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Development of a Situational Judgement Test and an assessment of its efficacy as a stimulus of metacognitive behaviour in engineering students

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**Development of a Situational Judgement Test and an assessment of its
efficacy as a stimulus of metacognitive behaviour in engineering students**



Submitted in partial fulfilment of
the requirements for the award of PhD

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DECLARATION

I certify that this thesis which I now submit for examination for the award of PhD Engineering Education, is entirely my own work and has not been taken from the work of others, save and to the extent that such work has been cited and acknowledged within the text of my work. This thesis was prepared according to the regulations for graduate study by research of TU Dublin and has not been submitted in whole or in part for another award in any other third level institution. The work reported on in this thesis conforms to the principles and requirements of the TU Dublin's guidelines for ethics in research. TU Dublin has permission to keep, lend or copy this thesis in whole or in part, on condition that any such use of the material of the thesis be duly acknowledged.

Signature: *Darren Carthy*

Date 08/11/2021

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ABSTRACT

Metacognition entails the conscious evaluation and control of one's cognitive processes. This meta-level control of cognitive process is not essential for all activities, but in the domain of problem solving and the development of new expertise, conscious control of mental functioning is essential to success. Previous studies have shown a relationship between metacognitive knowledge & skills and student self-regulated learning, self-efficacy and more generally, with success in academic and non-academic endeavours; they represent critical skills for an aspiring engineer to possess for their future employability. Metacognition can be stimulated by allowing students to engage and reflect on the problem-solving process. Studies in STEM education focus almost entirely on the use of technical problems for the source of this stimulation. The drawback of this approach is that these problems generally require prior knowledge of physics or mathematics for the students to engage in the process. Recent research utilising naturalistic observations of students' behaviour while they were engaged in technical problem solving found that metacognitive knowledge and skills can be categorised into discrete metacognitive behaviours. Specifically, metacognitive behaviour can be measured through analysis of students' discourse with one another as they engage in the problem-solving process.

This research utilised a sequential mixed methods design, which contained two strands – the first sought to develop a Situational Judgment Test (SJT) while the second strand sought to utilise the SJT as a stimulus of metacognitive behaviour. An SJT was developed, evaluated by fifty-three engineering professionals in eleven expert panels and rolled out to three hundred and third four final year and masters level engineering students at TU Dublin and KU Leuven, who took the SJT as a test. The SJT items were then delivered to a further fifty-five first year engineering students at TU Dublin, this time in groups, for them to choose responses and discuss them with their peers. The items which stimulated metacognitive behaviour amongst these students were identified using the Naturalistic Observations of Metacognition in Engineering students (NOME) protocol. The resulting items were provided to a group of eight first year engineering students and the NOME protocol was re-applied to evaluate the efficacy of the new metacognitive learning resource in stimulating metacognitive behaviour.

The development of a means of stimulating metacognitive behaviour that was not conditional on students' having prior knowledge of physics and mathematics or a reliance on inventory style assessment allowed

for a better-quality assessment of a students' metacognitive knowledge and skills. Allowing students to apply their metacognitive knowledge and skills in groups permitted students to construct tools of higher mental functioning though peer dialogue, using an SJT in the stimulation of this dialogue had pedagogical merit, as particular SJT items proved highly effective in eliciting the use of metacognitive skills.

This research work aims to add to engineering education scholarship in three ways. Firstly, to provide an engineering specific SJT to enable educators to identify areas of relative strength and weakness in students' professional judgements in order to better prepare them for their future careers. Secondly, to use the insights and resources generated from the development and evaluation of the SJT to develop a resource for engineering educators to stimulate students' metacognitive behaviour that does not rely on a students' prior knowledge of physics and mathematics, in order to provide them with the skills to self-regulate their learning. Thirdly, this research provides fresh insights into how engineering student's exhibit metacognitive behaviours when working in groups, adding to an existing body of literature about how students exhibit these behaviours during the problem-solving process.

