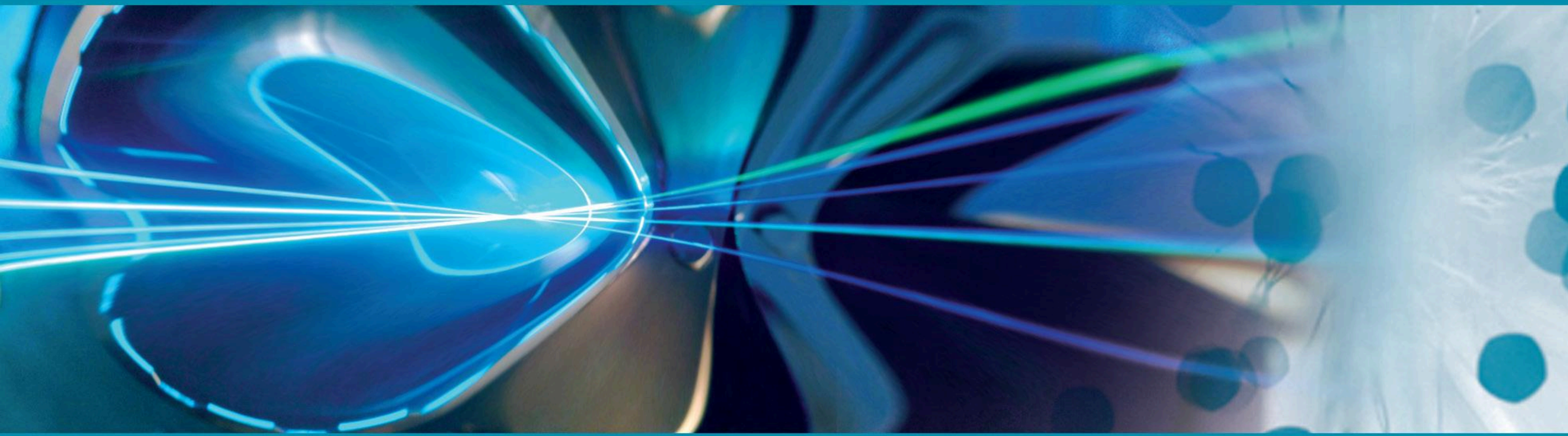

Mini-project deliverable

Analysis of critical thinking skills across an international, cross-institutional student group

The Higher Education Academy Engineering Subject Centre

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Abstract

Academic programmes implicitly require critical thinking, and increasingly the requirement for critical thinking is explicit as part of autonomous and enquiry-based learning. Because of the different cultural and learning backgrounds across an international student group, there is not a single, uniform understanding of and approach to critical thinking. This paper describes research conducted to explore engineering students' conceptualisation of critical thinking, with a view to using the findings to contribute to improved design of academic programmes in the future.

Research subjects were a cross-institutional, international group of master's level engineering students; the investigation spanned two separate academic cohorts in two different institutions. A set of attributes giving evidence of critical thinking was determined from the literature (Castle 2003; Colucciello 1997; Profetto-McGrath 2003). A combination of qualitative and quantitative methods was used to provide insights into emerging themes. Focus groups identified key themes, and questionnaires further explored those themes and confirmed the initial findings. Analysis of questionnaire data generated descriptive statistics that measured the incidence and variation in respondents' views around critical thinking and facilitated an exploration of data trends to verify and augment results from focus groups. It is anticipated that the research outputs will enable faculty staff to identify aspects of curricula that rely on critical thinking and to comment on appropriate ways to embed the development of critical thinking skills in academic programmes.

1. Introduction

This paper describes an investigation into how international students conceptualise critical thinking. The investigation was triggered by staff observations that students from some cultural backgrounds seemed to lack an understanding of the term 'critical thinking', and moreover were not able to or were unwilling to engage in the critical thinking process as it is understood in UK Higher Education (HE). These observations were made about engineering students, and the investigation that followed has revolved around engineering students.

UK HE engineering programmes have in recent years been shaped by the UK Standard for Professional Engineering Competence (UK-SPEC). Typically, universities in the UK seek accreditation from a relevant engineering professional institution whose accreditation criteria are aligned with the UK-SPEC. The UK-SPEC learning outcomes include both subject specific knowledge and generic abilities, for example abilities to: apply concepts from a range of areas to specific engineering projects, integrate and synthesize knowledge, analyse and classify, identify and employ the correct tools to solve problems, deal with limitations and uncertainty, identify and work with constraints, and evaluate outcomes (Engineering Council 2003). Engineering programmes include considerable project work to prepare students for employment in the engineering industry; often projects are open-ended and investigative, requiring a significant amount of student independence. Engineering programmes also now encourage students to take control of their individual learning processes, fostering reflective skills as well as deeper subject specific knowledge (Moore et al 2010).

The perceptions of staff that students from some cultural backgrounds were unable or unwilling to engage in critical thinking were based on the responses of students when they were expected, for example:

- To apply concepts laterally. When exam questions require students to do more than just memorise and reproduce material, marks tend to be lower than otherwise: few students have the deep understanding of their subject that they need to recognise and categorise a new problem so that they can choose an appropriate method to use in the solution. If, however, they are told the method to use, they can perform well because they can then draw upon memory of the method;
- To conduct a project. Staff believe that student expectations at the start of a project tend to be that staff will direct the project closely at each step of the way, rather than that the project organisation, identification of the project context, and decisions on the appropriate methodology will be led by the student;
- To give evidence of skills development. Students appear to not understand the benefits to be gained, in terms of learning and employability, when they analyse the knowledge and skills needed to achieve specific goals, then identify gaps in their knowledge and skills and find ways to close those gaps.

UK HE engineering degree programmes, influenced by professional bodies, by the engineering industry and by the problem/solution nature of engineering as a discipline, aim for graduates' attributes to include: in depth subject knowledge, ability to solve complex problems, self organisation, ability to apply technical knowledge laterally, ability to structure and manage a project, ability to identify relevant information and to synthesise information from multiple sources, and ability to reflect and critically evaluate. However, it is the same attributes that, according to staff perceptions, were not understood by students from some cultural backgrounds.

This section has presented the motivation for carrying out research into students' conceptualisation of critical thinking and has given background information about engineering degree programmes. The paper will present a brief background on critical thinking in section two, a description of the research methods in section three, a presentation and analysis of the findings in section four and conclusions and comments on future work in section five.

2. Background information on critical thinking

There is not a single concise definition of critical thinking. Resources produced as part of the Teaching International Students (TIS) project (Higher Education Academy 2010) describe critical thinking as both a set of skills and a mental attitude. The TIS resource, referencing (Mason 2008), describes critical thinking as including deep and evaluative reasoning skills, critical or questioning attitudes, and deep subject knowledge such that critical thinking is therefore linked to the context of the discipline. Bennett Moore (2010) links critical thinking to cultural context, acknowledging that in different cultures there are different definitions of critical thinking when it is applied to learning and teaching, for example some cultures use a focussed and prescriptive approach to guide students to deep learning, in contrast to the prevalent UK approach of student-directed investigation with loose guidance from tutors. The idea of cultural context is developed by Chan and Yan (2007), who refute the view that Eastern thinking is illogical and Western thinking logical, arguing that logic and reasoning are a part of both East and West but that thinking patterns may differ as a result of cultural context, and that students need to learn to “become more sensitive to their own ways of thinking” (p.400), which implies a meta-learning process. It seems likely that Western HE teaching styles, at least in the engineering discipline, do not facilitate this meta-learning process, but merely assume that it will take place.

