.084692	.6913062	-1.57	0.117	-2.439627	.2702431
Project10	-.870883	.6762583	-1.29	0.198	-2.196325	.4545589
Project11	0	(omitted)				
TsinghuaUniversity	1.163159	1.105104	1.05	0.293	-1.002805	3.329123
CentralAcademyofFineArt	-.72624	1.085896	-0.67	0.504	-2.854558	1.402078
ChinaAcademyofArt	.3568494	.8328085	0.43	0.668	-1.275425	1.989124
JiangnanUniversity	.1935972	.7794451	0.25	0.804	-1.334087	1.721282
NanjingUniversityoftheArt	.3692232	.769346	0.48	0.631	-1.138667	1.877114

TongjiUniversity	.013681	.9798123	0.01	0.989	-1.906716	1.934078
DonghuaUniversity	-.4274378	.8041557	-0.53	0.595	-2.003554	1.148678
ZhejiangUniversity	.1611701	1.581336	0.10	0.919	-2.938192	3.260532
CommunicationUniversityofC	.4205289	.8551608	0.49	0.623	-1.255555	2.096613
LuxunAcademyofFineArts	.0470258	.8128278	0.06	0.954	-1.546087	1.640139
SoochowUniversity	-.424826	.8876208	-0.48	0.632	-2.164531	1.314879
/cut1	-5.699024	1.483441			-8.606515	-2.791532
/cut2	-4.527041	1.451819			-7.372554	-1.681528
/cut3	-3.247732	1.437955			-6.066071	-.4293922
/cut4	-1.800258	1.428709			-4.600476	.9999588
/cut5	-.4188679	1.423497			-3.20887	2.371134
/cut6	1.218519	1.44449			-1.61263	4.049668

. ologit K2 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -366.50402
Iteration 1: log likelihood = -350.40868
Iteration 2: log likelihood = -350.11699
Iteration 3: log likelihood = -350.11655
Iteration 4: log likelihood = -350.11655

Ordered logistic regression	Number of obs	=	228
	LR chi2(24)	=	32.77
	Prob > chi2	=	0.1089
Log likelihood = -350.11655	Pseudo R2	=	0.0447

K2	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	.0390951	.0206023	1.90	0.058	-.0012846	.0794749
Age	-.4488657	.2791768	-1.61	0.108	-.9960422	.0983108
Gender	-.1806529	.2636017	-0.69	0.493	-.6973027	.3359969
Project1	-.650221	.611961	-1.06	0.288	-1.849642	.5492004
Project2	-.0017735	.6268318	-0.00	0.998	-1.230341	1.226794
Project3	-.6407507	.5537839	-1.16	0.247	-1.726147	.4446458
Project4	-.5660329	.6634219	-0.85	0.394	-1.866316	.7342501
Project5	-1.385943	.909455	-1.52	0.128	-3.168442	.3965562
Project6	-1.120646	.7498539	-1.49	0.135	-2.590333	.3490405
Project7	-.3200751	.6698025	-0.48	0.633	-1.632864	.9927136
Project8	-.94915	.6139373	-1.55	0.122	-2.152445	.2541451
Project9	-1.966793	.6850839	-2.87	0.004	-3.309533	-.6240536
Project10	.0526625	.7346966	0.07	0.943	-1.387316	1.492641
Project11	0	(omitted)				
TsinghuaUniversity	1.469018	1.190759	1.23	0.217	-.8648262	3.802863
CentralAcademyofFineArt	.769497	1.165529	0.66	0.509	-1.514898	3.053892
ChinaAcademyofArt	.6130129	.8766806	0.70	0.484	-1.10525	2.331275
JiangnanUniversity	-.0121975	.8276316	-0.01	0.988	-1.634326	1.609931
NanjingUniversityoftheArt	.2999592	.8168405	0.37	0.713	-1.301019	1.900937
TongjiUniversity	.5520022	1.058334	0.52	0.602	-1.522295	2.626299
DonghuaUniversity	-.254828	.8410498	-0.30	0.762	-1.903255	1.393599
ZhejiangUniversity	.1833262	1.419304	0.13	0.897	-2.598459	2.965111

CommunicationUniversityofC	1.017638	.9297198	1.09	0.274	-.8045794	2.839855
LuxunAcademyofFineArts	-.2244927	.8708343	-0.26	0.797	-1.931297	1.482311
SoochowUniversity	.4420821	.950255	0.47	0.642	-1.420384	2.304548
/cut1	-3.587067	1.512614			-6.551736	-.622397
/cut2	-2.455725	1.489726			-5.375534	.4640843
/cut3	-1.513411	1.481565			-4.417224	1.390403
/cut4	-.4239553	1.478092			-3.320961	2.473051
/cut5	1.815656	1.484663			-1.094231	4.725542
/cut6	3.990694	1.553876			.9451524	7.036236

. ologit K3 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -338.04208
Iteration 1: log likelihood = -327.72763
Iteration 2: log likelihood = -324.45146
Iteration 3: log likelihood = -323.92013
Iteration 4: log likelihood = -323.91651
Iteration 5: log likelihood = -323.91651

Ordered logistic regression   Number of obs = 228
LR chi2(24) = 28.25
Prob > chi2 = 0.2496
Log likelihood = -323.91651   Pseudo R2 = 0.0418

K3	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	.0042632	.0197241	0.22	0.829	-.0343952	.0429217
Age	-.1672391	.2662298	-0.63	0.530	-.68904	.3545618
Gender	-.5657211	.263355	-2.15	0.032	-1.081887	-.0495547
Project1	-1.038255	.618815	-1.68	0.093	-2.25111	.1746006
Project2	-.7498483	.6097984	-1.23	0.219	-1.945031	.4453346
Project3	-.9208163	.5408654	-1.70	0.089	-1.980893	.1392604
Project4	-.3363868	.641441	-0.52	0.600	-1.593588	.9208144
Project5	-.2569232	.8444287	-0.30	0.761	-1.911973	1.398127
Project6	-1.541164	.8117139	-1.90	0.058	-3.132094	.049766
Project7	-1.409566	.6795388	-2.07	0.038	-2.741438	-.0776945
Project8	-.4836511	.5940757	-0.81	0.416	-1.648018	.6807158
Project9	-1.03394	.6632904	-1.56	0.119	-2.333965	.2660856
Project10	-.4197052	.6909609	-0.61	0.544	-1.773964	.9345532
Project11	0	(omitted)				
TsinghuaUniversity	.4744351	1.284817	0.37	0.712	-2.04376	2.99263
CentralAcademyofFineArt	.1291679	1.176284	0.11	0.913	-2.176306	2.434642
ChinaAcademyofArt	1.034483	.9164786	1.13	0.259	-.7617819	2.830748
JiangnanUniversity	1.469245	.8732242	1.68	0.092	-.242243	3.180733
NanjingUniversityoftheArt	1.006176	.8570232	1.17	0.240	-.6735589	2.68591
TongjiUniversity	1.628717	1.073089	1.52	0.129	-.4744989	3.731932
DonghuaUniversity	1.017595	.8786763	1.16	0.247	-.7045792	2.739769
ZhejiangUniversity	-2.10703	1.464361	-1.44	0.150	-4.977125	.7630645
CommunicationUniversityofC	1.561335	.9404026	1.66	0.097	-.2818202	3.40449
LuxunAcademyofFineArts	.7687266	.9066855	0.85	0.397	-1.008344	2.545797

SoochowUniversity	1.581605	.988374	1.60	0.110	-.3555729	3.518782
/cut1	-5.326498	1.641014			-8.542826	-2.11017
/cut2	-3.405594	1.506304			-6.357895	-.4532928
/cut3	-1.806285	1.488755			-4.724192	1.111621
/cut4	.0444679	1.486626			-2.869266	2.958202
/cut5	1.28034	1.488419			-1.636908	4.197588

. ologit K4 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -338.87371
Iteration 1: log likelihood = -326.68726
Iteration 2: log likelihood = -326.60703
Iteration 3: log likelihood = -326.607

Ordered logistic regression — Number of obs = 228
LR chi2(24) = 24.53
Prob > chi2 = 0.4315
Log likelihood = -326.607 — Pseudo R2 = 0.0362

K4	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
MAI_SUM	.0418545	.0197933	2.11	0.034	.0030604	.0806487
Age	-.088587	.2687287	-0.33	0.742	-.6152856	.4381116
Gender	-.5107162	.2623324	-1.95	0.052	-1.024878	.0034459
Project1	.2147856	.6240504	0.34	0.731	-1.008331	1.437902
Project2	.8641408	.6444768	1.34	0.180	-.3990105	2.127292
Project3	.0387915	.5618302	0.07	0.945	-1.062375	1.139958
Project4	.242857	.6571458	0.37	0.712	-1.045125	1.530839
Project5	-.2372227	.8672724	-0.27	0.784	-1.937045	1.4626
Project6	-1.172652	.7996418	-1.47	0.143	-2.739922	.3946168
Project7	.2996391	.6747249	0.44	0.657	-1.022797	1.622076
Project8	.0564274	.6326865	0.09	0.929	-1.183615	1.29647
Project9	-.302382	.6769169	-0.45	0.655	-1.629115	1.024351
Project10	.2978461	.691686	0.43	0.667	-1.057834	1.653526
Project11	0	(omitted)				
TsinghuaUniversity	.2656032	1.230088	0.22	0.829	-2.145324	2.676531
CentralAcademyofFineArt	.3584384	1.183149	0.30	0.762	-1.960491	2.677367
ChinaAcademyofArt	.3472721	.9083154	0.38	0.702	-1.432993	2.127538
JiangnanUniversity	.2223744	.8488857	0.26	0.793	-1.441411	1.88616
NanjingUniversityoftheArt	.1616548	.8378467	0.19	0.847	-1.480495	1.803804
TongjiUniversity	.1461419	1.010871	0.14	0.885	-1.835129	2.127413
DonghuaUniversity	-.3654116	.8559507	-0.43	0.669	-2.043044	1.312221
ZhejiangUniversity	-1.280692	1.520059	-0.84	0.399	-4.259952	1.698569
CommunicationUniversityofC	-.191012	.9209945	-0.21	0.836	-1.996128	1.614104
LuxunAcademyofFineArts	.0181112	.8944725	0.02	0.984	-1.735023	1.771245
SoochowUniversity	.698412	.9745616	0.72	0.474	-1.211694	2.608518
/cut1	-3.582137	1.629615			-6.776123	-.3881504
/cut2	-3.167682	1.577407			-6.259344	-.07602
/cut3	-2.457573	1.524355			-5.445253	.5301077

```
               /cut4 |  -.0730497   1.480288                     -2.974361    2.828262
               /cut5 |   1.110309   1.483688                     -1.797665    4.018284
               /cut6 |   2.308605   1.489222                     -.6102169    5.227426
------------------------------------------------------------------------------

. ologit K5 MAI_SUM Age    Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8
Project9 Project10 Project11    TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity
ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity

note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -337.36534
Iteration 1:   log likelihood = -318.26926
Iteration 2:   log likelihood = -317.16165
Iteration 3:   log likelihood = -317.15443
Iteration 4:   log likelihood = -317.15443

Ordered logistic regression                     Number of obs     =        228
                                                LR chi2(24)       =      40.42
                                                Prob > chi2       =     0.0193
Log likelihood = -317.15443                     Pseudo R2         =     0.0599

------------------------------------------------------------------------------
                         K5 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------------+--------------------------------------------------
                    MAI_SUM |  -.0095757   .0200691    -0.48   0.633    -.0489105    .0297591
                        Age |   .2499662   .2686532     0.93   0.352    -.2765845    .7765169
                     Gender |  -.6691221   .2677492    -2.50   0.012    -1.193901   -.1443433
                   Project1 |    .372201    .602968     0.62   0.537    -.8095947    1.553997
                   Project2 |  -.2755723   .6009831    -0.46   0.647    -1.453478    .9023329
                   Project3 |  -.0293787   .5273778    -0.06   0.956     -1.06302    1.004263
                   Project4 |  -.7906553   .6363857    -1.24   0.214    -2.037948    .4566379
                   Project5 |  -3.102232   .8648785    -3.59   0.000    -4.797363   -1.407101
                   Project6 |  -1.189432   .7831617    -1.52   0.129    -2.724401    .3455363
                   Project7 |  -.9709443   .6919609    -1.40   0.161    -2.327163    .3852742
                   Project8 |   .0159505   .6129274     0.03   0.979    -1.185365    1.217266
                   Project9 |  -1.353845   .6600214    -2.05   0.040    -2.647463   -.0602265
                  Project10 |  -.2650084   .6600297    -0.40   0.688    -1.558643    1.028626
                  Project11 |          0  (omitted)
         TsinghuaUniversity |  -.1087338   1.161728    -0.09   0.925    -2.385678    2.168211
    CentralAcademyofFineArt |   1.746806   1.296037     1.35   0.178    -.7933803    4.286993
          ChinaAcademyofArt |   .8014299   .9109633     0.88   0.379    -.9840253    2.586885
         JiangnanUniversity |    .182387   .8499645     0.21   0.830    -1.483513    1.848287
  NanjingUniversityoftheArt |   1.114522    .837963     1.33   0.184    -.5278549      2.7569
           TongjiUniversity |  -.1486029   .9944002    -0.15   0.881    -2.097592    1.800386
          DonghuaUniversity |   .5262926   .8650308     0.61   0.543    -1.169137    2.221722
         ZhejiangUniversity |   1.017578   1.370617     0.74   0.458    -1.668782    3.703939
 CommunicationUniversityofC |   1.238292   .9412442     1.32   0.188    -.6065123    3.083097
     LuxunAcademyofFineArts |    .440442   .8732983     0.50   0.614    -1.271191    2.152075
          SoochowUniversity |   1.384402   .9574539     1.45   0.148    -.4921737    3.260977
---------------------------+--------------------------------------------------
                      /cut1 |  -3.389868   1.489706                     -6.309638   -.4700977
                      /cut2 |  -3.258017   1.484871                     -6.168311   -.3477225
                      /cut3 |  -2.920158   1.476584                     -5.814208   -.0261068
                      /cut4 |   -1.34136   1.460618                     -4.204118    1.521398
                      /cut5 |  -.3810418   1.458536                     -3.239719    2.477636
                      /cut6 |   .9098407    1.45813                     -1.948042    3.767723
```

```
. ologit K6 MAI_SUM Age  Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8
Project9 Project10 Project11  TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity
ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity

note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -381.09715
Iteration 1:   log likelihood = -364.18583
Iteration 2:   log likelihood = -363.69767
Iteration 3:   log likelihood = -363.69442
Iteration 4:   log likelihood = -363.69442

Ordered logistic regression                     Number of obs   =        228
                                                LR chi2(24)     =      34.81
                                                Prob > chi2     =     0.0713
Log likelihood = -363.69442                     Pseudo R2       =     0.0457
```