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CHAPTER 1: INTRODUCTION

1.1 CONTEXT

Over the past three decades, there has been a strong emphasis on improving the employability of engineering students in order to address the mismatch between graduate skills and labour market expectations in the field of engineering (Passow and Passow, 2017). A recent meta-analysis by Passow & Passow (2017) discovered fifty-two articles regarding the professional skills that engineering programmes should emphasise published over the past three decades. Looking at just the past decade, this strong emphasis on professional skills in engineering programmes has resulted in the development of a multitude of learning resources (Dravid and Duncan, 2011; Wun and Harun, 2015; Charité and Muller, 2016; Hernandez-Linares *et al.*, 2017; Andersson and Logofatu, 2018; Panthaloorkaran, 2018), courses (Gider *et al.*, 2012; Gonzalez *et al.*, 2012; Nylén and Pears, 2013; Abdulwahed *et al.*, 2014; Holzer *et al.*, 2014; Boulais *et al.*, 2015; Hahn and Sorenson, 2015; Alnajjar and Manzione, 2016; Ebentheuer, Kammermann and Herzog, 2017; Nelson and Ahn, 2017; Rosca, 2018), interventions (Boyeena and Goteti, 2011; González-Morales, Moreno De Antonio and Roda Garcia, 2011; Kaybiyaynen, 2013; Albayati, 2014; Idrus, 2014; Hahn and Sorenson, 2015; Hezmi *et al.*, 2017; Quezada-Sarmiento *et al.*, 2018) and assessments (Yu *et al.*, 2012; Al-Bahi, Taha and Turkmen, 2013; Schröder *et al.*, 2013; Cukierman and Palmieri, 2014; Kranov, Danaher and Schoepp, 2014; Zhang *et al.*, 2015; Him *et al.*, 2016; Chagas *et al.*, 2017) that attempt to address students' lack of these skills. This focus on professional skills, or what may be commonly termed “soft” skills as a component of engineering graduate employability has led to significantly less attention being paid to other non-technical skills that make an engineering graduate employable - including the metacognitive knowledge and skills that engineers need to self-regulate their own learning and to be effective problem solvers (Downing *et al.*, 2009). Metacognition can be thought of as the ability to think about one's own thinking (Schraw and Moshman, 1995) and represents a set of knowledge and skills which can be observed as behaviours (Mccord and Matusovich, 2019). Metacognition entails the conscious evaluation and control of one's cognitive processes (Brown, 1987) i.e. if you were asked to solve a simple mathematics problem, on a topic of mathematics that was familiar to you – that

would require a cognitive strategy to solve the problem, you would write down the formula, identify knowns/unknowns, etc. But if you were asked to apply what you know about that topic to something more abstract, such as a physics problem, a metacognitive strategy of self-questioning and self-evaluation forms a useful scaffolding to apply the cognitive problem-solving strategy to leverage what is known in a new context. This meta-level control of cognitive process is not essential for all activities, but in the domain of problem solving and the development of new expertise, conscious control of mental functioning is essential to success (Flavell, 1976). For example, a student might know that they are more effective at working on problems alone, rather than as part of a team, they may also be aware that their ability to solve a problem effectively requires them to draw a picture or otherwise illustrate the problem. They may then seek to plan out what they know and don't know about the problem, identify potential formulae that may or may not be of use to them, monitor their progress as they transpose the formula and evaluate the efficacy of applying that formula and the answer it provides. Of course it is worth noting that rigorous use of metacognitive skills is not observed in all decision making. When an individual is HALT (Hungry, Angry, Tired or Late) decisions tend to rely on intuition, rather than conscious evaluation and control (Tay, Ryan and Ryan, 2016).

Previous studies have shown a relationship between metacognitive knowledge & skills and student self-regulated learning (Follmer and Sperling, 2016), self-efficacy (Coutinho, 2008) and more generally, with success in academic and non-academic endeavours (Coutinho, 2007); they represent critical skills for an aspiring engineer to possess for their future employability and so form the basis of investigation in this PhD research.