Feng (2008) contrasts styles of learning in the UK with those in China. Feng suggests that the Chinese learner tends towards the Confucian style, in which the learner is respectful of knowledge and works hard to memorise and understand, whilst the Western learner tends toward the Socratic style in which the learner is encouraged to question accepted knowledge and to develop his or her own ideas based on accepted knowledge. In the Confucian style, the teacher is responsible for the learning processes of the student, but in the Socratic style, the student has overriding responsibility for his or her own learning. Feng quotes Biggs (1999) in linking good teaching with encouraging students to use higher cognitive level processes, for example, developing new ideas, reflecting, and applying knowledge laterally, and notes that the processes of memorising and understanding are lower cognitive level processes. The higher level cognitive processes are closely aligned with the description of critical thinking as involving deep and evaluative reasoning skills and critical and questioning attitudes. Charnock (2010) discusses the Confucian learning background resulting in unwillingness to challenge accepted knowledge. This can result in communication which gives a range of information but stops short of synthesis or stating significance, and instead leaves the reader to draw his or her own conclusions. This may appear, to the Western educator, as a lack of assertiveness and also a lack of critical and questioning attitudes.

Engineering problems are generally complex and require the problem solver to be systematic in analysis, typically working from the abstract to the refined in the definition of the problem and in the creation of a solution. There is therefore a preference for logical, abstract and deductive reasoning in the context of the engineering discipline. Peters (2008) discusses this ‘reductive’ thinking style, in which thinking is the means to an end, with the end being a solution to a problem. In engineering degree programmes, learning objectives will be set at all levels of Bloom’s taxonomy (Bloom 1956), for example starting with knowledge or memorisation and working up to evaluation and synthesis, across problems of increasing conceptual difficulty and complexity as the student progresses to the final year of the degree programme. The higher cognitive levels involving analysis, evaluation and synthesis, i.e. deep and evaluative reasoning skills and critical and questioning attitudes, are necessary to solve complex and conceptually difficult engineering problems. It follows, then, that the engineering problem solving process is an example of critical thinking.

3. Methodology

This section will describe the attributes chosen to characterise critical thinking in this project: attributes that are both skills and mental attitudes. Following that, the design and implementation of focus groups and questionnaires to gather data will be discussed, and the statistical methods used to analyse the data will be described.

3.1 Attributes of critical thinking

In engineering, as stated above, Bloom's taxonomy (Bloom 1956) can be used to help classify the levels of learning and development that students are expected to achieve in their courses and programmes. Anderson and Krathwohl (2001) modified the taxonomy to include creativity, which is certainly an important factor for practicing professional engineers. Professionally accredited engineering courses strive to achieve learning that starts with knowledge and information acquisition and moves to the higher levels of understanding, application, evaluation and creativity. At technician engineer level, professionals are expected to demonstrate knowledge and application, but only at higher levels of being a chartered engineer are synthesis, evaluation and creativity expected. Master's level courses typically lead to Chartership, therefore the expectation should be that a full range of attributes linked to critical thinking will be present. By the choice of attributes in this project, the research has been aligned with the Western view of critical thinking. In choosing attributes the 13 components of critical thinking developed by Castle (2006) have been considered. These were originally based on 17 consensus dimensions of critical thinking in nursing developed by Scheffer and Rubenfeld (2003). The 13 components are shown in Figure 1.

Component	Skills Required
Information seeking	Inquisitive seeker of knowledge, truth and understanding, identify and search relevant sources for evidence and gather data
Analysis	Break down the whole into parts to discover function, relationships, with a systematic approach
Evaluation	Make judgements and draw issues based on reliable evidence
Reflection	Contemplate own thinking, knowledge and assumptions to allow for a deeper understanding
Creativity	Generate, discover or re-structure ideas and imagine alternatives
Prediction	Predict potential outcomes and consequences
Discrimination	Identify inconsistencies, distinguishing relevant from irrelevant, recognising differences and similarities
Context	Consider background and influences relevant to an issue
Perseverance	Pursue a course of action with determination to overcome barriers
Flexibility	Ability to adapt, modify or change ideas, processes and behaviours
Open-mindedness	Tolerant of divergent views, identifying own beliefs and prejudices
Knowledge transfer	Change nature of form or function from one concept to another
Confidence	Develop effective communication style, trust own reasoning skills, with intuitive and insightful understanding

Figure 1. Components of critical thinking (modified versions of Castle (2006) and Scheffer and Rubenfeld (2003)).

The nine questions in Figure 2 were therefore derived for initial focus group consultation with engineering master's students. The questions in Figure 2 should be considered in the context of engineering degree programmes which include significant investigative project work, as stated above.

Questions	Critical Thinking Component	Themes for analysis
Q1. Where do you think students should find information during their academic courses?	Information seeking; Discrimination; Context	Information management skills
Q2. What do you think is the best way for students to decide what to read as part of their academic work?	Information seeking; Discrimination; Context	Information management skills
Q3. What do you think is the best way for a student to decide what tasks to do in their MSc project, and in what order to do these tasks?	Analysis	Inquisitiveness, organisation, systematicity skills
Q4. What do you think is the best approach to problem solving?	Analysis; Perseverance	Problem solving and analytical skills
Q5. Thinking about carrying out experiments, what do you think is the best approach to interpreting results?	Evaluation; Prediction	Problem solving and analytical skills
Q6. What does the term 'reflective practice' mean to you?	Reflection; Knowledge Transfer	Open-mindedness, reflexivity and evaluative skills
Q7. Suppose you were a project supervisor for an MSc student designing a robot. How would you expect the student to come up with the design in terms of the process?	Creativity; Context; Knowledge Transfer	Inquisitiveness, organisation, systematicity skills
Q8. If you were asked to write an essay that compares and contrasts two journal articles, how would you approach this?	Discrimination; Evaluation; Context; Flexibility; Open-mindedness	Open-mindedness, reflexivity and evaluative skills
Q9. If the project supervisor for your MSc project asked you to justify your use of a particular method for evaluating a set of data, how would you do this?	Confidence	Inquisitiveness, organisation, systematicity skills

Figure 2 Focus group questions based on critical thinking components

3.2 Focus groups

Two focus groups were conducted, one at each participating institution, to gather information on how students on a taught postgraduate engineering programme conceptualise critical thinking. The number of participants in each focus group ranged from 9 to 21, consisting predominantly of international students. The focus groups were facilitated by independent researchers, who posed a list of pre-defined questions (Figure 2) to participants in an interactive session. The structure for the focus groups allowed all participants to think about the questions and note down their answers prior to the discussion. The information gathered reflects collective responses from a representative group of students and reveals insights around students' conceptions of critical thinking.

From the analysis of the focus group data, a range of themes emerged. From participants in the focus group, there was a significant expectation of being closely guided by academic tutors that outweighed the expectation of self-directed learning. There was a lack of appreciation of any need to challenge, probe and evaluate established views. Finally, whilst there was some understanding of systematic approaches, participants predominantly demonstrated a lack of understanding of the need to provide a rationale to justify any particular approach. These themes informed the content of a questionnaire to gather more information about students' conceptualisation of critical thinking.