K6	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
MAI_SUM	.042094	.0202111	2.08	0.037	.0024809	.0817072
Age	-.2603856	.2542936	-1.02	0.306	-.7587919	.2380206
Gender	.2167197	.2569123	0.84	0.399	-.2868191	.7202586
Project1	.5756366	.6077322	0.95	0.344	-.6154967	1.76677
Project2	.3064689	.5976563	0.51	0.608	-.864916	1.477854
Project3	.0223365	.5157625	0.04	0.965	-.9885394	1.033212
Project4	-.2601295	.6343285	-0.41	0.682	-1.503391	.9831316
Project5	-.3632272	.7498863	-0.48	0.628	-1.832977	1.106523
Project6	.4337416	.8420618	0.52	0.606	-1.216669	2.084152
Project7	-.3251323	.6262876	-0.52	0.604	-1.552633	.9023689
Project8	.5244056	.5838549	0.90	0.369	-.6199289	1.66874
Project9	.549509	.644369	0.85	0.394	-.713431	1.812449
Project10	-1.028062	.6946082	-1.48	0.139	-2.389469	.3333453
Project11	0	(omitted)				
TsinghuaUniversity	.7127637	1.145696	0.62	0.534	-1.532758	2.958286
CentralAcademyofFineArt	-.9510606	1.184779	-0.80	0.422	-3.273185	1.371064
ChinaAcademyofArt	.3891329	.8818222	0.44	0.659	-1.339207	2.117473
JiangnanUniversity	-.4279428	.8411243	-0.51	0.611	-2.076516	1.22063
NanjingUniversityoftheArt	-.2006961	.8223694	-0.24	0.807	-1.812511	1.411118
TongjiUniversity	-.3275561	1.005233	-0.33	0.745	-2.297777	1.642665
DonghuaUniversity	.6223517	.8545319	0.73	0.466	-1.0525	2.297203
ZhejiangUniversity	-1.585355	1.474405	-1.08	0.282	-4.475135	1.304426
CommunicationUniversityofC	.7975286	.9092894	0.88	0.380	-.9846458	2.579703
LuxunAcademyofFineArts	-.3584548	.8672825	-0.41	0.679	-2.058297	1.341388
SoochowUniversity	.0965227	.9359942	0.10	0.918	-1.737992	1.931038
/cut1	-3.249151	1.507952			-6.204682	-.2936188
/cut2	-1.556527	1.444909			-4.388497	1.275443
/cut3	-.2812755	1.441432			-3.106429	2.543878
/cut4	.9968411	1.445668			-1.836616	3.830299
/cut5	2.392152	1.45152			-.4527744	5.237079
/cut6	4.60354	1.483849			1.695249	7.511831

. ologit K7 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -384.60007
Iteration 1: log likelihood = -376.8426
Iteration 2: log likelihood = -376.70656
Iteration 3: log likelihood = -376.70654
Iteration 4: log likelihood = -377.75861

Ordered logistic regression Number of obs = 228
LR chi2(24) = 15.79
Prob > chi2 = 0.8956
Log likelihood = -376.70654 Pseudo R2 = 0.0205

K7	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	.0135135	.0188644	0.72	0.474	-.02346	.0504871
ge	.0294433	.2799105	0.11	0.916	-.5191712	.5780577
Gender	.0239573	.2574155	0.09	0.926	-.4805677	.5284823
Project1	-.3860289	.6587853	-0.59	0.558	-1.677224	.9051665
Project2	-.7678265	.6667234	-1.15	0.249	-2.07458	.5389274
Project3	-.7076019	.5905494	-1.20	0.231	-1.865058	.4498537
Project4	.0046018	.6775369	0.01	0.995	-1.323346	1.33255
Project5	-.0096692	.8676772	-0.01	0.991	-1.710285	1.690947
Project6	-1.364116	.8257008	-1.65	0.099	-2.982459	.2542283
Project7	-1.169977	.6851764	-1.71	0.088	-2.512898	.172944
Project8	-.509889	.6548685	-0.78	0.436	-1.793408	.7736295
Project9	-.4663038	.6916051	-0.67	0.500	-1.821825	.8892172
Project10	-1.413403	.7042024	-2.01	0.045	-2.793615	-.033192
Project11	0	(omitted)				
TsinghuaUniversity	.0429	1.23062	0.03	0.972	-2.369071	2.454871
CentralAcademyofFineArt	-.7726942	1.145587	-0.67	0.500	-3.018003	1.472614
ChinaAcademyofArt	-.5685308	.8189677	-0.69	0.488	-2.173678	1.036616
JiangnanUniversity	-.7497863	.775692	-0.97	0.334	-2.270115	.7705421
NanjingUniversityoftheArt	-.6226775	.7553153	-0.82	0.410	-2.103068	.8577134
TongjiUniversity	-.6212796	.9347727	-0.66	0.506	-2.4534	1.210841
DonghuaUniversity	-.3907552	.7888762	-0.50	0.620	-1.936924	1.155414
ZhejiangUniversity	-1.390123	1.323709	-1.05	0.294	-3.984544	1.204299
CommunicationUniversityofC	-.3218808	.8892198	-0.36	0.717	-2.06472	1.420958
LuxunAcademyofFineArts	-.4648955	.8110571	-0.57	0.567	-2.054538	1.124747
SoochowUniversity	-.7274011	.8750238	-0.83	0.406	-2.442416	.9876142
/cut1	-3.262766	1.459628			-6.123584	-.4019487
/cut2	-2.404693	1.448447			-5.243596	.4342097
/cut3	-1.209655	1.443851			-4.03955	1.620241
/cut4	.0328535	1.444651			-2.798611	2.864318
/cut5	1.086411	1.447223			-1.750093	3.922916

. ologit K8 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -363.32977
Iteration 1: log likelihood = -338.6655
Iteration 2: log likelihood = -337.76226
Iteration 3: log likelihood = -337.75851
Iteration 4: log likelihood = -337.75851

Ordered logistic regression	Number of obs	=	228
	LR chi2(24)	=	51.14
	Prob > chi2	=	0.0010
Log likelihood = -337.75851	Pseudo R2	=	0.0704

K8	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	.048247	.0216961	2.22	0.026	.0057234	.0907707
Age	-.1361295	.2743679	-0.50	0.620	-.6738806	.4016217
Gender	.4510333	.2685244	1.68	0.093	-.075265	.9773315
Project1	-.4709297	.6197168	-0.76	0.447	-1.685552	.7436929
Project2	-.4060177	.631912	-0.64	0.521	-1.644542	.8325071
Project3	-.4693843	.5533086	-0.85	0.396	-1.553849	.6150807
Project4	-.3683177	.6577806	-0.56	0.576	-1.657544	.9209086
Project5	-.533747	.8344332	-0.64	0.522	-2.169206	1.101712
Project6	.0535958	.8166013	0.07	0.948	-1.546913	1.654105
Project7	-.2492021	.6887793	-0.36	0.717	-1.599185	1.10078
Project8	-.809148	.6177187	-1.31	0.190	-2.019854	.4015585
Project9	-2.189069	.7153955	-3.06	0.002	-3.591218	-.7869195
Project10	-2.331636	.714441	-3.26	0.001	-3.731915	-.9313577
Project11	0	(omitted)				
TsinghuaUniversity	1.539131	1.159842	1.33	0.185	-.7341172	3.812379
CentralAcademyofFineArt	-.1870623	1.271324	-0.15	0.883	-2.678812	2.304688
ChinaAcademyofArt	.7756393	.8818433	0.88	0.379	-.9527417	2.50402
JiangnanUniversity	.4440739	.8399404	0.53	0.597	-1.202179	2.090327
NanjingUniversityoftheArt	.411551	.819939	0.50	0.616	-1.1955	2.018602
TongjiUniversity	1.049908	.9885754	1.06	0.288	-.8876642	2.98748
DonghuaUniversity	.4492713	.8467774	0.53	0.596	-1.210382	2.108925
ZhejiangUniversity	-.0130655	2.077449	-0.01	0.995	-4.08479	4.058659
CommunicationUniversityofC	1.245302	.9014774	1.38	0.167	-.521561	3.012165
LuxunAcademyofFineArts	-.8544532	.8711343	-0.98	0.327	-2.561845	.8529386
SoochowUniversity	.4566111	.9712707	0.47	0.638	-1.447044	2.360267
/cut1	-1.842926	1.531574			-4.844756	1.158903
/cut2	-.9753851	1.515464			-3.945641	1.99487
/cut3	.7240973	1.511402			-2.238196	3.686391
/cut4	2.680953	1.52448			-.3069732	5.66888
/cut5	4.107267	1.543728			1.081615	7.132919
/cut6	5.095637	1.563643			2.030954	8.160321

. ologit K9 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts SoochowU
> niversity

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -413.86647
Iteration 1: log likelihood = -392.28077
Iteration 2: log likelihood = -391.77078
Iteration 3: log likelihood = -391.7686
Iteration 4: log likelihood = -391.7686

Ordered logistic regression	Number of obs	=	228
	LR chi2(24)	=	44.20
	Prob > chi2	=	0.0072
Log likelihood = -391.7686	Pseudo R2	=	0.0534

K9	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	.0570645	.0200757	2.84	0.004	.0177168	.0964122
Age	-.1516812	.2713477	-0.56	0.576	-.683513	.3801506
Gender	-.3148605	.256759	-1.23	0.220	-.818099	.1883779
Project1	-.2939151	.5653409	-0.52	0.603	-1.401963	.8141327
Project2	-.1842366	.5691782	-0.32	0.746	-1.299805	.9313323
Project3	-.6519794	.4870495	-1.34	0.181	-1.606579	.3026201
Project4	-.4695681	.6132295	-0.77	0.444	-1.671476	.7323397
Project5	-1.817976	.8087612	-2.25	0.025	-3.403119	-.2328333
Project6	-.9926806	.7194505	-1.38	0.168	-2.402778	.4174164
Project7	-.7483305	.6184039	-1.21	0.226	-1.96038	.4637189
Project8	-1.100861	.5768829	-1.91	0.056	-2.23153	.029809
Project9	-2.43132	.6316718	-3.85	0.000	-3.669374	-1.193266
Project10	-1.586088	.6809829	-2.33	0.020	-2.92079	-.2513859
Project11	0	(omitted)				
TsinghuaUniversity	.554851	1.096948	0.51	0.613	-1.595128	2.70483
CentralAcademyofFineArt	-.3952168	1.079901	-0.37	0.714	-2.511784	1.72135
ChinaAcademyofArt	-.8732621	.7995634	-1.09	0.275	-2.440378	.6938532
JiangnanUniversity	-1.253653	.7528238	-1.67	0.096	-2.72916	.2218548
NanjingUniversityoftheArt	-.5826487	.7353796	-0.79	0.428	-2.023966	.8586688
T ongjiUniversity	-.7350221	.9879664	-0.74	0.457	-2.671401	1.201356
DonghuaUniversity	-.355498	.768342	-0.46	0.644	-1.861421	1.150425
ZhejiangUniversity	-1.12808	2.19692	-0.51	0.608	-5.433964	3.177805
CommunicationUniversityofC	-.4126658	.8510672	-0.48	0.628	-2.080727	1.255395
LuxunAcademyofFineArts	-.6789536	.7821712	-0.87	0.385	-2.211981	.8540738
SoochowUniversity	.2988616	.8477429	0.35	0.724	-1.362684	1.960407
/cut1	-3.037729	1.436486			-5.85319	-.2222668
/cut2	-2.048303	1.418599			-4.828707	.732101
/cut3	-.9575842	1.41037			-3.721859	1.80669
/cut4	.1483299	1.406815			-2.608977	2.905637
/cut5	1.302868	1.409908			-1.4605	4.066237
/cut6	2.892542	1.427167			.0953452	5.689738

. ologit K10 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -408.09227
Iteration 1: log likelihood = -392.07123
Iteration 2: log likelihood = -391.76967
Iteration 3: log likelihood = -391.76927
Iteration 4: log likelihood = -391.76927

Ordered logistic regression	Number of obs	=	228
	LR chi2(24)	=	32.65
	Prob > chi2	=	0.1118
Log likelihood = -391.76927	Pseudo R2	=	0.0400