Metacognition can be stimulated by allowing students to engage in the problem solving process (Gourgey, 1998; Masui and De Corte, 1999; Schraw, Crippen and Hartley, 2006). Studies in STEM education focus predominantly on the use of technical problems for the source of this stimulation (Kapa, 2001; Pennequin *et al.*, 2010; Gurat and Medula, 2016). The drawback of using technical problems is that these problems generally require prior knowledge of physics or mathematics for the students to engage with them. In contrast, little research has been conducted on the efficacy of non-technical problems as the source of metacognitive stimulation. A study by Bannert and Mengelkamp (2008) utilised a series of modified questionnaires in which students were asked to think aloud about their responses, however these do not constitute problems to be solved.

A number of assessments of metacognition have been employed in order to assess whether metacognitive knowledge and skills have been demonstrated during a particular problem solving session or intervention (Deming, Valeri-Gold and Idleman, 1994; Schraw and Dennison, 1994; Sperling *et al.*, 2004). The drawback of most of these assessments is that they rely on students' self-assessment of their own performance based on predetermined criteria, typically relying on inventory-style assessments. Recent research utilising naturalistic observations of students' behaviour while they were engaged in technical problem solving, found that metacognitive knowledge and skills can be categorised into discrete metacognitive behaviours (Whitebread and Pino-Pasernak, 2013). Specifically, metacognitive behaviour can be measured through analysis of students' discourse with one another as they engage in the problem-solving process (Mccord and Matusovich, 2019). The ability to make direct observations of metacognition through the systematic analysis of dialogue provides a novel means of assessment which is not limited by the reliability of self-reporting. Recent observational studies of metacognitive behaviour during the technical problem solving process support the model of metacognition proposed by Brown (1978) and Flavell (1976). The similarities in their findings combined to form a cohesive theoretical framework which dichotomises metacognition into principal components of knowledge and skills. Other models of metacognition are described in chapter 2. The generalisability of the Brown-Flavell model requires further investigation; in particular, it remains to be seen if the results of these observational studies apply to more general problem-solving processes, including non-technical problem solving.

With the goal of developing an intervention to stimulate metacognitive behaviour in engineering students and to determine whether these behaviours could be stimulated during non-technical problem solving, a Situational Judgement Test (SJT) with items tailored to engineering was developed and reconfigured. The definition of engineering used to tailor these items is one situated in engineering practice, in particular drawing on the definition provided by (Trevelyan (2021) that:

"In essence, engineers are people with specialised technical knowledge and foresight, who conceive, plan, and organise the delivery, operation, and sustainment of manmade objects, processes, and systems. These engineered solutions enable people to be more productive: to do more with less effort, time, materials, energy, uncertainty, health risk, and environmental disturbances". p.4

SJT items are traditionally used in candidate selection by Human Resource (HR) professionals (Chan and Schmitt, 2005). The SJT item represents a professional dilemma for the student to navigate by rating the

relative appropriateness of a series of possible solutions to the dilemma. They are made up of an item stem that provides the context of the item - usually a dialogue between two actors – and a set of four potential responses to this dialogue that the candidate may rank or rate in terms of their level of appropriateness (Mcdaniel *et al.*, 2001). The use of an SJT to stimulate metacognitive behaviour, a method that would not rely on the student having any prior knowledge of engineering or mathematics, motivated this research as it had the potential to be applied pedagogically even in the early stages of an engineering student's academic endeavours.

1.2 RESEARCH AIMS

The overall aim of this research is to improve engineering student's career-readiness by providing them with opportunities to exhibit metacognitive behaviour and thus develop metacognitive knowledge and skills. These behaviours play a mediating role in self-regulated learning (Follmer and Sperling, 2016) and include planning a strategy to solve a problem, monitoring one's own performance and being able to evaluate the resulting solution (Sperling *et al.*, 2004). It is imperative that students are equipped with the ability to self-regulate their own learning, particularly in light of COVID 19 restrictions in Ireland limiting face-to-face student-student and student-educator interactions.