3.3 Questions in questionnaire

A questionnaire (see Appendix A) was used to further explore the themes arising from focus groups so as to understand how widely views are held. The questionnaire was distributed to a taught postgraduate engineering cohort of 109 students (approximately 50% from each institution). Questions from the focus groups were included in the questionnaire to assess the relative importance and links between the themes which emerged. Some questions were merged together as they covered similar critical thinking components (Figure 2). The factors for each question reflected the nuances and points raised by participants during focus groups, ensuring each response option was mutually exclusive. This combined approach was adopted to better understand the views expressed and to deal effectively with the challenge of evaluating and choosing among different perceptions of critical thinking and producing sufficient justification for proposed action.

3.4 Format of questionnaire

A closed format questionnaire was adopted to allow participants to choose an opinion on a particular issue that most or least reflected their view. One disadvantage of closed questions is that it decreases the likelihood of receiving unexpected and insightful views as it is not possible to predict the full range of opinions (Converse and Presser 1986; Graham and Shuman 1982), so each question included an option for respondents to raise other issues and shed new insights on the emerging themes. However, considering views that are isolated (i.e. not corroborated by other respondents in the sample) was difficult to interpret. The questionnaire measured attitudinal questions, such as respondents' views on the best approach to problem solving, over a complete range (e.g. strongly agree to strongly disagree). For all questions, the Likert scale measurement used included an odd number of alternatives to allow a neutral or no opinion response.

3.5 Statistical evaluation

The analysis of questionnaires was exploratory, largely because of the non-parametric nature of the data. This meant there was no scope for normalising the data, and little possibility of making predictions about how, in repeated samples of equal size, a particular statistic would behave (i.e. how it would be distributed). While further statistical analysis is planned to explore data trends across sub-groups (e.g. by nationality), preliminary analysis explored each variable in the data set separately to consider the range and spread of values and to describe the pattern of responses overall. This allowed the research team to assess the incidence and variation in respondents' views around critical thinking to verify and augment results from focus groups.

4. Findings

In creating the questionnaire, a decision was made to collapse critical thinking components into four themes because of the links between the components in each of these areas:

- Information management skills
- Inquisitiveness, organisation and systematicity skills
- Problem solving and analytical skills
- Open-mindedness, reflexivity and evaluative skills

These groupings correspond to the levels of the learning taxonomy, moving from the lower to the higher levels. The categories are not mutually exclusive; overlaps exist between them. Grouping the capabilities of critical thinking gives some advantage in the presentation of the findings: the relationship between responses related to the attributes that are grouped by category can be used to increase understanding. The findings are not intended to be a measurement of whether the students in the sample groups practised critical thinking, but instead an exploration of how the students conceptualised critical thinking. In presenting the findings, the way the students conceptualise the processes related to specific critical thinking attribute(s) will be inferred either from the practice that the students consider ‘best’ or from the practice that the students claim as their own. Appendix B details the findings from the questionnaire in graphical form.

4.1 Information management skills

The ability to find information independently and to understand the relative reliability of information sources in master’s level courses is typically linked to wider reading for taught courses and investigative reading for coursework or project work. Hence the questions asked explored where students found reading material and how they chose the best material. An inference is made that students will claim, on the questionnaire, to do what they believe to be best practice.

The most frequently used sources of information are the library and university sites (86% and 82% respectively). Whilst internet search engines are a popular source of information, there is greater use of general search engines (79%) compared to academic search engines (56%). This is also apparent in the number of students (68%) who felt the best information for coursework is found by searching the internet for quick solutions to questions. The majority of respondents (91%) felt it is important to understand the background and context of questions on coursework before looking for information. However, the approach to understanding questions differs amongst students. Some prefer to "Google the topic to find similar work done"; while others "assess the guidelines given on the problem" as a means of evaluating the nature and context of the question. A reliance on Google may indicate an overly simplistic approach to finding information, as contrasted to a probing analysis of the requirements of the coursework questions.

In identifying the best information and sources for coursework, there is a reliance on the course tutor. This is evident in data that show students largely refer to course reading lists (90%) and guidance from the module leader (80%). Other methods of sourcing information include identifying relevant articles (78%). Some students in the focus groups felt this calls for an independent assessment of "what is suitable for academic purposes" such as identifying most cited (57%) and recently published (52%) sources. These findings indicate that while students recognise the importance of exploring the background and context of questions to select relevant information, there is need to trust their own reasoning skills for more intuitive and insightful understanding. Reliance on guidance from tutors may link to a learning background which does not emphasise independent investigation.

4.2 Inquisitiveness, organisation, systematicity skills

The ability to analyse a large task (or a project) and to systematically break this down into smaller parts in master's level courses is typically linked to coursework or project work. Often the task will call for investigation into an area in which the student has no prior knowledge. A common approach is to produce a design of a solution, in the form of a model or prototype. Because solutions for Engineering problems are often complex, the design should show a structure which manages the complexity by systematic handling of the interrelated parts of the solution. Moreover, a master's level student needs to have the ability to understand and to give a justification for the processes chosen. Hence the questions asked explored the students' approach to planning project work, to creating a design, and to choosing and justifying methods for evaluating results.

When asked how they would come up with a plan for their master's project, most students (67%) showed independent thinking in saying that they would propose project tasks to their supervisor. Conversely a smaller proportion (31%) would be dependent on the supervisor to provide them with a project plan. On the other hand, a large proportion of students (81%) preferred to be guided by their supervisor in coming up with tasks for the project. More generally, the data showed unanimous agreement among students on the tasks to be undertaken in a master's project. Most relayed the need to understand the context and background of the project (98%), choose suitable methods (96%), identify limitations (93%) and define the scope by setting aims and objectives (92%). These results indicate a high level of agreement about how to approach project management, but an uncertainty about who should be the manager. This may show a lack of self-confidence or independence, or it may show the lack of assertiveness and the respect that is a part of the Confucian learning style, as discussed in Section 2.

Most students (77%) felt it was important to justify the choice of method for their master's project, while few (12%) felt it was not necessary. The most popular approach was comparing a range of methods (94%) and identifying similar methods used in previous project (77%). However, a large proportion of students (62%) stated that they would choose the easiest method available to them. These results show a significant strength of belief in the need to understand and justify processes used, however they also show a lack of independence and of deep analysis in deciding which processes to use.

4.3 Problem solving and analytical skills

Skills in problem solving are closely linked to the skills in inquisitiveness, organisation and systematicity discussed in section 4.2. Any engineering course will have an overarching aim that its graduates will be able to apply theory to real practical problems. Because engineering problems are typically complex, solving them will require organisation and systematicity as part of the problem solving process. Ideally the problem solving process will start with a full understanding of the problem, followed by an iterative sequence of proposing, developing, testing and evaluating a solution. Therefore, the questions asked explored students' view on the best approach to problem solving and the best approach to interpreting or evaluating results.

Students were asked what they thought the best approach to problem solving was, with a high proportion (98%) identifying the need to understand the cause of a given problem, with some saying that they would "isolate [the cause], to find where the problem is" and "try to look for abnormality in the system." Other students (65%) agreed with this approach to isolating the cause, but the majority (91%) felt there is a need to understand the parts of the problem and the relationships between them. These results are indicative of a systematic approach to problem solving, and show evidence of a good level of meta-process understanding.