K10	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	.0465495	.0203033	2.29	0.022	.0067558	.0863433
Age	-.1904884	.2597164	-0.73	0.463	-.6995232	.3185463
Gender	-.0155369	.2609126	-0.06	0.953	-.5269163	.4958424
Project1	-.2677416	.6027375	-0.44	0.657	-1.449085	.9136021
Project2	.3119309	.6020407	0.52	0.604	-.8680472	1.491909
Project3	-.7097767	.5507612	-1.29	0.197	-1.789249	.3696953
Project4	-.34854	.6543973	-0.53	0.594	-1.631135	.934055
Project5	-2.026722	.8574217	-2.36	0.018	-3.707238	-.3462065
Project6	-.0877435	.7832548	-0.11	0.911	-1.622895	1.447408
Project7	-.4475152	.6659857	-0.67	0.502	-1.752823	.8577928
Project8	-.5206083	.6327332	-0.82	0.411	-1.760743	.719526
Project9	-2.216528	.73044	-3.03	0.002	-3.648164	-.7848916
Project10	-1.267821	.685468	-1.85	0.064	-2.611313	.075672
Project11	0	(omitted)				
TsinghuaUniversity	-.350868	1.146672	-0.31	0.760	-2.598304	1.896568
CentralAcademyofFineArt	.7897467	1.306519	0.60	0.546	-1.770983	3.350476
ChinaAcademyofArt	.0232106	.8549787	0.03	0.978	-1.652517	1.698938
JiangnanUniversity	.0330187	.815834	0.04	0.968	-1.565987	1.632024
NanjingUniversityoftheArt	.0592792	.8072247	0.07	0.941	-1.522852	1.64141
TongjiUniversity	.4781109	.9695136	0.49	0.622	-1.422101	2.378323
DonghuaUniversity	.2486633	.8326123	0.30	0.765	-1.383227	1.880553
ZhejiangUniversity	-.6661441	1.772531	-0.38	0.707	-4.140241	2.807953
CommunicationUniversityofC	.1911096	.8939758	0.21	0.831	-1.561051	1.94327
LuxunAcademyofFineArts	-.3943829	.8758739	-0.45	0.653	-2.111064	1.322298
SoochowUniversity	.5443525	.9552299	0.57	0.569	-1.327864	2.416569
/cut1	-2.150006	1.453901			-4.9996	.699587
/cut2	-.9554341	1.44013			-3.778036	1.867168
/cut3	.0547606	1.43891			-2.76545	2.874972
/cut4	1.253433	1.440259			-1.569424	4.076289
/cut5	2.635817	1.446579			-.1994251	5.47106
/cut6	3.905471	1.467082			1.030042	6.7809

```
. ologit K11 MAI_SUM Age    Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8
Project9 Project10 Project11    TsinghuaUniversity CentralAcademyofFineArt
>    ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity
ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University

note: Project11 omitted because of collinearity
Iteration 0:     log likelihood =    -380.1498
Iteration 1:     log likelihood = -366.32974
Iteration 2:     log likelihood = -366.07278
Iteration 3:     log likelihood = -366.07125
Iteration 4:     log likelihood = -366.07125

Ordered logistic regression                          Number of obs      =          228
                                                      LR chi2(24)       =        28.16
                                                      Prob > chi2       =       0.2535
Log likelihood = -366.07125                          Pseudo R2          =       0.0370

------------------------------------------------------------------------------------------
                         K11 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------------+----------------------------------------------------------------
                     MAI_SUM |   .0129069   .0201885     0.64   0.523    -.0266619    .0524756
                         Age |  -.2494743   .2743727    -0.91   0.363     -.787235    .2882864
                      Gender |   .3023268   .2556925     1.18   0.237    -.1988213    .8034749
                    Project1 |   .0548546   .5767158     0.10   0.924    -1.075488    1.185197
                    Project2 |  -.0063146   .5804353    -0.01   0.991    -1.143947    1.131318
                    Project3 |   -.406876   .4927517    -0.83   0.409    -1.372652    .5588997
                    Project4 |    .115547   .6288162     0.18   0.854     -1.11691    1.348004
                    Project5 |  -.3594857   .8614935    -0.42   0.676    -2.047982    1.329011
                    Project6 |   .3888675   .7219129     0.54   0.590    -1.026056    1.803791
                    Project7 |  -.6997888   .6178691    -1.13   0.257     -1.91079    .5112124
                    Project8 |   .0320871   .5585908     0.06   0.954    -1.062731    1.126905
                    Project9 |   .2479297   .6318885     0.39   0.695     -.990549    1.486408
                   Project10 |   .6020298   .6616754     0.91   0.363    -.6948302     1.89889
                   Project11 |          0  (omitted)
          TsinghuaUniversity |    1.22308   1.472138     0.83   0.406    -1.662257    4.108417
     CentralAcademyofFineArt |  -.9680883   1.108401    -0.87   0.382    -3.140514    1.204338
           ChinaAcademyofArt |  -.2145788   .8555311    -0.25   0.802    -1.891389    1.462231
          JiangnanUniversity |  -.4864799   .8041009    -0.60   0.545    -2.062489    1.089529
   NanjingUniversityoftheArt |  -1.407556   .7968802    -1.77   0.077    -2.969413    .1543004
            TongjiUniversity |  -1.274303   .9844373    -1.29   0.196    -3.203764    .6551589
           DonghuaUniversity |  -.4822027   .8195182    -0.59   0.556    -2.088429    1.124023
          ZhejiangUniversity |  -4.412259   1.759169    -2.51   0.012    -7.860167   -.9643519
  CommunicationUniversityofC |  -.5242966   .8908242    -0.59   0.556     -2.27028    1.221687
      LuxunAcademyofFineArts |  -1.231334   .8514141    -1.45   0.148    -2.900074    .4374074
           SoochowUniversity |  -1.361824   .9265301    -1.47   0.142    -3.177789     .454142
-------------------------+----------------------------------------------------------------
                       /cut1 |  -5.193617   1.523391                       -8.17941   -2.207825
                       /cut2 |  -4.574054   1.483339                      -7.481345   -1.666762
                       /cut3 |  -2.718385   1.435451                      -5.531818    .0950481
                       /cut4 |  -1.088351   1.428785                      -3.888719    1.712017
                       /cut5 |  -.4506685   1.429443                      -3.252324    2.350987
                       /cut6 |     .70115   1.428202                      -2.098075    3.500375
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. ologit K12 MAI_SUM Age    Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8
Project9 Project10 Project11    TsinghuaUniversity CentralAcademyofFineArt
>    ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity
ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University

note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -390.48764
Iteration 1:   log likelihood =   -368.5121
Iteration 2:   log likelihood = -368.09021
Iteration 3:   log likelihood = -368.08942
Iteration 4:   log likelihood = -368.08942
Ordered logistic regression                     Number of obs     =        228
                                                LR chi2(24)       =      44.80
                                                Prob > chi2       =     0.0062
Log likelihood = -368.08942                     Pseudo R2         =     0.0574

-------------------------------------------------------------------------------------------
                       K12 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------------+---------------------------------------------------------------
                   MAI_SUM |   .0620578   .0206378     3.01   0.003     .0216086    .1025071
                       Age |  -.0890468   .2767212    -0.32   0.748    -.6314103    .4533167
                    Gender |   .3039013   .2639419     1.15   0.250    -.2134152    .8212179
                  Project1 |  -.7866675    .611479    -1.29   0.198    -1.985144    .4118093
                  Project2 |   .1668969   .6305246     0.26   0.791    -1.068909    1.402702
                  Project3 |  -.5455487   .5461816    -1.00   0.318    -1.616045    .5249476
                  Project4 |  -.3650791   .6408908    -0.57   0.569    -1.621202    .8910438
                  Project5 |  -1.442764   .7986634    -1.81   0.071    -3.008116    .1225874
                  Project6 |   .1550329   .8587258     0.18   0.857    -1.528039    1.838104
                  Project7 |  -1.568813   .6803691    -2.31   0.021    -2.902312    -.235314
                  Project8 |  -.6743741   .6036567    -1.12   0.264     -1.85752    .5087713
                  Project9 |  -.3474844   .6784693    -0.51   0.609     -1.67726     .982291
                 Project10 |  -.2718321   .7158786    -0.38   0.704    -1.674928    1.131264
                 Project11 |          0  (omitted)
        TsinghuaUniversity |  -.1476082   1.148595    -0.13   0.898    -2.398813    2.103597
   CentralAcademyofFineArt |  -2.208437   1.201138    -1.84   0.066    -4.562624    .1457504
         ChinaAcademyofArt |  -.0383915     .83879    -0.05   0.963     -1.68239    1.605607
        JiangnanUniversity |   .0259778   .7802247     0.03   0.973    -1.503235     1.55519
 NanjingUniversityoftheArt |   -1.53849   .7695517    -2.00   0.046    -3.046784   -.0301969
          TongjiUniversity |  -.5486117   .9422544    -0.58   0.560    -2.395396    1.298173
         DonghuaUniversity |  -.3146396   .7933282    -0.40   0.692    -1.869534    1.240255
        ZhejiangUniversity |  -1.195059   1.343885    -0.89   0.374    -3.829025    1.438907
CommunicationUniversityofC |   .5137735   .8469463     0.61   0.544    -1.146211    2.173758
    LuxunAcademyofFineArts |   -.940524   .8144122    -1.15   0.248    -2.536743    .6556946
         SoochowUniversity |  -1.111106    .914502    -1.21   0.224    -2.903497    .6812849
---------------------------+---------------------------------------------------------------
                     /cut1 |  -2.386558   1.493021                      -5.312825    .5397085
                     /cut2 |  -.7327854   1.470306                      -3.614533    2.148962
                     /cut3 |   .6035742   1.471598                      -2.280705    3.487853
                     /cut4 |   2.386661   1.476398                      -.5070255    5.280347
                     /cut5 |   3.038289   1.481313                       .1349696    5.941609
                     /cut6 |   4.104043   1.494439                       1.174996    7.033091
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. ologit K13 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -374.11413
Iteration 1: log likelihood = -366.88773
Iteration 2: log likelihood = -366.85651
Iteration 3: log likelihood = -366.8565

Ordered logistic regression — Number of obs = 228
LR chi2(24) = 14.52
Prob > chi2 = 0.9341
Log likelihood = -366.8565 — Pseudo R2 = 0.0194

K13	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	.0102593	.0200588	0.51	0.609	-.0290552	.0495738
Age	-.2697498	.2714237	-0.99	0.320	-.8017305	.2622309
Gender	-.0758641	.2632748	-0.29	0.773	-.5918732	.4401449
Project1	-.489242	.5831715	-0.84	0.402	-1.632237	.6537532
Project2	.1422	.5990106	0.24	0.812	-1.031839	1.316239
Project3	-.0263155	.5244664	-0.05	0.960	-1.054251	1.00162
Project4	-.1155062	.6251113	-0.18	0.853	-1.340702	1.109689
Project5	-.1317816	.7643797	-0.17	0.863	-1.629938	1.366375
Project6	-.1558652	.775489	-0.20	0.841	-1.675796	1.364065
Project7	-.7530625	.6534768	-1.15	0.249	-2.033854	.5277285
Project8	.190264	.58391	0.33	0.745	-.9541787	1.334707
Project9	-.855806	.6809741	-1.26	0.209	-2.190491	.4788787
Project10	-.926511	.6858679	-1.35	0.177	-2.270787	.4177654
Project11	0	(omitted)				
TsinghuaUniversity	-1.158778	1.242228	-0.93	0.351	-3.593501	1.275944
CentralAcademyofFineArt	-.4322051	1.148317	-0.38	0.707	-2.682865	1.818455
ChinaAcademyofArt	-.4276938	.8582854	-0.50	0.618	-2.109902	1.254515
JiangnanUniversity	-.7835014	.8267258	-0.95	0.343	-2.403854	.8368513
NanjingUniversityoftheArt	-.6724484	.8149324	-0.83	0.409	-2.269687	.9247897
TongjiUniversity	-.0588737	1.004889	-0.06	0.953	-2.02842	1.910672
DonghuaUniversity	-.80424	.8384931	-0.96	0.337	-2.447656	.8391763
ZhejiangUniversity	-.9481283	1.593584	-0.59	0.552	-4.071496	2.17524
CommunicationUniversityofC	-.6463392	.9032783	-0.72	0.474	-2.416732	1.124054
LuxunAcademyofFineArts	-1.086044	.8763901	-1.24	0.215	-2.803737	.6316491
SoochowUniversity	-1.07992	.9836598	-1.10	0.272	-3.007857	.8480182
/cut1	-6.888036	1.765494			-10.34834	-3.427732
/cut2	-5.481959	1.540067			-8.500435	-2.463482
/cut3	-2.700125	1.463402			-5.56834	.1680891
/cut4	-1.582671	1.454255			-4.432958	1.267615
/cut5	-.3324376	1.447352			-3.169195	2.504319
/cut6	.4661121	1.450138			-2.376106	3.30833

. ologit K14 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -355.59798
Iteration 1: log likelihood = -345.30919
Iteration 2: log likelihood = -344.41349
Iteration 3: log likelihood = -344.35976
Iteration 4: log likelihood = -344.35975

Ordered logistic regression	Number of obs	=	228
	LR chi2(24)	=	22.48
	Prob > chi2	=	0.5509
Log likelihood = -344.35975	Pseudo R2	=	0.0316

K14	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	-.0049528	.0198884	-0.25	0.803	-.0439333	.0340276
Age	-.2146991	.2631037	-0.82	0.414	-.7303729	.3009747
Gender	-.0292461	.2604455	-0.11	0.911	-.53971	.4812177
Project1	-1.015334	.6251065	-1.62	0.104	-2.24052	.2098524
Project2	-.311196	.6234592	-0.50	0.618	-1.533154	.9107615
Project3	-.0656048	.5497821	-0.12	0.905	-1.143158	1.011948
Project4	-.9500259	.6392354	-1.49	0.137	-2.202904	.3028524
Project5	-.785321	.8564383	-0.92	0.359	-2.463909	.8932672
Project6	-.4128377	.822338	-0.50	0.616	-2.024591	1.198915
Project7	-.331116	.7033126	-0.47	0.638	-1.709583	1.047351
Project8	-.0244553	.611562	-0.04	0.968	-1.223095	1.174184
Project9	-.8636761	.6817002	-1.27	0.205	-2.199784	.4724318
Project10	-.1802826	.7385252	-0.24	0.807	-1.627765	1.2672
Project11	0	(omitted)				
TsinghuaUniversity	-1.603537	1.365536	-1.17	0.240	-4.279938	1.072863
CentralAcademyofFineArt	.2653169	1.175759	0.23	0.821	-2.039128	2.569762
ChinaAcademyofArt	-.4234239	.9502684	-0.45	0.656	-2.285916	1.439068
JiangnanUniversity	-.6521229	.9150125	-0.71	0.476	-2.445514	1.141269
NanjingUniversityoftheArt	-.1564338	.9017344	-0.17	0.862	-1.923801	1.610933
TongjiUniversity	-.4486771	1.043672	-0.43	0.667	-2.494236	1.596882
DonghuaUniversity	-.1297985	.9275937	-0.14	0.889	-1.947849	1.688252
ZhejiangUniversity	-2.545745	1.468455	-1.73	0.083	-5.423865	.3323739
CommunicationUniversityofC	.3843155	.978504	0.39	0.694	-1.533517	2.302148
LuxunAcademyofFineArts	.0367998	.94787	0.04	0.969	-1.820991	1.894591
SoochowUniversity	.2989946	1.001915	0.30	0.765	-1.664723	2.262712
/cut1	-6.011438	1.623156			-9.192765	-2.83011
/cut2	-3.660912	1.518707			-6.637522	-.6843011
/cut3	-2.546567	1.50942			-5.504976	.411842
/cut4	-1.574499	1.506982			-4.528129	1.379131
/cut5	.3212887	1.502664			-2.623878	3.266455

. ologit K15 MAI_SUM Age Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11 TsinghuaUniversity CentralAcademyofFineArt
> ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University

note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -356.92385
Iteration 1: log likelihood = -352.54097
Iteration 2: log likelihood = -342.94207
Iteration 3: log likelihood = -342.84838
Iteration 4: log likelihood = -342.8483
Iteration 5: log likelihood = -342.8483

Ordered logistic regression	Number of obs	=	228
	LR chi2(24)	=	28.15
	Prob > chi2	=	0.2537
Log likelihood = -342.8483	Pseudo R2	=	0.0394

K15	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	.0280019	.0201875	1.39	0.165	-.0115649	.0675688
Age	-.0645382	.2610273	-0.25	0.805	-.5761424	.4470659
Gender	-.1088594	.2599032	-0.42	0.675	-.6182603	.4005416
Project1	.0424721	.6053285	0.07	0.944	-1.14395	1.228894
Project2	.6203472	.6140836	1.01	0.312	-.5832346	1.823929
Project3	.3919664	.5481217	0.72	0.475	-.6823324	1.466265
Project4	.4405922	.649621	0.68	0.498	-.8326416	1.713826
Project5	.1143412	.8388143	0.14	0.892	-1.529705	1.758387
Project6	-.3585934	.7767836	-0.46	0.644	-1.881061	1.163875
Project7	-.0933629	.6856539	-0.14	0.892	-1.43722	1.250494
Project8	.0308729	.596641	0.05	0.959	-1.138522	1.200268
Project9	.0250273	.6985898	0.04	0.971	-1.344184	1.394238
Project10	.4192186	.7317197	0.57	0.567	-1.014926	1.853363
Project11	0	(omitted)				
TsinghuaUniversity	-1.548591	1.294019	-1.20	0.231	-4.084821	.9876389
CentralAcademyofFineArt	1.723351	1.30771	1.32	0.188	-.8397133	4.286415
ChinaAcademyofArt	-.1004089	.9166441	-0.11	0.913	-1.896998	1.696181
JiangnanUniversity	.7526017	.8834827	0.85	0.394	-.9789926	2.484196
NanjingUniversityoftheArt	.1991751	.8753408	0.23	0.820	-1.516461	1.914812
TongjiUniversity	.5735515	1.07925	0.53	0.595	-1.541739	2.688842
DonghuaUniversity	.8427578	.8926495	0.94	0.345	-.9068031	2.592319
ZhejiangUniversity	-3.003562	1.467937	-2.05	0.041	-5.880665	-.1264582
CommunicationUniversityofC	.4691946	.9355078	0.50	0.616	-1.364367	2.302756
LuxunAcademyofFineArts	.5714185	.9235586	0.62	0.536	-1.238723	2.38156
SoochowUniversity	1.361962	1.006306	1.35	0.176	-.6103615	3.334286
/cut1	-2.87206	1.549077			-5.908196	.1640764
/cut2	-1.086763	1.474463			-3.976658	1.803132
/cut3	.456912	1.471233			-2.426652	3.340476
/cut4	1.959033	1.479226			-.9401968	4.858262
/cut5	3.27102	1.485523			.3594476	6.182593