This research aims to develop an activity to stimulate metacognitive behaviour in first year engineering students. Many studies regarding engineering students' employability focus on the professional skills that a good engineer should possess (Passow, 2012; Passow and Passow, 2017) while few focus on the metacognitive skills and knowledge required to be a successful engineer. These skills are as much professional skills as the more apparent 'communication', 'teamwork' and 'networking' skills are, however this is not reflected in the literature surrounding professional skills and has not been previously considered as part of a solution to addressing the skills mismatch in the field of engineering. A large-scale study of twelve-thousand students in the USA showed that engineering students' metacognitive skills, and in particular their ability to evaluate the outcome of a learning experience, compare unfavourably to students' in other fields of study (Lichtenstein *et al.*, 2010). Metacognitive knowledge and skills have been linked to success in academic and non-academic endeavours alike (Coutinho, 2007, Pennequin *et al.*, 2010). For instance, metacognitive skills have been linked with student self-efficacy (Coutinho, 2008), an attribute that will be critically important for student's to develop in years to come, given the effect of COVID-19

on students' in third level education across the world. This research aims to deliver a novel means of stimulating metacognitive behaviour in first year engineering students, thus developing student's metacognitive knowledge and skills.

1.3 RESEARCH CONTEXT

Since problem solving is so engrained in the engineering identity (Duffy, 2017) and the use of metacognitive knowledge and skills during the problem solving process leads to more effective problem solving strategies (Kapa, 2001) stimulating the use of metacognitive knowledge and skills has the potential to produce more effective engineers. Many studies focus on the use of technical problems as the source of this stimulation (Kapa, 2001; Pennequin *et al.*, 2010; Gurat and Medula, 2016), while little research has been carried out using non-technical problems as the source of this stimulation. Since these problems do not necessitate a prior knowledge of physics or mathematics for students to engage with them, they represent a new avenue of research into how metacognitive knowledge and skills can be stimulated.

In addition to this, Ireland has been the subject of some scrutiny at a European level regarding its high degree of occupational mismatch. The occupational skill mismatch indicator, which is described as a nation's ability to match job relevant skills to the relevant job is particularly high for engineering professionals and technicians in Ireland (*Prospects for Science and Engineering Professionals*, 2014). Despite three decades of research and interventions into students' professional skills, the skills mismatch for engineering professions in Ireland is not reducing (European Commission, 2016). Little research has looked at the metacognitive components of graduate employability, highlighting a new avenue of exploration for reducing the skill mismatch in Ireland.

The available models of metacognition are presented in chapter 2, in which a literature review is undertaken. There are a number of models of metacognition. Some are complimentary, such as the model proposed by Brown (1978) & Flavell (1976) and Activity theory (Engestrom, Miettinen and Punamaki, 1999), which when placed in tandem describe both the self-regulatory components of metacognition and the means by which individuals interact to develop these skills. In contrast, some models of metacognition are competing, such as the MARSL model (Efklides, 2011) and BASEIS model (Hartman, 2002), which both attempt to explain the role of motivation and affect (emotion) on metacognitive development.

Regarding how to stimulate metacognitive behaviour, the available methods are addressed in chapter 2, where the literature regarding technical problems, SJT's and other such ill-structured are discussed in terms of their utility for stimulating metacognitive behaviour. In previous research, mathematics or physics problems have been used for this purpose (Kapa, 2001; Pennequin *et al.*, 2010; Gurat and Medula, 2016), however there are other forms of problems which do not require any prior knowledge of physics or mathematics which may be useful for stimulating metacognitive behaviour meriting discussion.

Regarding how best to determine if metacognitive skills are being demonstrated, this will be addressed in chapter 2 & 3. A number of articles have emphasised student self-assessment of metacognition (Deming, Valeri-Gold and Idleman, 1994; Schraw and Dennison, 1994; Sperling *et al.*, 2004) the drawbacks and limitations of which are discussed in chapter 2. However, some recent research utilising naturalistic observations of metacognition have shown that metacognitive knowledge and skills can be observed directly as behaviours (Whitebread and Pino-Pasernak, 2013; Mccord and Matusovich, 2019). This new approach provides a more rigorous approach to the study of metacognition compared with self-assessments; respondents claims about their ability are rarely a reflection of their true ability (Kruger and Dunning, 1999; Krueger and Mueller, 2002; Dunning *et al.*, 2003).