Overall students' responses indicated knowledge of a sequence in problem solving, from understanding the problem, exploring possible solutions, and then looking to other sources for solutions if necessary. Some students (73%) claimed to be more proactive in that they establish their own solutions to a given problem, while others tended to rely on solutions from other sources including those from experts (91%), exploring similar problems (85%) and reviewing the literature to identify possible solutions (83%). These results give evidence of problem solving processes that are consistent with exemplar engineering methods, in which lateral thinking includes being able to adapt a solution in one domain to fit a problem in another domain.

When asked about analysing data from an experiment they conducted, students generally agreed that it is useful to visually present the data, with one student stating that they would let the reader "view graphs and tables because [then] you can evaluate the results and explain them in a better form…". When others were asked the question whether they would only present the data in a visual form and allow readers to draw their own conclusions, 51% disagreed. The fact that a large percentage (49%) would not state their conclusions from the results but would allow the reader to draw their own resonates with Charnock's (2010) view discussed in section 2 that students from a Confucian learning background may stop short of synthesis and stating significance.

In relation to how students make judgements and draw conclusions from the results, the majority (98%) drew attention to "comparing experimental results to theoretical results", and the need to assess the variables and controls in the experiment (92%). Others (77%) drew attention to considering the uncertainty in experiments.   These results may indicate proficiency with laboratory based work, and further work could explore whether or not the teaching and learning approaches in a laboratory setting have more consistency across cultures than teaching and learning approaches in a classroom setting.

4.4 Open-mindedness, reflexivity and evaluative skills

Reflective practice is at the top of the learning taxonomy, and at this level there is an expectation that students can make sense of similar or contrasting viewpoints, can formulate their own viewpoints having analysed those of others and can analyse and learn from experience. Master's level engineering students might be expected to show evidence of these skills during project work or during non-prescriptive coursework. Assessors of this type of work would be looking for evidence-based analysis. Therefore, the questions about these skills sought to discover whether students had an understanding of the term "reflective practice" and of the process of dealing with and adding to multiple viewpoints.

There appears to be no general consensus on what reflective practice is, with few students showing an understanding of the term. From the focus groups, it appeared that most students did not understand the concept, misinterpreted it or had not heard of the approach before, whilst only few showed a basic understanding: "if faced with the same or similar issue, I could use what I learnt from a previous [experience]".

When asked how they would go about writing an essay to compare and contrast multiple views, there was unanimous (100%) agreement amongst students on the need to identify key points in a source and most (84%) saw the need to thoroughly read a source prior to developing the essay. In one question, students were asked whether they rely on their own ideas or the viewpoints of authors to prepare an essay. Given the overwhelming support for both options (68% to 83%) it is possible that students misinterpreted the question.

Because of the apparently contradictory views and lack of consensus on questions in this theme, it is not possible to draw conclusions about students' understanding of reflective practice, open-mindedness and evaluative skills. It seems likely that the questions posed in this theme were ambiguous, and further work could explore this theme using an improved question set.

5. **Conclusions**

This paper has described an investigation into how international students conceptualise critical thinking, using engineering master's level students in two UK HE institutions as research subjects. Attributes of critical thinking were determined and were couched in terms that aligned with the engineering discipline. Focus groups revealed an initial picture of students' conceptualisation of critical thinking, from which, questionnaires were developed to explore emerging themes. Statistical analysis of the questionnaire results supported the focus group findings that students' views of critical thinking are not well developed, and that the meta-learning that would result from a well-developed understanding of critical thinking is not present. However, there is some evidence of learned skills (for example in a laboratory setting) which align to the critical thinking mindset, although students are not necessarily aware of this alignment. If students could be made aware of their use of critical thinking in a task based domain, they are likely to be able to adapt and expand that skill to other learning domains.

Making students aware of their own use of critical thinking and building on that awareness to explain the thinking practices that are expected in UK HE institutions could be part of induction programmes and could be reinforced in assignment and project work by explicitly setting out the expectations regarding critical thinking. The findings of this study support the staff observations described in the introduction of the paper, i.e. that "students from some cultural backgrounds seemed to lack an understanding of the term 'critical thinking', and moreover were not able to or were unwilling to engage in the critical thinking process", but having established that this is a real problem, the next step should be to work to ensure that students do understand the critical thinking process.

Further work is required with the data gathered, particularly to distinguish between cultural backgrounds in the analysis of student responses and the effect, if any, this has on students' conceptualisations of critical thinking. However, with the work done to date, it is clear that engineering curricula, especially as related to project work, would benefit from an explicit statement of UK HE expectations of students' thinking skills, from guiding students to become aware of their own thinking practices, and from making staff aware of the need to establish common ground in thinking practices. This explicit coverage of thinking practices would reduce the risk of mismatched expectations and lead to deeper learning.

6. References

Anderson, L. W. and Krathwold, R. (Eds.) (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives.* New York: Longmans.

Bennett Moore, Z., Faltin, L. & Wright, M. (2010). Critical Thinking and International Postgraduate Students. *Discourse* vol 3 pp63-94. Available online at http://www.prs.heacademy.ac.uk/view.html/PrsDiscourseArticles/152) [Accessed 8 April 2011]

Bloom B. S. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain.* New York: David McKay Co Inc.

Castle, A., (2006). Assessment of the critical thinking skills of student radiographers. *Radiography*, 12, 88-95.

Chan, H.M. and Yan, H.K.T., (2007). Is there a Geography of Thought for East-West Differences? Why or why not?, *Educational Philosophy and Theory,* 39(4), 383-403.

Chanock, K.,(2010). 'The right to reticence', *Teaching in Higher Education*, 15: 5, 543 — 552.

Colucciello, M., (1997). Critical thinking skills and dispositions of baccalaureate nursing students—a conceptual model for evaluation. *Journal of Professional Nursing,* 13, 236-245.

Converse, J. and Presser, S. (1986). 'Survey Questions: Handcrafting the Standardised Questionnaire'. New Delhi, India: Sage Publications.

Engineering Council (2003), UK Standards for Professional Engineering Competence (UK-SPEC). http://www.engc.org.uk/ecukdocuments/internet/document%20library/UK-SPEC.pdf) [Accessed 8 April 2011]

Feng, A., (2008). Presentation from 'Culture of learning: What? Why? and How? — Enhancing the academic experience of Chinese students Workshop', Sheffield, 26 June 2008, available online at http://shef.ac.uk/content/1/c6/08/39/87/Sheffield%20Talk%2026-06-08.ppt [Accessed 8 April 2011]

Graham, K. and Schuman, H. (1982). *The Effect of the Question on Survey Responses: A Review*. *Journal of the Royal Statistical Society*, 145 (1), p. 42 – 73.

Higher Education Academy, Teaching International Students Project, (2010). *Critical Thinking.* Available online at http://www.heacademy.ac.uk/ourwork/teachingandlearning/internationalisation/alldisplay?type=resources&newid=ourwork/internationalisation/ISL_Critical_Thinking&site=york [Accessed 8 April 2011]

Mason, M. (Ed). (2008). *Critical thinking and learning*. Oxford: Blackwell Publishing

Moore, I., Elfving-Hwang, J., Garnett, K. and Corker, C. (Eds), (2010). Centre for Promoting Learner Autonomy, *Case Studies: Volume 1*. Sheffield Hallam University.