```
. ologit K16 MAI_SUM Age    Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8
Project9 Project10 Project11    TsinghuaUniversity CentralAcademyofFineArt
>    ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity
ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University

note: Project11 omitted because of collinearity
Iteration 0:     log likelihood = -358.39745
Iteration 1:     log likelihood = -345.45494
Iteration 2:     log likelihood = -338.46943    (backed up)
Iteration 3:     log likelihood = -338.04897
Iteration 4:     log likelihood = -338.04716
Iteration 5:     log likelihood = -338.04716

Ordered logistic regression                      Number of obs     =        228
                                                  LR chi2(24)      =      40.70
                                                  Prob > chi2      =     0.0180
Log likelihood = -338.04716                      Pseudo R2         =     0.0568
```

K16	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
MAI_SUM	.040478	.0204857	1.98	0.048	.0003267	.0806293
Age	-.6198913	.2716638	-2.28	0.022	-1.152343	-.08744
Gender	.1952656	.2605884	0.75	0.454	-.3154783	.7060096
Project1	-.7366723	.6134187	-1.20	0.230	-1.938951	.4656063
Project2	.2070669	.6194685	0.33	0.738	-1.007069	1.421203
Project3	-.237977	.537439	-0.44	0.658	-1.291338	.815384
Project4	-.0268851	.6467446	-0.04	0.967	-1.294481	1.240711
Project5	-.3286141	.8210707	-0.40	0.689	-1.937883	1.280655
Project6	-1.082677	.7994275	-1.35	0.176	-2.649526	.484172
Project7	-.6051181	.6522702	-0.93	0.354	-1.883544	.673308
Project8	-.4352149	.6085404	-0.72	0.474	-1.627932	.7575024
Project9	-.0713749	.6787283	-0.11	0.916	-1.401658	1.258908
Project10	-.1565483	.7389061	-0.21	0.832	-1.604778	1.291681
Project11	0	(omitted)				
TsinghuaUniversity	-.6438818	1.232281	-0.52	0.601	-3.059108	1.771344
CentralAcademyofFineArt	2.232059	1.250257	1.79	0.074	-.2184005	4.682519
ChinaAcademyofArt	-.1235661	.8547202	-0.14	0.885	-1.798787	1.551655
JiangnanUniversity	-.0744525	.805219	-0.09	0.926	-1.652653	1.503748
NanjingUniversityoftheArt	-.2362404	.8008107	-0.30	0.768	-1.805801	1.33332
TongjiUniversity	-.0432254	1.00233	-0.04	0.966	-2.007755	1.921305
DonghuaUniversity	.5084721	.8186876	0.62	0.535	-1.096126	2.11307
ZhejiangUniversity	-4.714319	1.639006	-2.88	0.004	-7.926712	-1.501927
CommunicationUniversityofC	.5993958	.8767063	0.68	0.494	-1.118917	2.317708
LuxunAcademyofFineArts	.4904249	.8440264	0.58	0.561	-1.163836	2.144686
SoochowUniversity	.6553598	.9457464	0.69	0.488	-1.198269	2.508989
/cut1	-4.866695	1.586719			-7.976607	-1.756784
/cut2	-2.39618	1.489612			-5.315765	.5234061
/cut3	-1.006305	1.480041			-3.907132	1.894523
/cut4	.7156372	1.476384			-2.178023	3.609297
/cut5	1.721053	1.480642			-1.180951	4.623057

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. ologit K17 MAI_SUM Age    Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8
Project9 Project10 Project11    TsinghuaUniversity CentralAcademyofFineArt
>    ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity
ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University

note: Project11 omitted because of collinearity
Iteration 0:    log likelihood = -332.08767
Iteration 1:    log likelihood =   -306.6684
Iteration 2:    log likelihood = -305.87672
Iteration 3:    log likelihood = -305.87418
Iteration 4:    log likelihood = -305.87418

Ordered logistic regression                     Number of obs     =        228
                                                LR chi2(24)       =      52.43
                                                Prob > chi2       =     0.0007
Log likelihood = -305.87418                     Pseudo R2         =     0.0789
```

K17	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
MAI_SUM	.0671738	.0218522	3.07	0.002	.0243442	.1100034
Age	-.3441112	.2775197	-1.24	0.215	-.8880398	.1998175
Gender	.195882	.2688382	0.73	0.466	-.3310311	.7227952
Project1	-.9830458	.607481	-1.62	0.106	-2.173687	.2075951
Project2	-.572219	.6018478	-0.95	0.342	-1.751819	.607381
Project3	-1.310868	.5346901	-2.45	0.014	-2.358841	-.2628945
Project4	-1.149823	.6463187	-1.78	0.075	-2.416584	.1169388
Project5	-1.64639	.805554	-2.04	0.041	-3.225247	-.0675332
Project6	-1.547698	.8206131	-1.89	0.059	-3.15607	.0606739
Project7	-1.652684	.6960104	-2.37	0.018	-3.01684	-.2885288
Project8	-.7364224	.5999508	-1.23	0.220	-1.912304	.4394596
Project9	-1.108007	.6717425	-1.65	0.099	-2.424598	.2085843
Project10	-.1997998	.7392908	-0.27	0.787	-1.648783	1.249184
Project11	0	(omitted)				
TsinghuaUniversity	-.0149167	1.253539	-0.01	0.991	-2.471809	2.441975
CentralAcademyofFineArt	-2.422345	1.282749	-1.89	0.059	-4.936487	.0917957
ChinaAcademyofArt	.7681202	.9643681	0.80	0.426	-1.122007	2.658247
JiangnanUniversity	.1298402	.9359259	0.14	0.890	-1.704541	1.964221
NanjingUniversityoftheArt	-1.289918	.9288981	-1.39	0.165	-3.110524	.5306891
TongjiUniversity	-.9976682	1.112444	-0.90	0.370	-3.178019	1.182683
DonghuaUniversity	.7322237	.9534337	0.77	0.442	-1.136472	2.600919
ZhejiangUniversity	-.3910297	1.51103	-0.26	0.796	-3.352594	2.570534
CommunicationUniversityofC	.7853284	1.004551	0.78	0.434	-1.183555	2.754212
LuxunAcademyofFineArts	-.6647743	.9701861	-0.69	0.493	-2.566304	1.236756
SoochowUniversity	.0749871	1.075567	0.07	0.944	-2.033085	2.183059
/cut1	-5.345621	1.836656			-8.9454	-1.745841
/cut2	-3.912373	1.625156			-7.097619	-.727126
/cut3	-2.383762	1.573534			-5.467833	.7003077
/cut4	-.5595936	1.565683			-3.628277	2.509089
/cut5	1.638976	1.564029			-1.426465	4.704418
/cut6	3.208415	1.569577			.1321001	6.284729

```
. ologit K18 MAI_SUM Age    Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8
Project9 Project10 Project11    TsinghuaUniversity CentralAcademyofFineArt
>   ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity
ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University

note: Project11 omitted because of collinearity
Iteration 0:    log likelihood = -398.84513
Iteration 1:    log likelihood = -375.62465
Iteration 2:    log likelihood = -374.81146
Iteration 3:    log likelihood = -374.80965
Iteration 4:    log likelihood = -374.80965

Ordered logistic regression                     Number of obs    =       228
                                                LR chi2(24)      =     48.07
                                                Prob > chi2      =    0.0025
Log likelihood = -374.80965                     Pseudo R2        =    0.0603

------------------------------------------------------------------------------------------
                        K18 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
----------------------------+-------------------------------------------------------------
                    MAI_SUM |   .0670912   .0202523    3.31   0.001     .0273975    .1067849
                        Age |  -.1764235    .256068   -0.69   0.491    -.6783076    .3254606
                     Gender |   .1555533   .2555971    0.61   0.543    -.3454078    .6565144
                   Project1 |   .4164504   .6273821    0.66   0.507     -.813196    1.646097
                   Project2 |   .9673998    .640644    1.51   0.131    -.2882393    2.223039
                   Project3 |  -.1163725   .5550087   -0.21   0.834     -1.20417    .9714246
                   Project4 |   .4297775   .6750541    0.64   0.524    -.8933042    1.752859
                   Project5 |   1.382843   .8122874    1.70   0.089    -.2092111    2.974897
                   Project6 |  -.4046257   .7604506   -0.53   0.595    -1.895081     1.08583
                   Project7 |    .793279   .6590223    1.20   0.229    -.4983809    2.084939
                   Project8 |   .9343787   .6252796    1.49   0.135    -.2911469    2.159904
                   Project9 |   -.472211   .6848564   -0.69   0.491    -1.814505    .8700829
                  Project10 |    .029039   .7291353    0.04   0.968     -1.40004    1.458118
                  Project11 |          0  (omitted)
         TsinghuaUniversity |   1.335626   1.107139    1.21   0.228    -.8343276    3.505579
    CentralAcademyofFineArt |   1.822869   1.195417    1.52   0.127    -.5201057    4.165843
          ChinaAcademyofArt |   .6459634   .8582508    0.75   0.452    -1.036177    2.328104
         JiangnanUniversity |  -.5877367   .7884093   -0.75   0.456    -2.132991    .9575171
  NanjingUniversityoftheArt |  -.6179846   .7808327   -0.79   0.429    -2.148389    .9124192
           TongjiUniversity |  -1.136283   .9767937   -1.16   0.245    -3.050764    .7781973
          DonghuaUniversity |   -.328183    .798642   -0.41   0.681    -1.893493    1.237127
         ZhejiangUniversity |   .3237977   1.336946    0.24   0.809    -2.296568    2.944163
 CommunicationUniversityofC |   .3663116   .8633735    0.42   0.671    -1.325869    2.058493
     LuxunAcademyofFineArts |   .5341402   .8341273    0.64   0.522    -1.100719       2.169
          SoochowUniversity |  -.5587658   .9071185   -0.62   0.538    -2.336685    1.219154
----------------------------+-------------------------------------------------------------
                      /cut1 |  -.9005805   1.446608                      -3.73588    1.934719
                      /cut2 |  -.2167557   1.437138                     -3.033493    2.599982
                      /cut3 |   .7039052   1.433076                     -2.104872    3.512683
                      /cut4 |   2.229709   1.440695                      -.594002     5.05342
                      /cut5 |    3.48662   1.453437                      .6379354    6.335304
                      /cut6 |   4.945429   1.468197                      2.067817    7.823041
------------------------------------------------------------------------------------------
```

```
. ologit K19 MAI_SUM Age    Gender Project1 Project2 Project3 Project4 Project5 Project6 Project7 Project8
Project9 Project10 Project11    TsinghuaUniversity CentralAcademyofFineArt
>    ChinaAcademyofArt JiangnanUniversity NanjingUniversityoftheArt TongjiUniversity DonghuaUniversity
ZhejiangUniversity CommunicationUniversityofC LuxunAcademyofFineArts Soochow
> University
note: Project11 omitted because of collinearity
Iteration 0:     log likelihood = -329.70408
Iteration 1:     log likelihood = -309.70352
Iteration 2:     log likelihood = -308.92694
Iteration 3:     log likelihood = -308.92499
Iteration 4:     log likelihood = -308.92499
Ordered logistic regression                       Number of obs     =        228
                                                  LR chi2(24)       =      41.56
                                                  Prob > chi2       =     0.0145
Log likelihood = -308.92499                       Pseudo R2         =     0.0630
------------------------------------------------------------------------------
                       K19 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------------+--------------------------------------------------
                   MAI_SUM |   .0797108   .0213361     3.74   0.000     .0378928    .1215288
                       Age |  -.1606852   .2686208    -0.60   0.550    -.6871723    .3658019
                    Gender |    .094184   .2693939     0.35   0.727    -.4338182    .6221863
                  Project1 |  -.2166779   .6575002    -0.33   0.742    -1.505355    1.071999
                  Project2 |   .9014842   .6693736     1.35   0.178    -.4104639    2.213432
                  Project3 |   .3624655   .5923904     0.61   0.541    -.7985983    1.523529
                  Project4 |   .2025569   .7025106     0.29   0.773    -1.174339    1.579452
                  Project5 |   .4456341   .8752818     0.51   0.611    -1.269887    2.161155
                  Project6 |   -.557668   .8693735    -0.64   0.521    -2.261609    1.146273
                  Project7 |   .4659118   .7027014     0.66   0.507    -.9113578    1.843181
                  Project8 |   .9526336   .6386406     1.49   0.136    -.2990789    2.204346
                  Project9 |  -.0132235   .7174837    -0.02   0.985    -1.419466    1.393019
                 Project10 |  -.0041401   .7689318    -0.01   0.996    -1.511219    1.502939
                 Project11 |          0  (omitted)
        TsinghuaUniversity |  -.7450969   1.229261    -0.61   0.544    -3.154404     1.66421
   CentralAcademyofFineArt |   1.713714   1.239786     1.38   0.167    -.7162221    4.143651
         ChinaAcademyofArt |   .2368753    .928986     0.25   0.799    -1.583904    2.057654
        JiangnanUniversity |  -.9475116     .88936    -1.07   0.287    -2.690625     .795602
 NanjingUniversityoftheArt |  -.2634372   .8858734    -0.30   0.766    -1.999717    1.472843
          TongjiUniversity |  -.8586863   1.119607    -0.77   0.443    -3.053075    1.335702
         DonghuaUniversity |  -.4852923   .8999214    -0.54   0.590    -2.249106    1.278521
        ZhejiangUniversity |  -1.518714   1.504645    -1.01   0.313    -4.467764    1.430336
CommunicationUniversityofC |  -.1626216   .9508691    -0.17   0.864    -2.026291    1.701048
    LuxunAcademyofFineArts |  -.9803194   .9443168    -1.04   0.299    -2.831146    .8705076
         SoochowUniversity |  -.4661353   1.042961    -0.45   0.655    -2.510302    1.578031
---------------------------+--------------------------------------------------
                     /cut1 |  -2.527081   1.649578                      -5.760196    .7060329
                     /cut2 |  -1.589238   1.555025                      -4.637031    1.458555
                     /cut3 |  -.2711671   1.512551                      -3.235713    2.693379
                     /cut4 |   2.122575   1.521858                      -.8602122    5.105363
                     /cut5 |   4.077263   1.539673                       1.059559    7.094967
                     /cut6 |   5.264463   1.552035                       2.222531    8.306396
------------------------------------------------------------------------------
. log close
      name:  <unnamed>
       log:  E:\Research Plans\yangyang\16.07.2017\China 2nd attempt\regress.log
  log type:  text
 closed on:  16 Jul 2017, 16:12:53
--------------------------------------------------------------------------------------------------------
```