1.4 RESEARCH QUESTION & OBJECTIVES

As stated in the research aims, one of the aims of this PhD research was to develop an activity that developed and stimulated engineering students' metacognitive behaviour. In particular, to develop an activity that did not require the student to have any prior knowledge of physics or mathematics. The question, which arose from this aim was "*can a SJT be utilised to stimulate metacognitive behaviour in groups of first year engineering students*".

A key objective of the research was to develop, evaluate and test an SJT as a stimulus for metacognitive behaviour. Chapter 3, along with providing the underpinnings of this research, outlines the methods employed to achieve this objective. Several research sub-objectives arise from this, including the need to:

- Develop an novel SJT with items tailored specifically to engineering professional scenarios.
- Evaluate the SJT with all stakeholders including students, academics and industry professionals.
- Identify the items which best stimulate metacognitive behaviour in engineering students.
- Deliver a learning resource capable of stimulating these behaviour in engineering students.

The first and second objective, to develop and evaluate an SJT, are addressed in chapter 4 where the development and evaluation process are outlined. The third objective, to identify the items of the SJT most suited to stimulating metacognitive behaviour is outlined in chapter 5. The final objective, to deliver a novel learning resource capable of stimulating this behaviour not reliant on prior knowledge of physics or mathematics, is outlined in chapter 5, while chapter 6 provides an in-depth discussion about whether or not these objectives were achieved.

1.5 RATIONALE

The rationale for this PhD research comes from three key areas of research. First, is the existing skills mismatch in Europe; in particular in the engineering sector in Ireland (European Commission, 2016). Ireland ranks 28th out of 28 in Europe on the occupational skill mismatch indicator, which is described as a nation's ability to match these skills to the relevant job. In particular, engineering professionals and technicians were identified as a sector with a high degree of mismatch (*Prospects for Science and Engineering Professionals*, 2014). Persons working outside their field of education are considered as individuals with *horizontal* skills mismatch and the level of mismatch for an occupation is calculated by comparing the skills acquired through education and the skills needed for a particular job (*Skills mismatch experimental indicators*, 2020). This mismatch represents a misalignment between what engineering graduates possess in terms of their training and what employers expect. Much research has pointed to a lack of engineering “professional skills”, such as communication and teamwork, as the cause for this mismatch. However despite three decades of research and interventions into students' professional skills, the skills mismatch for engineering professions in Ireland is not reducing (European Commission, 2016). Little research has looked at the metacognitive components of graduate employability, highlighting a new avenue of exploration for reducing the skills mismatch in Ireland.

Second, many interventions focus on developing professional skills and fail to address what Downing and colleagues would argue is the core objective of student-centred interventions – the development of metacognitive knowledge and skills (Downing *et al.*, 2009). Engineering students’ metacognitive skills, and in particular their ability to evaluate the outcome of a learning experience, compares unfavourably to students’ in other fields of study (Lichtenstein *et al.*, 2010) making it an imperative that engineering academics intervene.

Finally, there is a need for a more direct means of assessment of metacognitive knowledge and skills as many tests of student ability rely on student’s self-reported ability on inventory style assessments. Accordingly, a strong need emerges for a means of making direct observations of this knowledge and skills in engineering students to legitimise claims about the efficacy of interventions.

1.5.1 SKILLS MISMATCH

Higher education in Ireland has been the subject of scrutiny at a European level with regard to some key indicators on the European skills index (*European Skills Index Technical report*, 2018). The skill index concerns all skills, both technical and non-technical, being developed in formal and compulsory education in Europe, with a particular emphasis on lifelong learning skills (CEDEFOP, 2017), while this study emphasises metacognitive knowledge and skills in particular, it is important to note that the skills mismatch is not only defined as “soft” skills, but actually encompasses all skills being developed through formal education. Ireland ranks 28th out of 28 in Europe on the occupational skill mismatch indicator, which is described as a nation’s ability to match these skills to the relevant job. In particular, engineering professionals and technicians were identified as a sector with a high degree of mismatch (*Prospects for Science and Engineering Professionals*, 2014). The engineering sector in Ireland has enjoyed rapid growth over the past decade, with employment levels in science and engineering professions growing by 17% from 2005 to 2015 a figure which is set to continue to grow by another 13% by 2025 (*Researchers & engineers: skills opportunities and challenges*, 2016). With the Irish manufacturing sector continuing to decline and employment in professional services seeing steady incline (CEDEFOP, 2015) the skill requirements of engineering professionals to meet this shift has altered (Schettkat and Yocarini, 2003). The challenge to third level institutions is to either train students in these skills and constantly adjust as the

required skill set changes, or to provide students with the knowledge and skills to self-direct their learning and therefore self-adapt to this changing employment landscape.