Peters, M. A. (2007). Kinds of Thinking, Styles of Reasoning. *Educational Philosophy and Theory,* 39(4), 350-363.

Profetto-McGrath, J., (2003). The relationship of critical thinking skills and critical thinking dispositions of baccalaureate nursing students. *Journal of Advanced Nursing*, 43(6), 569-577.

Scheffer, B.K. and Rubenfeld M.G., (2000). A consensus statement on critical thinking in nursing, *Journal of Nursing Education*, 39:352-9.

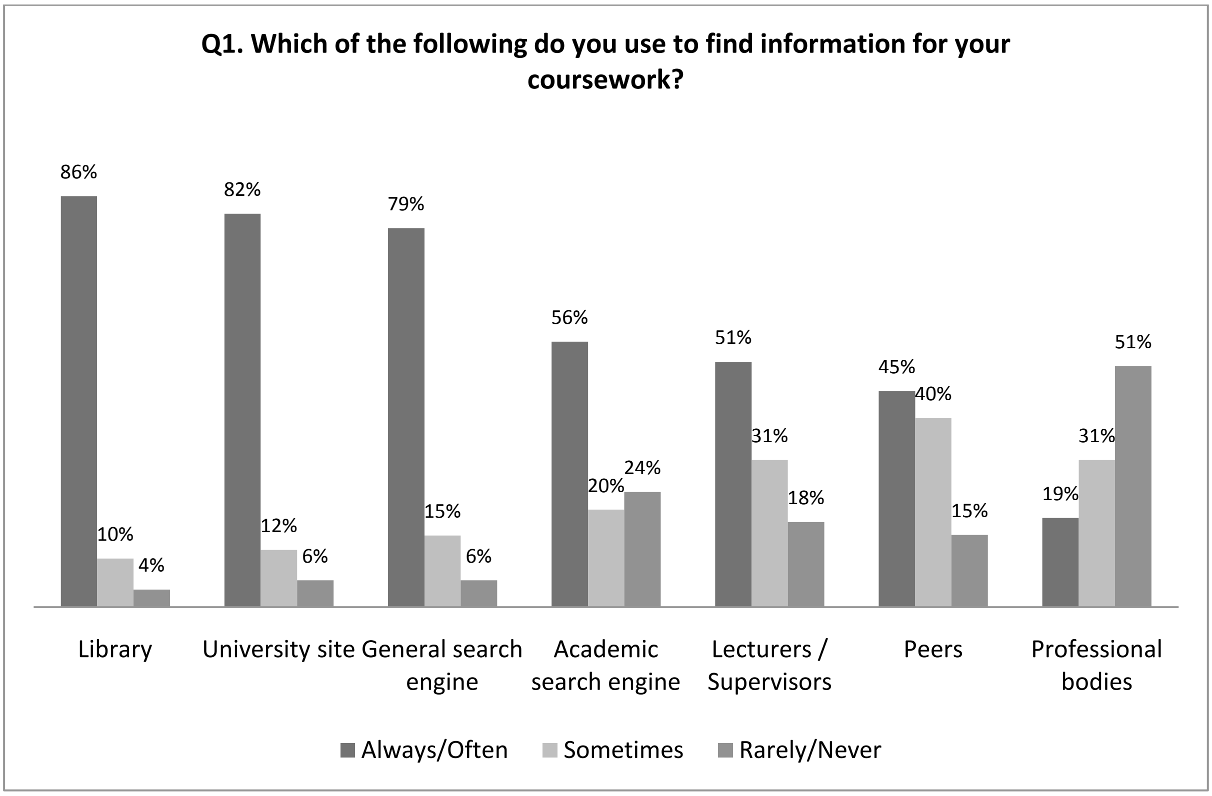
7. Appendices

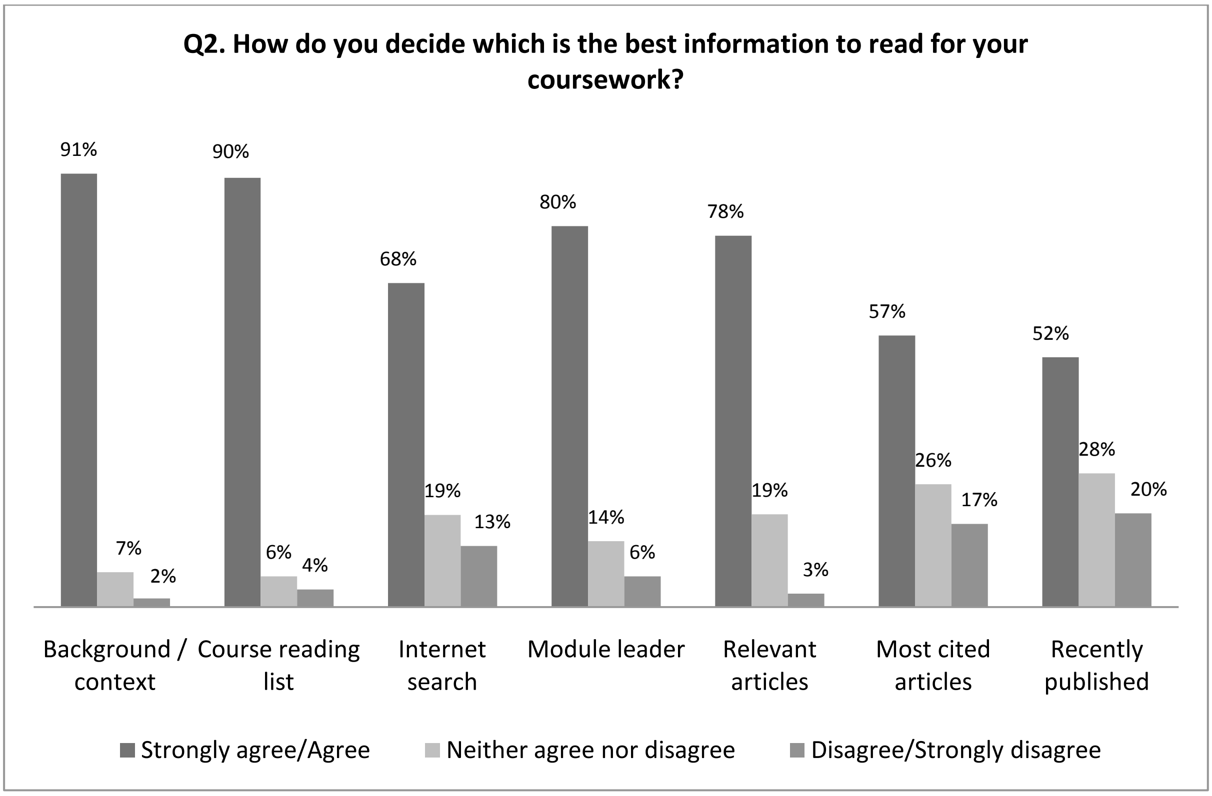
Appendix A: Questionnaire

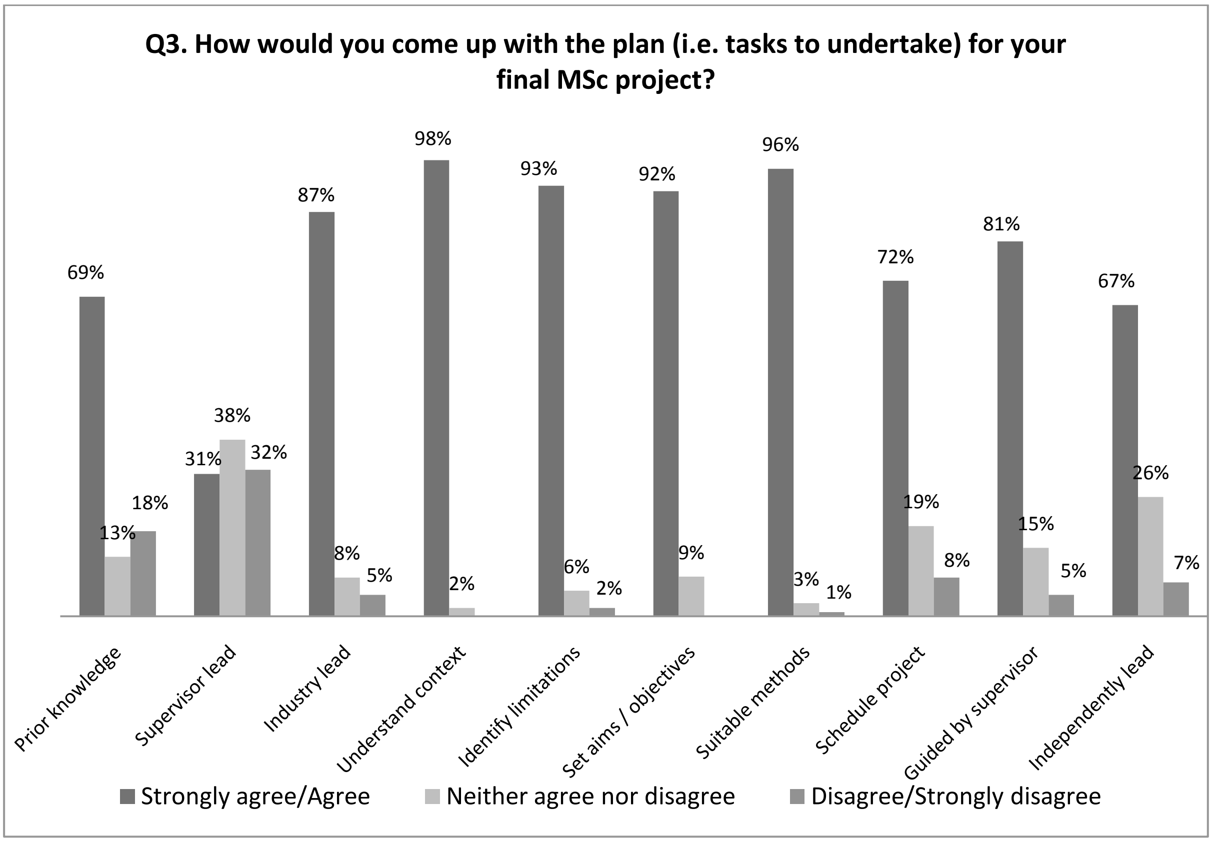
Question	**Answers (string of feeling about each assessed with Likert range)**	**Critical thinking theme**
1) Which of the following do you use to find information for your coursework?	i) Libraries including digital and paper based sources (e.g. books, texts, journals, case studies) ii) University teaching support site (e.g. Blackboard, MOLE, MUSE) iii) General search engine (e.g. Google, Yahoo) iv) Academic search engine (e.g. Google scholar, Google books, Litsearch, JSTOR, Scopus, Web of Knowledge) v) Lecturers/Supervisors vi) Peers (e.g. classmates, previous students) vii) Professional bodies viii) Other (please state: ___________________________________)	Information management
2) How do you decide what is the <u>BEST</u> information to read for your coursework?	i) I ensure that I understand the background and context of the question before looking for information ii) I identify sources of information from course reading lists iii) I search the internet (e.g. Google, Yahoo, other search engine) to identify quick solutions to the question iv) I get guidance from the Module Leader v) I assess the relevance of articles to the topic vi) I look for the most cited articles or books vii) I look for recently published articles or books viii) Other (please state: ___________________________________)	Information management