Appendix 6-2. The UK results

```
------------------------------------------------------------------------------------------------------------------------------------------------
----------------------------
      name:  <unnamed>
       log:  E:\Research Plans\yangyang\16.07.2017\second attempt\Regress.log
  log type:  text
 opened on:  16 Jul 2017, 15:58:15

. ologit K1 SumMAI Age Sex     EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1 P
> roject2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -258.45338
Iteration 1:   log likelihood =  -247.9101
Iteration 2:   log likelihood = -247.34746
Iteration 3:   log likelihood = -247.29461
Iteration 4:   log likelihood = -247.29456
Iteration 5:   log likelihood = -247.29456

Ordered logistic regression                     Number of obs   =        147
                                                LR chi2(21)     =      22.32
                                                Prob > chi2     =     0.3814
Log likelihood = -247.29456                     Pseudo R2       =     0.0432
```

K1	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SumMAI	.0124154	.0247797	0.50	0.616	-.0361521	.0609828
Age	.3916028	.3164379	1.24	0.216	-.2286042	1.01181
Sex	.0681693	.3284993	0.21	0.836	-.5756776	.7120162
EuropeAsia	1.569546	.677373	2.32	0.020	.2419192	2.897173
Loughborough	-.1173701	.5333904	-0.22	0.826	-1.162796	.9280558
Northumbria	.0928861	.535566	0.17	0.862	-.956804	1.142576
CoventryUniversity	-.2643391	.5528732	-0.48	0.633	-1.347951	.8192724
BrunelUniversity	-.5183443	.671558	-0.77	0.440	-1.834574	.7978851
UniversityofLincoln	1.288575	.6257114	2.06	0.039	.0622029	2.514946
UniversityofLeeds	-1.044798	.6911073	-1.51	0.131	-2.399344	.3097471
UniversityofBrighton	-.246223	.6894148	-0.36	0.721	-1.597451	1.105005
Others	0	(omitted)				
Project1	.5955879	.7227114	0.82	0.410	-.8209003	2.012076
Project2	.4252591	.5279864	0.81	0.421	-.6095751	1.460093
Project3	.5328891	.4930996	1.08	0.280	-.4335683	1.499347
Project4	.5550444	.8518483	0.65	0.515	-1.114548	2.224636
Project5	1.113192	.5824235	1.91	0.056	-.0283372	2.254721
Project6	3.728964	1.773065	2.10	0.035	.2538216	7.204107
Project7	1.439313	1.045059	1.38	0.168	-.6089646	3.487591
Project8	.6521498	.9693793	0.67	0.501	-1.247799	2.552098
Project9	-.0548894	.7142615	-0.08	0.939	-1.454816	1.345037
Project10	.3565694	.9327097	0.38	0.702	-1.471508	2.184647
Project11	0	(omitted)				
/cut1	-1.660475	1.874775			-5.334967	2.014017
/cut2	.1979829	1.649926			-3.035812	3.431778
/cut3	1.442712	1.635335			-1.762486	4.64791
/cut4	2.390089	1.645626			-.835278	5.615457

```
            /cut5 |   3.858365    1.67063                      .5839903    7.13274
            /cut6 |   5.240809   1.683005                       1.94218   8.539439
            /cut7 |   6.556363   1.704786                      3.215045   9.897682
------------------------------------------------------------------------------

. ologit K2 SumMAI Age Sex     EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1 P
> roject2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -236.08296
Iteration 1:   log likelihood = -222.90497
Iteration 2:   log likelihood =   -222.6494
Iteration 3:   log likelihood = -222.64894
Iteration 4:   log likelihood = -222.64894

Ordered logistic regression                     Number of obs   =        147
                                                LR chi2(21)     =      26.87
                                                Prob > chi2     =     0.1753
Log likelihood = -222.64894                     Pseudo R2       =     0.0569

------------------------------------------------------------------------------
                 K2 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------------+---------------------------------------------------------
             SumMAI |   .0880546   .0276886     3.18   0.001      .033786    .1423232
                Age |     .09027   .3296341     0.27   0.784    -.5558009    .7363409
                Sex |   .3217044   .3383379     0.95   0.342    -.3414257    .9848345
         EuropeAsia |   -.368138   .6853888    -0.54   0.591    -1.711475    .9751995
       Loughborough |  -.7839554   .5279468    -1.48   0.138    -1.818712    .2508012
        Northumbria |  -.0950974   .5384754    -0.18   0.860     -1.15049    .9602949
 CoventryUniversity |   -.274636   .5819319    -0.47   0.637    -1.415202    .8659295
   BrunelUniversity |   .3654579   .7665573     0.48   0.634    -1.136967    1.867883
UniversityofLincoln |  -.3700034   .6082857    -0.61   0.543    -1.562221    .8222146
  UniversityofLeeds |   -.941105   .7009039    -1.34   0.179    -2.314851    .4326413
UniversityofBrighton |   -.075196   .7250184    -0.10   0.917    -1.496206    1.345814
             Others |          0  (omitted)
           Project1 |  -.5849805   .7335594    -0.80   0.425     -2.02273    .8527695
           Project2 |  -.3568096   .5485962    -0.65   0.515    -1.432038    .7184193
           Project3 |   .1347418   .5276634     0.26   0.798    -.8994595    1.168943
           Project4 |  -.0001653    .888959    -0.00   1.000    -1.742493    1.742162
           Project5 |   .3052728   .6486071     0.47   0.638    -.9659736    1.576519
           Project6 |    .619415   1.887999     0.33   0.743    -3.080995    4.319825
           Project7 |   .0226816   1.031563     0.02   0.982    -1.999146    2.044509
           Project8 |   .1717445   1.051954     0.16   0.870    -1.890048    2.233537
           Project9 |  -.5144641   .6932939    -0.74   0.458    -1.873295    .8443671
          Project10 |  -.4377222   .8274932    -0.53   0.597    -2.059579    1.184135
          Project11 |          0  (omitted)
--------------------+---------------------------------------------------------
              /cut1 |   .1742368   1.738554                     -3.233266    3.581739
              /cut2 |   .5331193   1.736395                     -2.870152    3.936391
              /cut3 |   1.038676   1.734341                      -2.36057    4.437921
              /cut4 |   2.262085   1.737752                     -1.143846    5.668015
              /cut5 |   4.087414    1.76653                      .6250793    7.549748
              /cut6 |   5.836223   1.794107                      2.319837    9.352608
------------------------------------------------------------------------------
```

. ologit K3 SumMAI Age Sex EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1 P
> roject2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -214.66251
Iteration 1: log likelihood = -204.34499
Iteration 2: log likelihood = -204.09363
Iteration 3: log likelihood = -204.09317
Iteration 4: log likelihood = -204.09317

Ordered logistic regression Number of obs = 147
LR chi2(21) = 21.14
Prob > chi2 = 0.4505
Log likelihood = -204.09317 Pseudo R2 = 0.0492

K3	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SumMAI	-.0227451	.0247217	-0.92	0.358	-.0711988	.0257086
Age	-.2814579	.3120617	-0.90	0.367	-.8930875	.3301717
Sex	.0282484	.3417613	0.08	0.934	-.6415915	.6980882
EuropeAsia	.5176409	.8277671	0.63	0.532	-1.104753	2.140035
Loughborough	-.3713789	.5564521	-0.67	0.505	-1.462005	.7192472
Northumbria	-.7687423	.5482242	-1.40	0.161	-1.843242	.3057574
CoventryUniversity	-.6347418	.576533	-1.10	0.271	-1.764726	.495242
BrunelUniversity	-1.190689	.7318254	-1.63	0.104	-2.62504	.2436627
UniversityofLincoln	-.774481	.6175513	-1.25	0.210	-1.984859	.4358974
UniversityofLeeds	-1.107119	.6882158	-1.61	0.108	-2.455997	.2417589
UniversityofBrighton	-1.143636	.7549217	-1.51	0.130	-2.623255	.3359833
Others	0	(omitted)				
Project1	-.2585341	.7464345	-0.35	0.729	-1.721519	1.204451
Project2	-.7988415	.5405071	-1.48	0.139	-1.858216	.260533
Project3	.0760996	.5299593	0.14	0.886	-.9626015	1.114801
Project4	.718121	.9586458	0.75	0.454	-1.16079	2.597032
Project5	.8168721	.6593854	1.24	0.215	-.4754996	2.109244
Project6	-.9723599	1.835998	-0.53	0.596	-4.57085	2.62613
Project7	-.5286949	1.162857	-0.45	0.649	-2.807853	1.750463
Project8	.398318	.9118811	0.44	0.662	-1.388936	2.185572
Project9	-1.644415	.828813	-1.98	0.047	-3.268859	-.0199715
Project10	.2106259	.8129495	0.26	0.796	-1.382726	1.803978
Project11	0	(omitted)				
/cut1	-5.969937	1.791323			-9.480864	-2.459009
/cut2	-5.24096	1.747248			-8.665503	-1.816417
/cut3	-3.708032	1.704137			-7.048079	-.3679855
/cut4	-1.936849	1.685158			-5.239698	1.366001
/cut5	-.3971749	1.678146			-3.686281	2.891931

```
. ologit K4 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1 P
> roject2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:    log likelihood = -219.33315
Iteration 1:    log likelihood = -207.92298
Iteration 2:    log likelihood = -207.81373
Iteration 3:    log likelihood = -207.81362
Iteration 4:    log likelihood = -207.81362

Ordered logistic regression                    Number of obs     =        147
                                               LR chi2(21)       =      23.04
                                               Prob > chi2       =     0.3419
Log likelihood = -207.81362                    Pseudo R2         =     0.0525

------------------------------------------------------------------------------
                  K4 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
              SumMAI |   .0048117   .0260099     0.18   0.853    -.0461667    .0557901
                 Age |   .2084655   .3123251     0.67   0.504    -.4036805    .8206115
                 Sex |   .1243968   .3343265     0.37   0.710    -.5308711    .7796646
          EuropeAsia |  -.2962692   .6785924    -0.44   0.662    -1.626286    1.033748
        Loughborough |  -.1244683   .5467394    -0.23   0.820    -1.196058    .9471212
         Northumbria |  -.3700615   .5271132    -0.70   0.483    -1.403184    .6630613
  CoventryUniversity |  -.6359083   .6117447    -1.04   0.299    -1.834906    .5630893
     BrunelUniversity |  -.3503682   .6802741    -0.52   0.607    -1.683681    .9829445
  UniversityofLincoln |  -.2323699   .6200665    -0.37   0.708    -1.447678     .982938
    UniversityofLeeds |  -1.532713   .7097846    -2.16   0.031    -2.923865   -.1415609
 UniversityofBrighton |  -.1540924   .7419101    -0.21   0.835     -1.60821    1.300025
              Others |          0  (omitted)
            Project1 |  -.7646537    .710396    -1.08   0.282    -2.157004    .6276969
            Project2 |  -1.069094   .5391127    -1.98   0.047    -2.125736   -.0124528
            Project3 |   .6390805   .5357297     1.19   0.233    -.4109305    1.689091
            Project4 |  -.3321918   .9832762    -0.34   0.735    -2.259378    1.594994
            Project5 |   -.023518   .6085704    -0.04   0.969    -1.216294    1.169258
            Project6 |   .5435157   1.753043     0.31   0.757    -2.892385    3.979417
            Project7 |   1.534499   1.266825     1.21   0.226    -.9484333     4.01743
            Project8 |   .1686446   1.007261     0.17   0.867    -1.805551     2.14284
            Project9 |  -.7269599   .7667941    -0.95   0.343    -2.229849    .7759289
           Project10 |   -1.27503   .8570675    -1.49   0.137    -2.954852    .4047911
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------
               /cut1 |  -4.429561   1.856866                     -8.068952   -.7901695
               /cut2 |  -3.468349   1.759078                      -6.91608   -.0206193
               /cut3 |  -1.339552   1.689593                     -4.651094     1.97199
               /cut4 |  -.2317011   1.688001                     -3.540123    3.076721
               /cut5 |    1.11915   1.693991                     -2.201011    4.439312
------------------------------------------------------------------------------
```

```
. ologit K5 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1 P
> roject2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -210.27416
Iteration 1:   log likelihood =  -196.8465
Iteration 2:   log likelihood = -196.58435
Iteration 3:   log likelihood = -196.58374
Iteration 4:   log likelihood = -196.58374

Ordered logistic regression                       Number of obs   =        147
                                                  LR chi2(21)     =      27.38
                                                  Prob > chi2     =     0.1586
Log likelihood = -196.58374                       Pseudo R2       =     0.0651

------------------------------------------------------------------------------------
                  K5 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
              SumMAI |   .0071817   .0250315     0.29   0.774     -.041879    .0562425
                 Age |   .1881978   .3422683     0.55   0.582    -.4826357    .8590312
                 Sex |   -.073262   .3465775    -0.21   0.833    -.7525414    .6060174
          EuropeAsia |   .3480964   .7037738     0.49   0.621    -1.031275    1.727468
        Loughborough |     .02303   .5848791     0.04   0.969    -1.123312    1.169372
         Northumbria |  -.9543679   .5460131    -1.75   0.080    -2.024534    .1157982
  CoventryUniversity |  -.7236409   .5891643    -1.23   0.219    -1.878382    .4310999
     BrunelUniversity |  -.5532219   .6875498    -0.80   0.421    -1.900795     .794351
 UniversityofLincoln |   .7865204   .7003727     1.12   0.261    -.5861849    2.159226
   UniversityofLeeds |   -2.19662   .6907006    -3.18   0.001    -3.550369    -.842872
UniversityofBrighton |  -.0712748   .7277058    -0.10   0.922    -1.497552    1.355002
              Others |          0  (omitted)
            Project1 |  -1.271212   .7412646    -1.71   0.086    -2.724064    .1816397
            Project2 |   .1179024   .5494763     0.21   0.830    -.9590515    1.194856
            Project3 |   .0122222   .5377651     0.02   0.982    -1.041778    1.066222
            Project4 |  -.1411655   .9784432    -0.14   0.885    -2.058879    1.776548
            Project5 |   .6141881   .6484555     0.95   0.344    -.6567614    1.885138
            Project6 |   .2665046   1.780166     0.15   0.881    -3.222557    3.755567
            Project7 |  -1.449947   1.199437    -1.21   0.227      -3.8008     .900905
            Project8 |   .0927132   .9333874     0.10   0.921    -1.736692    1.922119
            Project9 |  -.8223143   .7053456    -1.17   0.244    -2.204766    .5601377
           Project10 |  -.6608798   .8286543    -0.80   0.425    -2.285012    .9632527
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------------
               /cut1 |  -3.560348   1.794252                      -7.077017   -.0436791
               /cut2 |  -2.790575    1.76203                      -6.244091    .6629418
               /cut3 |  -1.450139   1.746601                      -4.873413    1.973136
               /cut4 |  -.0816173   1.729254                      -3.470892    3.307657
               /cut5 |    1.34498   1.726125                      -2.038162    4.728122
------------------------------------------------------------------------------------
```

```
. ologit K6 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1 P
> roject2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:    log likelihood = -235.47135
Iteration 1:    log likelihood =   -216.6912
Iteration 2:    log likelihood = -216.17454
Iteration 3:    log likelihood = -216.17256
Iteration 4:    log likelihood = -216.17256

Ordered logistic regression                          Number of obs    =        147
                                                     LR chi2(21)      =      38.60
                                                     Prob > chi2      =     0.0110
Log likelihood = -216.17256                          Pseudo R2        =     0.0820
```