1.5.2 ISSUES WITH PREVIOUS INTERVENTIONS TO REDUCE THE MISMATCH

Studies reporting on the efficacy of standalone courses, webinars and seminars attempting to address the skills mismatch in engineering tend to suffer from methodologically flawed approaches to assessment, relying on students self-report to determine their ability in a range of skills (Veety and Carolina, 2014; Schwartz, 2016; Ercan and Khan, 2017; Hezmi *et al.*, 2017; Pastor, González and Rodríguez, 2017; Shahbazi, 2017). Boud (2007) suggests that educational practice needs to deviate from the traditional views of assessment, i.e. those in which assessment is used to confirm the achievement of a particular learning outcome. This reduces students to passive subjects who are assessed only to fulfil an assessment bureaucracy. Boud argues that assessment needs to be re-framed around the use of assessment as a tool for informing judgement. In this tacit model of assessment, the role of assessment is to build students capacity to reliably evaluate evidence, appraise situations and to draw sound conclusions from that evidence. It would be naïve to think that what is being *measured* before or after the above interventions approximates true ability. In reality what is being measured are students' perceptions of their ability. Furthermore, the standalone nature of these interventions and assessments does not facilitate knowledge transfer to other subjects on the premise that such a learning environment does not share a common purpose, goal or idea with the rest of the curriculum (Vygotsky, 1978). These studies also fail to tap in to what Downing regards as the most important outcome of such an intervention, which is the development of students' metacognitive skills (Downing *et al.*, 2009). It is therefore an imperative that:

- Any intervention into students' skills, either professional or self-regulatory, needs to be well integrated into existing curricula
- Reliable and consistent strategies that enable students to learn self-regulatory skills need to be established.

Masui and De Corte (1999) remark that more attention needs to be paid to the development of learning environments where metacognitive and professional activities are combined. There is already a strong

emphasis placed on professional skills development (Sánchez-alejo *et al.*, 2010; González-Morales, Moreno De Antonio and Roda Garcia, 2011; Boyeena and Goteti, 2011; Dravid and Duncan, 2011; Gonzalez *et al.*, 2012; Gider *et al.*, 2012; Kaybiyaynen, 2013; Nylén and Pears, 2013; Abdulwahed *et al.*, 2014; Albayati, 2014; Holzer *et al.*, 2014; Idrus, 2014; Hahn and Sorenson, 2015; Wun and Harun, 2015; Boulais *et al.*, 2015; Alnajjar and Manzione, 2016; Schwartz, 2016; Charité and Muller, 2016; Hezmi *et al.*, 2017; Nelson and Ahn, 2017; Pastor, González and Rodríguez, 2017; Ebentheuer, Kammermann and Herzog, 2017; Panthalookaran, 2018; Quezada-Sarmiento *et al.*, 2018; Rosca, 2018; Andersson and Logofatu, 2018) and on the assessment of these skills in engineering education research and practice (Garcia-Panella and Badia-Corróns, 2010; Mohan *et al.*, 2010; Petkovic *et al.*, 2010; Rusinaru, Popescu and Nistorescu, 2010; Yu *et al.*, 2012; Al-Bahi, Taha and Turkmen, 2013; Schröder *et al.*, 2013; Cukierman and Palmieri, 2014; Kranov, Danaher and Schoepp, 2014; Zhang *et al.*, 2015; Him *et al.*, 2016; Chagas *et al.*, 2017). In particular, an emphasis has been placed on the development of these skills, their utility in the labour market and assessing students' perceived level of mastery of these skills. Despite over a decade of intervention and assessment of student's professional skills (Passow, 2012; Passow and Passow, 2017) the skills mismatch in Europe is not declining. This suggests that despite the importance of professional skills to the employability of engineers, that professional skill development alone is not the answer to reducing the skills mismatch.