3) How would you come up with the plan (i.e. tasks to undertake) for your final MSc project?	i) I could only formulate a plan if I had some prior knowledge of the topic ii) I would be dependent on my supervisor to provide me with a project plan iii) I would decide on how my project work relates to current work in industry or in research on the topic iv) I would ensure that I understood the context and background of the project v) I would identify the limitations (e.g. time and other resources) of the project vi) I would define the scope of the project by setting aims and objectives vii) I would choose suitable methods for data collection and analysis viii) I would develop a schedule for the project (e.g. use a Gantt Chart, flow chart or other scheduling tool) ix) I would carry out tasks which are assigned by my supervisor x) I would propose project tasks to my supervisor xi) Other (please state: ___________________________________)	Inquisitiveness, organisation, systematicity
4) How would you justify your use of a particular method for evaluating a set of data or results for your final MSc project?	i) I would describe why my chosen method was the easiest ii) I would evaluate, compare and contrast various methods against the chosen method iii) I would explain why I had adopted a similar method to those used in previous projects iv) It is not necessary to justify why a method is chosen v) Other (please state: ___________________________________)	Inquisitiveness, organisation, systematicity
5) What do you think is the best approach to problem solving?	i) Assessing similar problems and outcomes ii) Identifying possible solutions from experts in the field iii) Developing my own solutions to the problem iv) Getting a clear understanding of the possible causes of the problem v) Simplifying the problem by isolating the cause vi) Reviewing the literature to identify possible solutions vii) Identifying the parts of the problem and the relationships between the parts viii) Other (please state: ___________________________________)	Problem solving and analysis