K6	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SumMAI	.0707227	.0260971	2.71	0.007	.0195732	.1218721
Age	-.3361202	.3133864	-1.07	0.283	-.9503463	.2781059
Sex	.0470276	.3424389	0.14	0.891	-.6241403	.7181955
EuropeAsia	-.409839	.6718757	-0.61	0.542	-1.726691	.9070132
Loughborough	-.443011	.5503386	-0.80	0.421	-1.521655	.6356329
Northumbria	1.038717	.558828	1.86	0.063	-.0565662	2.133999
CoventryUniversity	-.6633186	.5728125	-1.16	0.247	-1.786011	.4593734
BrunelUniversity	2.485327	.7283549	3.41	0.001	1.057777	3.912876
UniversityofLincoln	-.0033567	.6280969	-0.01	0.996	-1.234404	1.227691
UniversityofLeeds	-.0204149	.6775235	-0.03	0.976	-1.348337	1.307507
UniversityofBrighton	1.426641	.8187771	1.74	0.081	-.1781326	3.031415
Others	0	(omitted)				
Project1	.6993846	.7346803	0.95	0.341	-.7405624	2.139332
Project2	.1696194	.5545663	0.31	0.760	-.9173106	1.256549
Project3	-.1583628	.5163297	-0.31	0.759	-1.17035	.8536247
Project4	.3224211	.9271596	0.35	0.728	-1.494778	2.139621
Project5	-.3199383	.6419365	-0.50	0.618	-1.578111	.9382342
Project6	-2.050078	1.791842	-1.14	0.253	-5.562023	1.461867
Project7	-1.435541	1.075448	-1.33	0.182	-3.543381	.6722993
Project8	-.1847764	.9334446	-0.20	0.843	-2.014294	1.644741
Project9	.34825	.7399631	0.47	0.638	-1.102051	1.798551
Project10	.1496346	.7804673	0.19	0.848	-1.380053	1.679322
Project11	0	(omitted)				
/cut1	-2.523788	1.721968			-5.898783	.8512071
/cut2	-1.79233	1.675816			-5.07687	1.492209
/cut3	-.5897023	1.654564			-3.832588	2.653183
/cut4	.482318	1.653763			-2.758998	3.723635
/cut5	2.043045	1.654782			-1.200269	5.286358
/cut6	4.13902	1.678843			.8485485	7.429492

```
. ologit K7 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1 P
> roject2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -237.19257
Iteration 1:   log likelihood = -220.18168
Iteration 2:   log likelihood = -219.80297
Iteration 3:   log likelihood = -219.80202
Iteration 4:   log likelihood = -219.80202

Ordered logistic regression                       Number of obs   =        147
                                                  LR chi2(21)     =      34.78
                                                  Prob > chi2     =     0.0298
Log likelihood = -219.80202                       Pseudo R2       =     0.0733

------------------------------------------------------------------------------
                  K7 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
              SumMAI |   .0790986   .0261311     3.03   0.002     .0278827    .1303146
                 Age |  -.5121637   .3154687    -1.62   0.104    -1.130471    .1061435
                 Sex |   .0090154   .3399791     0.03   0.979    -.6573313    .6753621
          EuropeAsia |  -1.562177   .6750767    -2.31   0.021    -2.885303   -.2390509
        Loughborough |  -.0484133   .6051785    -0.08   0.936    -1.234541    1.137715
         Northumbria |   .3323786   .5252336     0.63   0.527    -.6970604    1.361818
  CoventryUniversity |  -.8512964   .6054682    -1.41   0.160    -2.037992    .3353994
     BrunelUniversity |   .5561933    .666854     0.83   0.404    -.7508166    1.863203
 UniversityofLincoln |   -.324582   .6381301    -0.51   0.611    -1.575294      .92613
   UniversityofLeeds |  -.2134479   .6783987    -0.31   0.753    -1.543085    1.116189
UniversityofBrighton |   .0363713    .756032     0.05   0.962    -1.445424    1.518167
              Others |          0  (omitted)
            Project1 |  -.9617403   .7155206    -1.34   0.179    -2.364135    .4406542
            Project2 |  -1.264277   .5444144    -2.32   0.020     -2.33131   -.1972446
            Project3 |  -.6313126   .5452703    -1.16   0.247    -1.700023    .4373975
            Project4 |   .2440425   1.002147     0.24   0.808     -1.72013    2.208215
            Project5 |  -.7913472   .6380894    -1.24   0.215    -2.041979    .4592851
            Project6 |  -1.419968   1.749492    -0.81   0.417     -4.84891    2.008974
            Project7 |  -2.654001   1.065665    -2.49   0.013    -4.742666   -.5653355
            Project8 |  -1.149334   .8845765    -1.30   0.194    -2.883072    .5844041
            Project9 |  -.9876369   .7453116    -1.33   0.185    -2.448421    .4731469
           Project10 |  -1.091287   .8672661    -1.26   0.208    -2.791098    .6085231
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------
               /cut1 |  -4.320438    1.68672                      -7.626349   -1.014527
               /cut2 |  -2.927574   1.647128                      -6.155885    .3007373
               /cut3 |  -1.929229   1.642879                      -5.149212    1.290755
               /cut4 |  -.7000033   1.633475                      -3.901556    2.501549
               /cut5 |   1.013164   1.627984                      -2.177626    4.203955
------------------------------------------------------------------------------
```

```
. ologit K8 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1 P
> roject2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:     log likelihood = -243.90884
Iteration 1:     log likelihood = -226.14146
Iteration 2:     log likelihood = -225.27832
Iteration 3:     log likelihood = -225.27508
Iteration 4:     log likelihood = -225.27508

Ordered logistic regression                        Number of obs     =        147
                                                   LR chi2(21)       =      37.27
                                                   Prob > chi2       =     0.0157
Log likelihood = -225.27508                        Pseudo R2         =     0.0764

------------------------------------------------------------------------------
                  K8 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
              SumMAI |   .0679747   .0270158     2.52   0.012     .0150248    .1209247
                 Age |    .632547   .3161852     2.00   0.045     .0128354    1.252259
                 Sex |   .0747806   .3388984     0.22   0.825    -.5894479    .7390092
          EuropeAsia |  -.5055902   .7052899    -0.72   0.473    -1.887933    .8767525
        Loughborough |  -.5567587    .532471    -1.05   0.296    -1.600383    .4868652
         Northumbria |  -1.157961   .5857702    -1.98   0.048    -2.306049   -.0098725
  CoventryUniversity |  -.5176072   .5557393    -0.93   0.352    -1.606836    .5716217
     BrunelUniversity |   .1626139   .7433927     0.22   0.827    -1.294409    1.619637
 UniversityofLincoln |  -.6465532   .5784558    -1.12   0.264    -1.780306    .4871993
   UniversityofLeeds |   -2.43332   .7035267    -3.46   0.001    -3.812207   -1.054433
UniversityofBrighton |  -.2669062   .6792848    -0.39   0.694     -1.59828    1.064467
              Others |          0  (omitted)
            Project1 |  -1.698788   .7040886    -2.41   0.016    -3.078776   -.3187994
            Project2 |  -.2831554   .5435576    -0.52   0.602    -1.348509     .782198
            Project3 |  -.5524262   .5002125    -1.10   0.269    -1.532825    .4279723
            Project4 |   -2.18814    .895727    -2.44   0.015    -3.943733   -.4325479
            Project5 |  -.1783592   .6442051    -0.28   0.782    -1.440978     1.08426
            Project6 |    1.34161   1.851857     0.72   0.469    -2.287963    4.971183
            Project7 |  -1.734593   1.089291    -1.59   0.111    -3.869564    .4003774
            Project8 |  -.2797155   .8687837    -0.32   0.747      -1.9825    1.423069
            Project9 |  -.1339749   .6849567    -0.20   0.845    -1.476465    1.208516
           Project10 |  -1.811598   .8834596    -2.05   0.040    -3.543147   -.0800487
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------
               /cut1 |  -1.296908   1.666475                      -4.563138    1.969323
               /cut2 |   .1687094   1.610866                      -2.988529    3.325948
               /cut3 |   1.807101   1.608466                      -1.345434    4.959636
               /cut4 |   3.159853     1.6188                      -.0129369    6.332643
               /cut5 |   5.038237   1.652511                       1.799376    8.277098
               /cut6 |    6.36947     1.6882                       3.060659    9.678282
------------------------------------------------------------------------------
```

```
. ologit K9 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1 P
> roject2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -238.94527
Iteration 1:   log likelihood = -220.89961
Iteration 2:   log likelihood = -220.32237
Iteration 3:   log likelihood = -220.32036
Iteration 4:   log likelihood = -220.32036

Ordered logistic regression                       Number of obs   =        147
                                                  LR chi2(21)     =      37.25
                                                  Prob > chi2     =     0.0158
Log likelihood = -220.32036                       Pseudo R2       =     0.0779

------------------------------------------------------------------------------------
                  K9 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
              SumMAI |   .0836136   .0268982     3.11   0.002      .030894    .1363331
                 Age |   .5983299   .3221321     1.86   0.063    -.0330373    1.229697
                 Sex |   .0365737   .3424939     0.11   0.915     -.634702    .7078495
          EuropeAsia |  -.8126238   .7625553    -1.07   0.287    -2.307205    .6819571
        Loughborough |  -.3848478   .5592254    -0.69   0.491    -1.480909    .7112138
         Northumbria |  -.8493292   .5332769    -1.59   0.111    -1.894533    .1958743
   CoventryUniversity |  -.3109669   .5757533    -0.54   0.589    -1.439423    .8174889
     BrunelUniversity |  -1.477583   .7741654    -1.91   0.056    -2.994919    .0397531
  UniversityofLincoln |  -.8276324   .6461099    -1.28   0.200    -2.093985    .4387198
    UniversityofLeeds |  -1.495894   .6993504    -2.14   0.032    -2.866595   -.1251922
 UniversityofBrighton |  -.8161946   .7029096    -1.16   0.246    -2.193872     .561483
               Others |          0  (omitted)
             Project1 |  -1.205525   .7120725    -1.69   0.090    -2.601162     .190111
             Project2 |  -.8590835    .548209    -1.57   0.117    -1.933553    .2153865
             Project3 |   .2743021   .5425406     0.51   0.613     -.789058    1.337662
             Project4 |  -1.502601   .9665341    -1.55   0.120    -3.396973    .3917704
             Project5 |   .8631018   .6966786     1.24   0.215    -.5023631    2.228567
             Project6 |   1.097252   1.788011     0.61   0.539    -2.407186    4.601689
             Project7 |  -1.981498   1.036308    -1.91   0.056    -4.012624    .0496273
             Project8 |   .3245983   .9432623     0.34   0.731    -1.524162    2.173358
             Project9 |   .0602045    .711324     0.08   0.933    -1.333965    1.454374
            Project10 |  -1.323352   .8337182    -1.59   0.112     -2.95741    .3107056
            Project11 |          0  (omitted)
---------------------+--------------------------------------------------------------
                /cut1 |  -.0080908   1.688949                     -3.318369    3.302188
                /cut2 |   .6719668   1.679013                     -2.618837    3.962771
                /cut3 |     1.7203   1.687124                     -1.586402    5.027001
                /cut4 |   2.802243   1.700529                     -.5307338    6.135219
                /cut5 |   4.468573   1.716974                      1.103366     7.83378
                /cut6 |   7.177816   1.786621                      3.676104    10.67953
------------------------------------------------------------------------------------
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```
. ologit K10 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -252.10318
Iteration 1:   log likelihood = -236.37175
Iteration 2:   log likelihood = -235.59236
Iteration 3:   log likelihood = -235.59051
Iteration 4:   log likelihood = -235.59051

Ordered logistic regression                     Number of obs     =        147
                                                LR chi2(21)       =      33.03
                                                Prob > chi2       =     0.0459
Log likelihood = -235.59051                     Pseudo R2         =     0.0655

------------------------------------------------------------------------------------