The development of professional skills is undoubtedly valuable if one is to be regarded as a successful engineer. But with such a strong emphasis on these components of employability, little attention has been paid to the self-regulatory and behavioural aspects of being an employable engineer. Metacognitive knowledge and skill are the regulatory components of cognition, or the knowledge and skills required to think about ones' own cognitive processes. They have been linked to student self-efficacy, success in STEM and success in academic and non-academic endeavours alike (Coutinho, 2007, 2008; Pennequin *et al.*, 2010).

A growing body of work attempting to address engineering students' career readiness make use of Problem Based Learning (PBL) as a learning environment (Qian, Hall and Duan, 2006;; Mendoza *et al.*, 2008; Johnson *et al.*, 2015; Alnajjar and Manzione, 2016; Friend, 2016; Pastor, González and Rodríguez, 2017; Chassidim, Almog and Mark, 2017; Ercan and Khan, 2017). It is important to understand that 'Problem based learning' does not refer to any particular teaching method (Barrows, 1986) but it can be

leveraged as a means of training students in particular skills. Downing *et al.* (2009) affirm that a well-designed PBL intervention could enable students to develop metacognitive skills by placing students in unfamiliar territory while applying the necessary supports and scaffolding for them to succeed.

Walther and Radcliffe (2007) conducted several focus groups with engineering students who were transitioning from university to industry which sought to gain a holistic picture of what influenced their learning during PBL sessions. The focus groups made use of the critical incident technique to collect data from 68 engineering students who had no more than 4 months of work experience from Germany, Australia, the United States and Thailand. The research adopted a grounded theory approach, whereby the factors which influenced the students' professional formulation emerged from an iterative process of discovering and confirming patterns within the qualitative data. These students identified *group work*, *social interaction* and *meta-influences*, such as who their instructor was as a person, as pivotal to their development. The work of Walther and Radcliff highlights that students view social interaction as pivotal to their professional formulation – speech and dialogue being the mediating factor in their development.

Downing *et al* (2009) points out that few studies focus on how PBL can impact on students' metacognitive development. As mentioned previously, the development of students' metacognitive skills has been linked to student self-efficacy (Coutinho, 2008), success in academic and non-academic endeavours (Coutinho, 2007) and achievement in mathematics and problem solving in STEM related disciplines (Pennequin *et al.*, 2010; Tosun and Senocak, 2013). Walther *et al* (2011) set out to explore what students were learning within PBL environments and what impact it had on engineering students' professional development. Most significantly, Walther and colleagues found that learning was not simply the result of formal, intentional instruction, but rather learning was influenced by many social factors including students' interactions with one another, the extra-curricular activities they took part in, their own dispositions and their interactions and attitudes toward their instructors. This highlights the need for discovery-oriented learning environments over more traditional environments if authentic learning is to occur. This is echoed in Vygotsky's work who argued that for metacognitive skills to be developed and transferred into other domains, a powerful learning environment must be created to facilitate that learning process (Vygotsky, 1978)

Regarding the impact of developing metacognitive skills on STEM specific tasks such as mathematical problem solving, Pennequin *et al.* (2010) found that low achieving students benefitted from training of

specific metacognitive strategies when solving mathematics word problems. These included reading the problem aloud several times, or what Vygotsky (1986) called egocentric speech: making a drawing or a graph, highlighting important information and checking that the result obtained made sense. Additionally, Pennequin found that applying these scaffolding techniques significantly improved the maths performance of the low achieving students in a pre-post test format, while the normal group saw no significant improvement. Coutinho (2008) found strong correlations between metacognition and academic performance in a sample of one hundred and thirty seven university students, although it should be pointed out that the MSLQ and MAI, both self-reported measures, were used to draw these correlations. The findings do suggest however, that students who are both confident in their abilities and who could regulate their mental processes outperformed those without these abilities in university examinations. This further highlights the need for interventions which focus on developing self-regulatory, metacognitive skills in engineering students to better prepare them for the labour market.