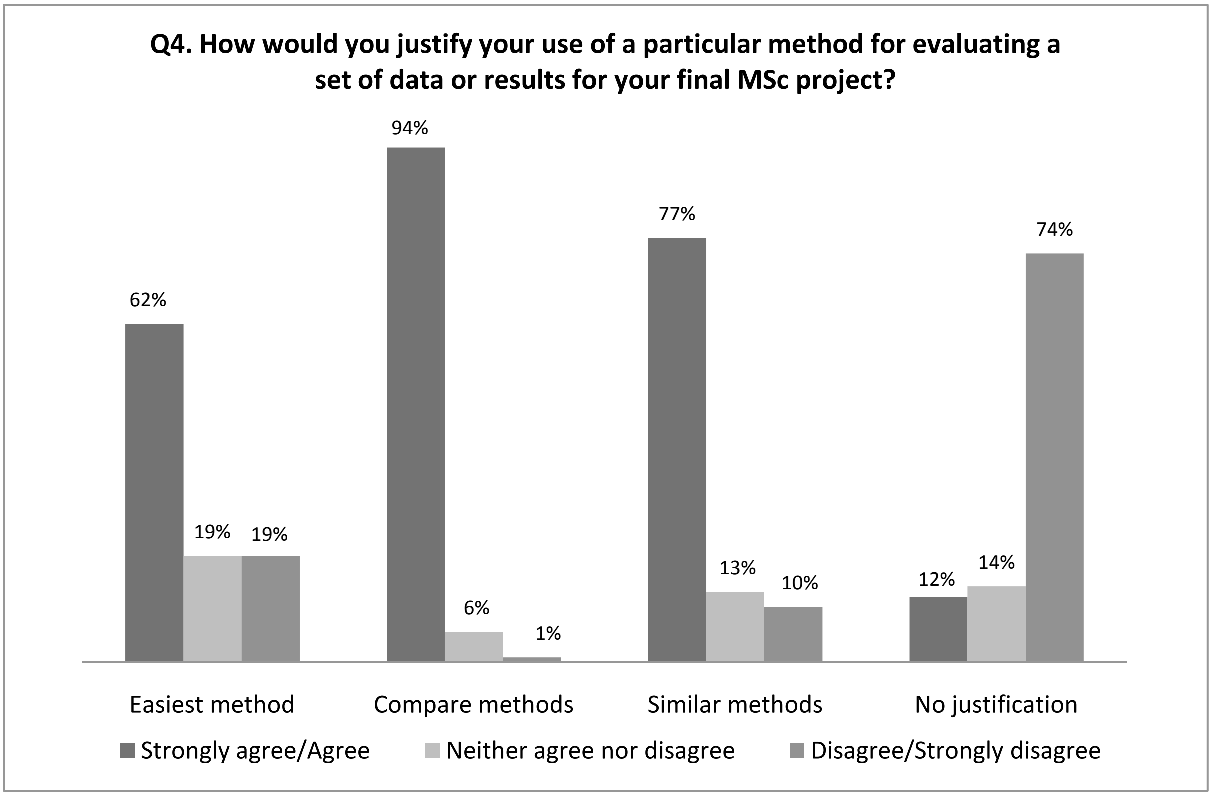
6) What is the best approach for evaluating the results from an experiment that you have conducted?	i) Establishing patterns and relationships in the data, and comparing the results to expected results ii) Assessing the variables and control values used in the experiment, and considering how these have affected the results iii) Only presenting the data in visual form (e.g. graphs, tables and charts) and allowing the readers to draw their own conclusions iv) Drawing conclusions only on the basis of the results with no references to literature v) Considering the effect of uncertainty on the data and how that limits the conclusions drawn vi) Other (please state: __________________________________)	Open-mindedness, reflexivity and evaluative
7) If you were asked to write an essay by evaluating two journal articles and reflecting on your own experiences of the subject, how would you approach this?	i) I would read each article thoroughly ii) I would identify key points in the articles iii) I would first develop ideas based on my own experiences and then refer to the articles for useful further references iv) I would assess the viewpoints of the authors to establish my own ideas v) I would look for ways to apply the ideas in the articles to further understand the topic vi) I would first gather ideas from the articles and then relate this to my own experiences of the subject vii) Other (please state: __________________________________)	Open-mindedness, reflexivity and evaluative

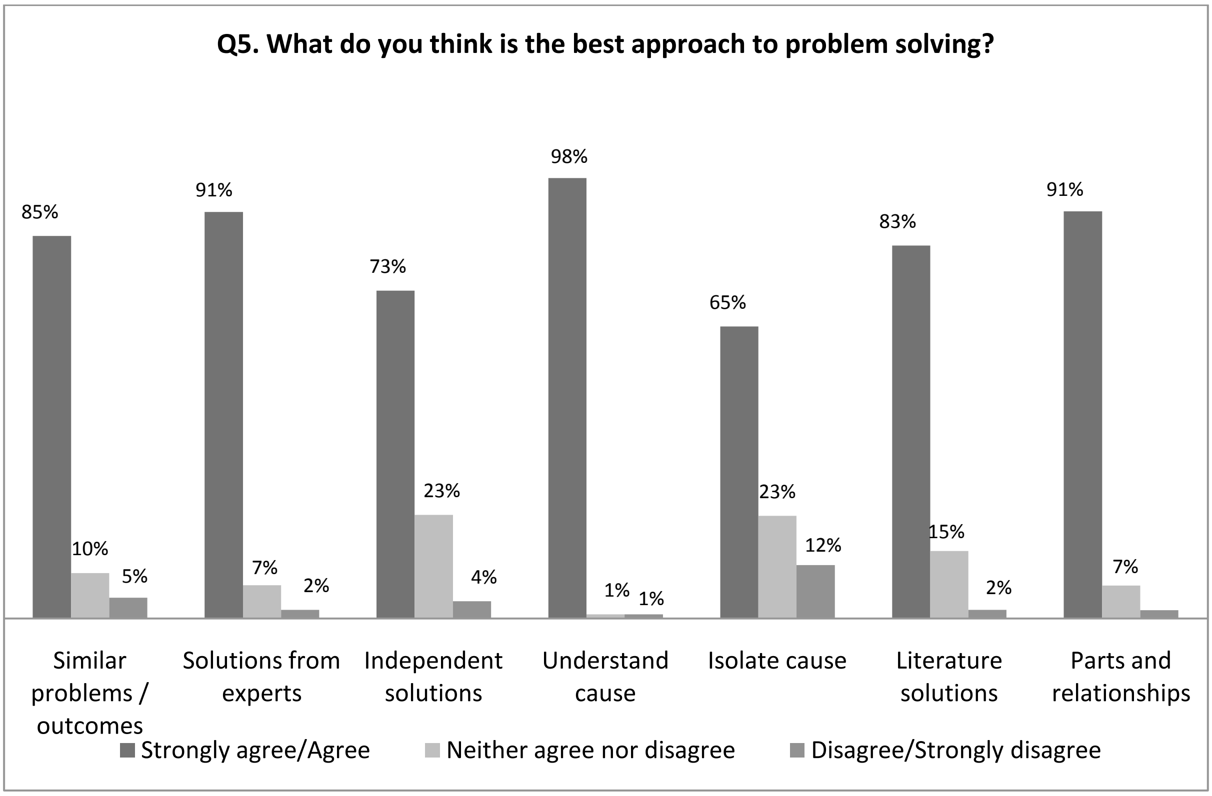
Appendix B: Graphs of results from questionnaire