                 K10 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
              SumMAI |  -.0098781   .0248868    -0.40   0.691    -.0586554    .0388993
                 Age |   .9873913   .3313783     2.98   0.003     .3379018    1.636881
                 Sex |  -.6741984   .3409012    -1.98   0.048    -1.342353   -.0060442
          EuropeAsia |   1.158222   .6863892     1.69   0.092     -.187076     2.50352
        Loughborough |  -.2447064   .5199483    -0.47   0.638    -1.263786    .7743736
         Northumbria |   .2047521   .5556209     0.37   0.712    -.8842449    1.293749
  CoventryUniversity |   .1516231   .5743534     0.26   0.792    -.9740888    1.277335
     BrunelUniversity |   .5942327   .7164688     0.83   0.407    -.8100203    1.998486
 UniversityofLincoln |    -.18916   .5713877    -0.33   0.741    -1.309059    .9307393
   UniversityofLeeds |  -.5748681    .655938    -0.88   0.381    -1.860483    .7107468
UniversityofBrighton |  -.0923521    .710351    -0.13   0.897    -1.484614     1.29991
              Others |          0  (omitted)
            Project1 |  -.5426693   .7043551    -0.77   0.441     -1.92318    .8378413
            Project2 |   -.484112   .5489211    -0.88   0.378    -1.559978    .5917535
            Project3 |  -.6338755   .5224466    -1.21   0.225    -1.657852    .3901011
            Project4 |  -3.149168   .9122662    -3.45   0.001    -4.937177   -1.361159
            Project5 |  -.7471116   .6367634    -1.17   0.241    -1.995145    .5009218
            Project6 |   .9428835   1.815551     0.52   0.604    -2.615531    4.501298
            Project7 |  -.8986862   1.031693    -0.87   0.384    -2.920768    1.123395
            Project8 |   -1.06966   .9534796    -1.12   0.262    -2.938446    .7991257
            Project9 |  -1.717163   .7175799    -2.39   0.017    -3.123593    -.310732
           Project10 |  -1.943308   .8175086    -2.38   0.017    -3.545595   -.3410205
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------------
               /cut1 |  -1.347942   1.675765                     -4.632381    1.936497
               /cut2 |  -.8235842   1.659594                     -4.076328     2.42916
               /cut3 |   1.244915   1.646477                     -1.982119     4.47195
               /cut4 |   2.432023   1.650045                     -.8020057    5.666052
               /cut5 |   3.551595    1.65657                      .3047767    6.798413
               /cut6 |   5.255231   1.690985                      1.940962      8.5695
------------------------------------------------------------------------------------
```

```
. ologit K11 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -231.86312
Iteration 1:   log likelihood = -221.34103
Iteration 2:   log likelihood = -221.14878
Iteration 3:   log likelihood = -221.14745
Iteration 4:   log likelihood = -221.14712
Iteration 5:   log likelihood = -221.14706
Iteration 6:   log likelihood = -221.14704

Ordered logistic regression                       Number of obs   =        147
                                                  LR chi2(21)     =      21.43
                                                  Prob > chi2     =     0.4328
Log likelihood = -221.14704                       Pseudo R2       =     0.0462

------------------------------------------------------------------------------------
                 K11 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
              SumMAI |  -.0342168   .0249691    -1.37   0.171    -.0831553    .0147216
                 Age |  -.1956698   .3095073    -0.63   0.527    -.8022929    .4109532
                 Sex |   .0407859   .3392006     0.12   0.904     -.624035    .7056068
          EuropeAsia |   .9934407    .642141     1.55   0.122    -.2651326    2.252014
        Loughborough |  -.0893773   .6048567    -0.15   0.883    -1.274875     1.09612
         Northumbria |   .0090579    .565201     0.02   0.987    -1.098716    1.116831
   CoventryUniversity |  -.9296594   .5879269    -1.58   0.114    -2.081975    .2226562
     BrunelUniversity |   .5799343     .63949     0.91   0.364    -.6734431    1.833312
  UniversityofLincoln |    .300796   .5972561     0.50   0.615    -.8698044    1.471396
    UniversityofLeeds |  -1.329899   .6741264    -1.97   0.049    -2.651163   -.0086355
  UniversityofBrighton |   .1496265   .6589522     0.23   0.820    -1.141896    1.441149
               Others |          0  (omitted)
             Project1 |   .5113508   .7476463     0.68   0.494     -.954009    1.976711
             Project2 |   .3101888   .5440488     0.57   0.569    -.7561273    1.376505
             Project3 |  -.3942989   .5092049    -0.77   0.439    -1.392322    .6037245
             Project4 |   -.023885   .9020309    -0.03   0.979    -1.791833    1.744063
             Project5 |  -.3320621   .5910216    -0.56   0.574    -1.490443    .8263191
             Project6 |   13.06716   520.2187     0.03   0.980    -1006.543    1032.677
             Project7 |  -.1860303   1.137133    -0.16   0.870    -2.414771     2.04271
             Project8 |   -.301753   .8815944    -0.34   0.732    -2.029646     1.42614
             Project9 |  -.2915014   .7878254    -0.37   0.711    -1.835611    1.252608
            Project10 |   -.869707   .7895982    -1.10   0.271    -2.417291     .677877
            Project11 |          0  (omitted)
---------------------+--------------------------------------------------------------
                /cut1 |  -5.733018   1.745932                     -9.154983   -2.311053
                /cut2 |  -5.031497   1.672484                     -8.309505   -1.753489
                /cut3 |  -3.660241   1.627047                     -6.849196   -.4712867
                /cut4 |  -2.068552   1.614593                     -5.233097    1.095992
                /cut5 |  -1.256635   1.609328                      -4.41086     1.89759
                /cut6 |   .8168532   1.601735                     -2.322489    3.956196
------------------------------------------------------------------------------------
```

```
. ologit K12 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -232.50996
Iteration 1:   log likelihood = -222.37192
Iteration 2:   log likelihood = -222.22398
Iteration 3:   log likelihood = -222.22386
Iteration 4:   log likelihood = -222.22386

Ordered logistic regression                     Number of obs   =        147
                                                LR chi2(21)     =      20.57
                                                Prob > chi2     =     0.4853
Log likelihood = -222.22386                     Pseudo R2       =     0.0442

------------------------------------------------------------------------------
                 K12 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
              SumMAI |   .0423462   .0259392     1.63   0.103    -.0084938    .0931861
                 Age |    .074646   .3166027     0.24   0.814    -.5458838    .6951759
                 Sex |   .2243987   .3412277     0.66   0.511    -.4443953    .8931927
          EuropeAsia |   .8555915   .6355048     1.35   0.178    -.3899749    2.101158
        Loughborough |  -.6016404   .5564972    -1.08   0.280    -1.692355     .489074
         Northumbria |   .6149052   .5237379     1.17   0.240    -.4116023    1.641413
   CoventryUniversity |   .2342744    .580988     0.40   0.687    -.9044411     1.37299
      BrunelUniversity |  -.1188094   .6892656    -0.17   0.863    -1.469745    1.232126
  UniversityofLincoln |   .4269158   .6506008     0.66   0.512    -.8482384     1.70207
    UniversityofLeeds |   .4629625    .667736     0.69   0.488    -.8457761    1.771701
 UniversityofBrighton |  -1.519904   .6883609    -2.21   0.027    -2.869067   -.1707416
              Others |          0  (omitted)
            Project1 |  -.2186767   .7333946    -0.30   0.766    -1.656104     1.21875
            Project2 |  -.4305047   .5238431    -0.82   0.411    -1.457218     .596209
            Project3 |   .3906155   .4975652     0.79   0.432    -.5845944    1.365825
            Project4 |  -.2323232   .9151483    -0.25   0.800    -2.025981    1.561334
            Project5 |   .0414697   .6395201     0.06   0.948    -1.211967    1.294906
            Project6 |   .9481195   1.778361     0.53   0.594    -2.537404    4.433643
            Project7 |  -.7800787   1.287352    -0.61   0.545    -3.303243    1.743086
            Project8 |   .3877823   .8928342     0.43   0.664    -1.362141    2.137705
            Project9 |  -.7577836   .7088726    -1.07   0.285    -2.147148    .6315812
           Project10 |   .4589721   .7743448     0.59   0.553    -1.058716     1.97666
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------
               /cut1 |  -.0466483   1.680392                     -3.340155    3.246859
               /cut2 |   .6952499   1.672423                      -2.58264    3.973139
               /cut3 |   2.267401   1.672615                     -1.010865    5.545667
               /cut4 |   3.687679   1.691338                      .3727186     7.00264
               /cut5 |   5.724224   1.737139                      2.319494    9.128954
------------------------------------------------------------------------------
```

```
. ologit K13 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -224.37956
Iteration 1:   log likelihood = -214.39164
Iteration 2:   log likelihood = -214.08131
Iteration 3:   log likelihood =  -214.0807
Iteration 4:   log likelihood =  -214.0807

Ordered logistic regression                       Number of obs   =        147
                                                  LR chi2(21)     =      20.60
                                                  Prob > chi2     =     0.4837
Log likelihood =  -214.0807                       Pseudo R2       =     0.0459

------------------------------------------------------------------------------
                 K13 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
              SumMAI |   .0355244   .0255353     1.39   0.164    -.0145239    .0855728
                 Age |   .1560952   .3021839     0.52   0.605    -.4361744    .7483647
                 Sex |   .3114199   .3386699     0.92   0.358    -.3523608    .9752007
          EuropeAsia |  -.2487098   .6718618    -0.37   0.711    -1.565535    1.068115
        Loughborough |  -.0532406    .562847    -0.09   0.925    -1.156401    1.049919
         Northumbria |  -.3164986   .5121969    -0.62   0.537    -1.320386    .6873889
  CoventryUniversity |  -.9549028    .613272    -1.56   0.119    -2.156894    .2470883
     BrunelUniversity |    -.85367   .6792661    -1.26   0.209    -2.185007    .4776671
 UniversityofLincoln |   -.606024   .6114613    -0.99   0.322    -1.804466    .5924181
   UniversityofLeeds |  -.5438886   .6855011    -0.79   0.428    -1.887446    .7996689
UniversityofBrighton |  -.0939469    .678919    -0.14   0.890    -1.424604     1.23671
              Others |          0  (omitted)
            Project1 |  -.0200718   .7491833    -0.03   0.979    -1.488444      1.4483
            Project2 |  -.7905234   .5311361    -1.49   0.137    -1.831531    .2504842
            Project3 |  -.4097256    .508299    -0.81   0.420    -1.405973    .5865222
            Project4 |   .0809102    1.07232     0.08   0.940    -2.020797    2.182618
            Project5 |   .2738493   .6265979     0.44   0.662    -.9542599    1.501959
            Project6 |   .9322135   1.781096     0.52   0.601     -2.55867    4.423097
            Project7 |  -3.089051    1.21899    -2.53   0.011    -5.478227   -.6998744
            Project8 |  -.1590228   .8526342    -0.19   0.852    -1.830155     1.51211
            Project9 |  -1.689247   .6971009    -2.42   0.015     -3.05554   -.3229542
           Project10 |  -.8907873   .7908852    -1.13   0.260    -2.440894    .6593193
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------
               /cut1 |  -3.500995   1.718506                      -6.869205   -.1327838
               /cut2 |  -1.478623   1.582913                      -4.581075    1.623829
               /cut3 |   .2953038   1.564746                      -2.771542     3.36215
               /cut4 |   1.907064    1.58182                      -1.193247    5.007374
               /cut5 |   3.563101   1.609548                       .4084458    6.717757
------------------------------------------------------------------------------
```