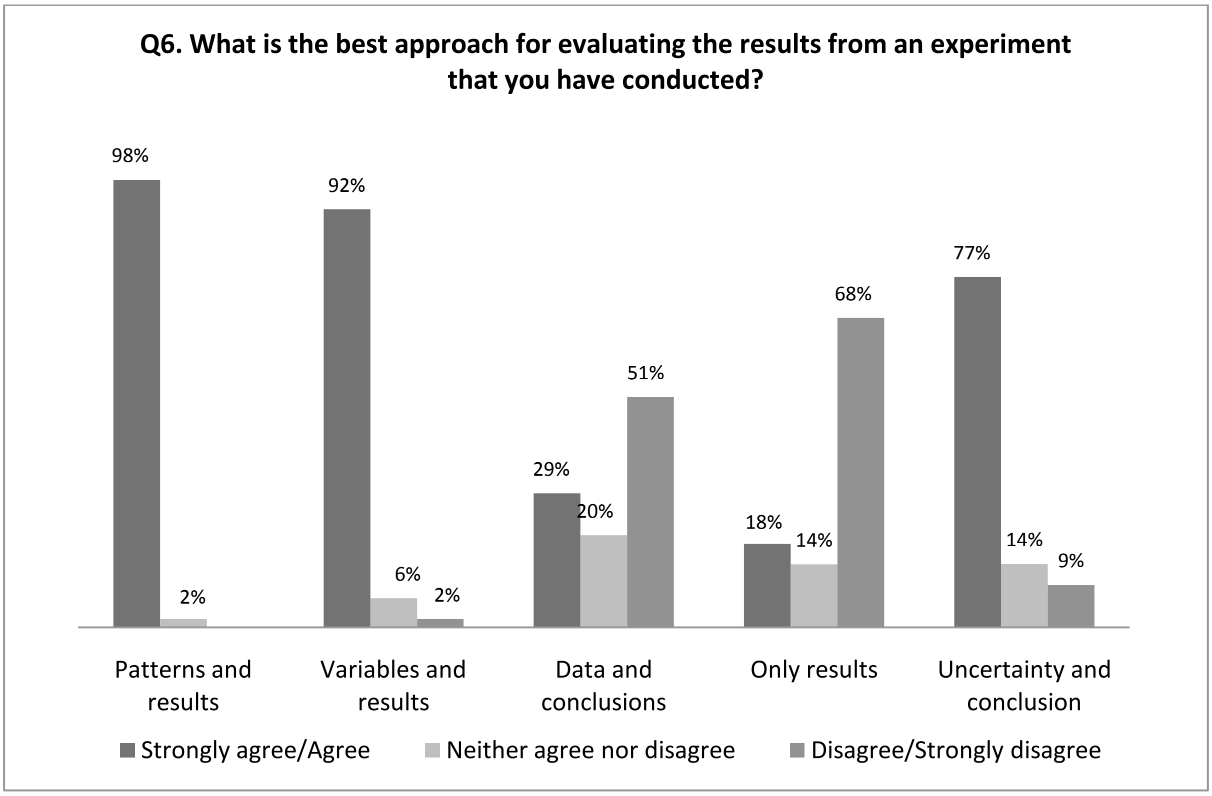


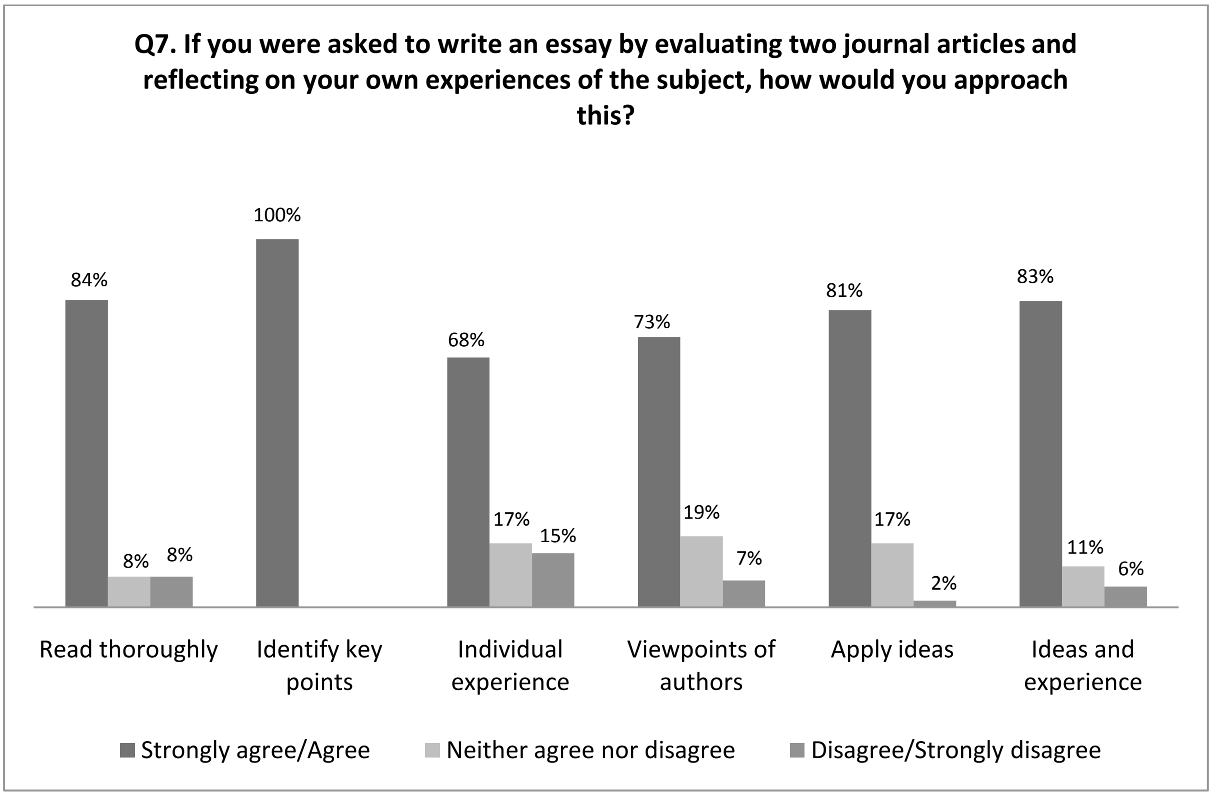



Q3. How would you come up with the plan (i.e. tasks to undertake) for your final MSc project?
69%
13%
18%
31%
38%
32%
87%
8%
5%
98%
2%
93%
6%
2%
92%
9%
96%
3%
1%
72%
19%
8%
81%
15%
5%
67%
26%
7%
Prior knowledge
Supervisor lead
Industry lead
Understand context
Identify limitations
Set aims / objectives
Suitable methods
Schedule project
Guided by supervisor
Independently lead
Strongly agree/Agree
Neither agree nor disagree
Disagree/Strongly disagree


Q4. How would you justify your use of a particular method for evaluating a set of data or results for your final MSc project?
62%
19%
19%
94%
6%
1%
77%
13%
10%
12%
14%
74%
Easiest method
Compare methods
Similar methods
No justification
Strongly agree/Agree
Neither agree nor disagree
Disagree/Strongly disagree


Q5. What do you think is the best approach to problem solving?
85%
10%
5%
91%
7%
2%
73%
23%
4%
98%
1%
1%
65%
23%
12%
83%
15%
2%
91%
7%
Similar problems / outcomes
Solutions from experts
Independent solutions
Understand cause
Isolate cause
Literature solutions
Parts and relationships
Strongly agree/Agree
Neither agree nor disagree
Disagree/Strongly disagree


Q6. What is the best approach for evaluating the results from an experiment that you have conducted?
98%
2%
92%
6%
2%
29%
20%
51%
18%
14%
68%
77%
14%
9%
Patterns and results
Variables and results
Data and conclusions
Only results
Uncertainty and conclusion
Strongly agree/Agree
Neither agree nor disagree
Disagree/Strongly disagree


Q7. If you were asked to write an essay by evaluating two journal articles and reflecting on your own experiences of the subject, how would you approach this?
84%
8%
8%
100%
68%
17%
15%
73%
19%
7%
81%
17%
2%
83%
11%
6%
Read thoroughly
Identify key points
Individual experience
Viewpoints of authors
Apply ideas
Ideas and experience
Strongly agree/Agree
Neither agree nor disagree
Disagree/Strongly disagree