. ologit K14 SumMAI Age Sex EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0: log likelihood = -206.0208
Iteration 1: log likelihood = -190.99395
Iteration 2: log likelihood = -190.61078
Iteration 3: log likelihood = -190.60943
Iteration 4: log likelihood = -190.60943

Ordered logistic regression Number of obs = 147
LR chi2(21) = 30.82
Prob > chi2 = 0.0767
Log likelihood = -190.60943 Pseudo R2 = 0.0748

K14	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SumMAI	.1101319	.0270936	4.06	0.000	.0570294	.1632344
Age	.3550558	.3092414	1.15	0.251	-.2510462	.9611578
Sex	.1923809	.3459014	0.56	0.578	-.4855734	.8703352
EuropeAsia	-.2061241	.6582582	-0.31	0.754	-1.496286	1.084038
Loughborough	.0330844	.5648941	0.06	0.953	-1.074088	1.140257
Northumbria	.1911745	.5551313	0.34	0.731	-.8968628	1.279212
CoventryUniversity	-.3864612	.6142467	-0.63	0.529	-1.590363	.8174403
BrunelUniversity	.3272184	.6716652	0.49	0.626	-.9892213	1.643658
UniversityofLincoln	.2442524	.65466	0.37	0.709	-1.038858	1.527362
UniversityofLeeds	-.1316975	.6850628	-0.19	0.848	-1.474396	1.211001
UniversityofBrighton	-.0370861	.7547644	-0.05	0.961	-1.516397	1.442225
Others	0	(omitted)				
Project1	.1870541	.7427661	0.25	0.801	-1.268741	1.642849
Project2	.4180615	.5597223	0.75	0.455	-.678974	1.515097
Project3	-.3806791	.5305845	-0.72	0.473	-1.420606	.6592474
Project4	.6449547	.9850059	0.65	0.513	-1.285621	2.575531
Project5	-.0386196	.6088002	-0.06	0.949	-1.231846	1.154607
Project6	.4346764	1.77386	0.25	0.806	-3.042024	3.911377
Project7	-.8477117	1.099565	-0.77	0.441	-3.002819	1.307395
Project8	-1.568089	.9351435	-1.68	0.094	-3.400936	.2647588
Project9	-1.375534	.7833733	-1.76	0.079	-2.910918	.159849
Project10	1.107858	.8724323	1.27	0.204	-.6020776	2.817794
Project11	0	(omitted)				
/cut1	.6079151	1.796241			-2.912652	4.128483
/cut2	2.167091	1.683037			-1.131602	5.465784
/cut3	3.459842	1.664022			.1984183	6.721265
/cut4	5.019046	1.686133			1.714286	8.323805
/cut5	7.805667	1.778756			4.31937	11.29196

```
. ologit K15 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -224.66975
Iteration 1:   log likelihood = -207.62817
Iteration 2:   log likelihood = -206.09174
Iteration 3:   log likelihood = -206.07998
Iteration 4:   log likelihood = -206.07997

Ordered logistic regression                       Number of obs   =        147
                                                  LR chi2(21)     =      37.18
                                                  Prob > chi2     =     0.0161
Log likelihood = -206.07997                       Pseudo R2       =     0.0827

------------------------------------------------------------------------------
                 K15 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
              SumMAI |   .0287052   .0256875     1.12   0.264    -.0216413    .0790517
                 Age |   .6809386   .3077644     2.21   0.027     .0777315    1.284146
                 Sex |  -.0859747   .3294491    -0.26   0.794    -.7316831    .5597336
          EuropeAsia |   .0789705   .6423148     0.12   0.902    -1.179943    1.337884
        Loughborough |  -.3065667   .5330501    -0.58   0.565    -1.351326    .7381922
         Northumbria |   .5723052   .5585544     1.02   0.306    -.5224413    1.667052
  CoventryUniversity |  -.1999085   .6122987    -0.33   0.744    -1.399992    1.000175
     BrunelUniversity |   .2738926     .69807     0.39   0.695    -1.094299    1.642085
 UniversityofLincoln |   .0727297   .5660247     0.13   0.898    -1.036658    1.182118
   UniversityofLeeds |  -.2339604   .7505615    -0.31   0.755    -1.705034    1.237113
UniversityofBrighton |   .3419494   .7961056     0.43   0.668    -1.218389    1.902288
              Others |          0  (omitted)
            Project1 |  -.9067981   .7331201    -1.24   0.216    -2.343687    .5300908
            Project2 |  -.3776296   .5321538    -0.71   0.478    -1.420632    .6653728
            Project3 |  -.7956268   .5236892    -1.52   0.129    -1.822039    .2307851
            Project4 |   .6010331   .9446572     0.64   0.525    -1.250461    2.452527
            Project5 |  -.5056045   .6292818    -0.80   0.422    -1.738974    .7277652
            Project6 |   1.130236   1.818093     0.62   0.534     -2.43316    4.693632
            Project7 |  -.7934619   .9664205    -0.82   0.412    -2.687611    1.100687
            Project8 |  -.8781932   .8901066    -0.99   0.324     -2.62277    .8663837
            Project9 |  -3.809541   .8456551    -4.50   0.000    -5.466994   -2.152087
           Project10 |   .8542354   .8330854     1.03   0.305    -.7785819    2.487053
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------
               /cut1 |  -1.378566   1.672379                     -4.656369    1.899237
               /cut2 |  -.7671112   1.645997                     -3.993207    2.458984
               /cut3 |   1.466026   1.610925                     -1.691329    4.623381
               /cut4 |   2.713969   1.612516                      -.446505    5.874443
               /cut5 |   4.526066   1.645186                       1.30156    7.750572
------------------------------------------------------------------------------
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```
. ologit K16 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -212.93367
Iteration 1:   log likelihood = -190.90422
Iteration 2:   log likelihood =  -189.0504
Iteration 3:   log likelihood = -189.03585
Iteration 4:   log likelihood = -189.03585

Ordered logistic regression                       Number of obs   =        147
                                                  LR chi2(21)     =      47.80
                                                  Prob > chi2     =     0.0007
Log likelihood = -189.03585                       Pseudo R2       =     0.1122

------------------------------------------------------------------------------
                 K16 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
              SumMAI |   .0960231   .0278791     3.44   0.001      .041381    .1506652
                 Age |   .5627523    .316774     1.78   0.076    -.0581134    1.183618
                 Sex |  -.6772307   .3497036    -1.94   0.053    -1.362637    .0081758
          EuropeAsia |   1.243606   .7219963     1.72   0.085    -.1714806    2.658693
        Loughborough |  -.7720272   .5841279    -1.32   0.186    -1.916897    .3728425
         Northumbria |   1.295873   .5811487     2.23   0.026     .1568421    2.434903
  CoventryUniversity |   .6546073   .6200367     1.06   0.291    -.5606423    1.869857
     BrunelUniversity |   .5525668   .7132835     0.77   0.439    -.8454433    1.950577
 UniversityofLincoln |   .0316436   .6243402     0.05   0.960    -1.192041    1.255328
   UniversityofLeeds |   1.761429   .7645384     2.30   0.021     .2629616    3.259897
UniversityofBrighton |  -.2762857   .7171999    -0.39   0.700    -1.681972      1.1294
              Others |          0  (omitted)
            Project1 |   .8533698   .8570609     1.00   0.319    -.8264388    2.533178
            Project2 |   .0724953   .5880685     0.12   0.902    -1.080098    1.225088
            Project3 |  -.0011724   .5609852    -0.00   0.998    -1.100683    1.098338
            Project4 |    1.15709   1.007156     1.15   0.251    -.8168984    3.131079
            Project5 |   .3517184    .677587     0.52   0.604    -.9763277    1.679765
            Project6 |  -1.134909   1.767241    -0.64   0.521    -4.598638     2.32882
            Project7 |   .1437486   1.123171     0.13   0.898    -2.057626    2.345123
            Project8 |  -.7179312    .943762    -0.76   0.447    -2.567671    1.131808
            Project9 |  -1.617656   .7800118    -2.07   0.038    -3.146451   -.0888611
           Project10 |   .2760176   .8877753     0.31   0.756     -1.46399    2.016025
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------
               /cut1 |   1.958181   1.848353                     -1.664525    5.580887
               /cut2 |   3.930317   1.792303                      .4174685    7.443166
               /cut3 |   4.828466   1.791365                      1.317456    8.339476
               /cut4 |    7.46981   1.853368                      3.837276    11.10234
               /cut5 |   8.909603   1.897738                      5.190106     12.6291
------------------------------------------------------------------------------
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. ologit K17 SumMAI Age Sex EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -222.07346
Iteration 1:   log likelihood = -203.17142
Iteration 2:   log likelihood = -202.36608
Iteration 3:   log likelihood = -202.36364
Iteration 4:   log likelihood = -202.36364

Ordered logistic regression                       Number of obs   =        147
                                                  LR chi2(21)     =      39.42
                                                  Prob > chi2     =     0.0087
Log likelihood = -202.36364                       Pseudo R2       =     0.0888

------------------------------------------------------------------------------
                 K17 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
              SumMAI |   .1129527   .0288364     3.92   0.000     .0564344    .1694709
                 Age |   .5695754   .3451234     1.65   0.099    -.1068541    1.246005
                 Sex |  -.1390456   .3411718    -0.41   0.684    -.8077301    .5296388
          EuropeAsia |   .0850959   .6706239     0.13   0.899    -1.229303    1.399495
        Loughborough |   .4448957   .5267934     0.84   0.398    -.5876004    1.477392
         Northumbria |  -1.201771   .5681594    -2.12   0.034    -2.315343   -.0881991
   CoventryUniversity |  -.5852061   .6163889    -0.95   0.342    -1.793306    .6228941
     BrunelUniversity |  -2.238146   .7931883    -2.82   0.005    -3.792766   -.6835253
  UniversityofLincoln |   .5013593   .5712546     0.88   0.380    -.6182792    1.620998
    UniversityofLeeds |  -.4336037   .6799993    -0.64   0.524    -1.766378    .8991704
 UniversityofBrighton |  -2.000194   .8065527    -2.48   0.013    -3.581008   -.4193794
              Others |          0  (omitted)
            Project1 |   .1949083   .7009099     0.28   0.781     -1.17885    1.568667
            Project2 |  -.0303249   .5521008    -0.05   0.956    -1.112423    1.051773
            Project3 |  -.1695449   .5217002    -0.32   0.745    -1.192058    .8529687
            Project4 |  -.2560897   .9082804    -0.28   0.778    -2.036287    1.524107
            Project5 |   .8712733   .6171899     1.41   0.158    -.3383967    2.080943
            Project6 |   3.408193   1.879326     1.81   0.070    -.2752176    7.091604
            Project7 |   -.621464   1.116408    -0.56   0.578    -2.809583    1.566655
            Project8 |  -.1581348   .9075002    -0.17   0.862    -1.936802    1.620533
            Project9 |  -1.081632   .7140614    -1.51   0.130    -2.481167    .3179023
           Project10 |  -.9590913   .8316908    -1.15   0.249    -2.589175    .6709926
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------
               /cut1 |   2.974645   1.710419                      -.3777144    6.327005
               /cut2 |   4.496236   1.714893                       1.135108    7.857364
               /cut3 |   6.391797   1.748211                       2.965367    9.818228
               /cut4 |   7.448047   1.776214                       3.966732    10.92936
------------------------------------------------------------------------------
```

```
. ologit K18 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:   log likelihood = -254.23723
Iteration 1:   log likelihood = -235.70479
Iteration 2:   log likelihood = -235.16947
Iteration 3:   log likelihood = -235.16822
Iteration 4:   log likelihood = -235.16822

Ordered logistic regression                       Number of obs   =        147
                                                  LR chi2(21)     =      38.14
                                                  Prob > chi2     =     0.0124
Log likelihood = -235.16822                       Pseudo R2       =     0.0750

------------------------------------------------------------------------------
                 K18 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
              SumMAI |   .0984483   .0265513     3.71   0.000     .0464086    .1504879
                 Age |  -.1179376   .3033648    -0.39   0.697    -.7125217    .4766466
                 Sex |   .3383278   .3359375     1.01   0.314    -.3200976    .9967532
          EuropeAsia |   .1517409   .6700064     0.23   0.821    -1.161447    1.464929
        Loughborough |  -.5508804   .5446911    -1.01   0.312    -1.618455    .5166945
         Northumbria |   .5225391   .5461767     0.96   0.339    -.5479474    1.593026
  CoventryUniversity |  -.5838585   .5946571    -0.98   0.326    -1.749365    .5816479
     BrunelUniversity |   1.878315   .7055813     2.66   0.008     .4954016    3.261229
 UniversityofLincoln |   .0361179   .6366962     0.06   0.955    -1.211784     1.28402
   UniversityofLeeds |  -.4111082   .6675169    -0.62   0.538    -1.719417     .897201
UniversityofBrighton |   -.312056   .7295857    -0.43   0.669    -1.742018    1.117906
              Others |          0  (omitted)
            Project1 |    .614262   .6950505     0.88   0.377    -.7480119    1.976536
            Project2 |  -.8228904   .5561249    -1.48   0.139    -1.912875    .2670944
            Project3 |  -.1977165   .5096018    -0.39   0.698    -1.196518    .8010847
            Project4 |   .7812526   .8854603     0.88   0.378    -.9542178    2.516723
            Project5 |  -.5942291   .6011373    -0.99   0.323    -1.772437    .5839784
            Project6 |  -.6490443   1.779792    -0.36   0.715    -4.137372    2.839283
            Project7 |   .9473506   1.187146     0.80   0.425    -1.379413    3.274114
            Project8 |  -1.059988    1.17955    -0.90   0.369    -3.371864    1.251889
            Project9 |   .0393168   .7403977     0.05   0.958    -1.411836     1.49047
           Project10 |  -.0883754   .7788027    -0.11   0.910    -1.614801     1.43805
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------
               /cut1 |   .6505552   1.637212                      -2.55832    3.859431
               /cut2 |   1.186831   1.629607                     -2.007141    4.380803
               /cut3 |   1.763113   1.625377                     -1.422568    4.948793
               /cut4 |   3.041081   1.622229                     -.1384288    6.220591
               /cut5 |   4.565399   1.644658                       1.34193    7.788869
               /cut6 |   5.676759   1.671315                      2.401042    8.952476
------------------------------------------------------------------------------
```

```
. ologit K19 SumMAI Age Sex      EuropeAsia Loughborough Northumbria CoventryUniversity BrunelUniversity
UniversityofLincoln UniversityofLeeds UniversityofBrighton Others Project1
> Project2 Project3 Project4 Project5 Project6 Project7 Project8 Project9 Project10 Project11

note: Others omitted because of collinearity
note: Project11 omitted because of collinearity
Iteration 0:    log likelihood = -224.09211
Iteration 1:    log likelihood = -212.13533
Iteration 2:    log likelihood = -211.78497
Iteration 3:    log likelihood =   -211.7844
Iteration 4:    log likelihood =   -211.7844

Ordered logistic regression                      Number of obs     =        147
                                                 LR chi2(21)       =      24.62
                                                 Prob > chi2       =     0.2642
Log likelihood =   -211.7844                     Pseudo R2         =     0.0549

------------------------------------------------------------------------------------
                 K19 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
              SumMAI |   .1019051     .02837     3.59   0.000      .046301    .1575092
                 Age |   .0154068   .3178325     0.05   0.961    -.6075335    .6383472
                 Sex |   .6059922   .3433671     1.76   0.078    -.0669949    1.278979
          EuropeAsia |   .2885897   .6400307     0.45   0.652    -.9658475    1.543027
        Loughborough |  -.2362117   .5354752    -0.44   0.659    -1.285724    .8133003
         Northumbria |  -.0023197   .5568252    -0.00   0.997    -1.093677    1.089038
  CoventryUniversity |  -.1355732   .5932727    -0.23   0.819    -1.298366     1.02722
     BrunelUniversity |   .1299826   .7505514     0.17   0.863    -1.341071    1.601036
 UniversityofLincoln |  -.3218773   .5952067    -0.54   0.589    -1.488461    .8447065
   UniversityofLeeds |  -.3265433   .7241311    -0.45   0.652    -1.745814    1.092728
UniversityofBrighton |  -1.168115   .7194556    -1.62   0.104    -2.578222    .2419925
              Others |          0  (omitted)
            Project1 |   .4084259   .7295282     0.56   0.576    -1.021423    1.838275
            Project2 |   .1398295   .5564471     0.25   0.802    -.9507867    1.230446
            Project3 |   .6150764   .5188481     1.19   0.236    -.4018472       1.632
            Project4 |    .503628   .9036971     0.56   0.577    -1.267586    2.274842
            Project5 |  -.0461846   .6200329    -0.07   0.941    -1.261427    1.169058
            Project6 |   1.411887   1.902807     0.74   0.458    -2.317546    5.141319
            Project7 |   .7873231   1.107177     0.71   0.477    -1.382704     2.95735
            Project8 |   .8702624   1.065941     0.82   0.414    -1.218943    2.959468
            Project9 |  -.2109202     .73118    -0.29   0.773    -1.644007    1.222166
           Project10 |   .2757998   .8045842     0.34   0.732    -1.301156    1.852756
           Project11 |          0  (omitted)
---------------------+--------------------------------------------------------------
               /cut1 |   .6523677   1.748976                      -2.775562    4.080297
               /cut2 |   1.394791    1.70534                      -1.947614    4.737197
               /cut3 |   2.251899   1.684631                      -1.049916    5.553715
               /cut4 |   3.531538   1.677743                       .2432231    6.819854
               /cut5 |   5.693881   1.715507                       2.331548    9.056213
               /cut6 |   6.923545    1.75558                       3.482671    10.36442
------------------------------------------------------------------------------------
. log close
      name:  <unnamed>
       log:  E:\Research Plans\yangyang\16.07.2017\second attempt\Regress.log
  log type:  text
 closed on:  16 Jul 2017, 16:00:48
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