1.5.3 TOWARD A MEASUREMENT OF METACOGNITION

If a greater emphasis is to be placed on metacognitive knowledge and skills as essential components of graduate employability, then direct assessments of interventions targeting this knowledge and skills needs to be utilised. The most recurrent assessments of metacognition in the literature are the Metacognitive Awareness Inventory (MAI) (Schraw and Dennison, 1994; Sperling *et al.*, 2004; Akin, Abaci and Cetin, 2007; Tosun and Senocak, 2013), the Learning And Study Strategy Inventory (LASSI) (Weinstein and Palmer, 1990; Deming, Valeri-Gold and Idleman, 1994; Prevatt *et al.*, 2006; Karpicke, Butler and Roediger, 2009) and the Motivated Strategies for Learning Questionnaire (MSLQ) (De Groot and Pintrich, 1999; Pintrich, 2002; Sperling *et al.*, 2004). The limiting factor in all the above assessments of metacognition is their reliance on self-report. Self-reported measures are a very attractive form of assessment in that they return data much more quickly than any qualitative method ever could, the trade off being the loss of the truth of the matter, in the pursuit of the 'certainly' afforded by quantitative data. The metacognitive awareness inventory asks students to evaluate a series of statements about their metacognitive knowledge and skills by responding "yes" or "no" to a series of statements about their ability. The case is much the same for the LASSI and MSLQ. In the MSLQ, respondents are asked to

respond to a series of statements on a 1-7 Likert scale ranging from “*this is not true for me*” to “*this is true for me*” (De Groot and Pintrich, 1999) while on the LASSI respondents are asked a series of statements on a 5 point Likert scale ranging from “*very much like me*” to “*not at all like me*” (Weinstein and Palmer, 1990). The inherent issue with these assessments is the Dunning Kruger effect, in which academically underperforming students will over estimate their abilities on self-assessed measures (Kruger and Dunning, 1999). Undoubtedly aware of the shortcomings of self-assessed measures of metacognition, Whitebread and Pino-Pasernak (2013) developed a coding strategy for observing metacognitive knowledge and skills as behaviours. This was further examined by McCord and Matusovich (2019) who developed the Naturalistic Observations of Metacognition in Engineering (NOME) protocol for the direct assessment of metacognition during interventions aimed at developing such knowledge and skills in engineering students. This novel approach to evaluating the efficacy of interventions targeting metacognitive knowledge and skills presents a new avenue of exploration into metacognition and self-regulated learning that is yearning to be explored in even greater detail.

1.6 PREFER PROJECT

The initial research and development of the SJT was carried out by the author of this PhD as part of the PREFER (Professional Roles and Future Employability of EngineerRs) project, a European commission funded research project under the Erasmus+ funding scheme (Reference: 2014-1-BE02- KA200-000462). As a Knowledge Alliance project, the main purpose was to develop and share knowledge and good practices between academics at TU Dublin, KU Leuven and TU Delft and the industry partners to the project, including ESB, Engineers Ireland, ie-net, Agoria, ENGIE, KIVI and Siemens. The overall aim of the PREFER project was to reduce the skills horizontal skills mismatch in the field of engineering, which was realised through the completion of several work packages. KU Leuven was responsible for leading the development of a model of professional roles for students to better navigate the range of jobs that are available to them after graduation and in TU Delft, the focus was on leading the development of unique curriculum elements to encourage students to consider their strengths and weaknesses in a range of professional skills. The curriculum elements are not discussed in this PhD, however one of the resources developed within this PhD project - the SJT - is informed by the role model developed by KU Leuven and

the skills associated with the model and so further elaboration on the role model will be provided in this section. The key responsibility of the author of this PhD was to develop a resource which allowed students to reflect on their future professional role and on their relative strengths and weaknesses in the skills required to fulfil that role. The aims of the PREFER project and the aims of this PhD research were well aligned. The goal of PREFER was to develop a resource for engineers to reflect on their abilities, while the PhD research sought to develop a metacognitive tool to stimulate the use of metacognitive knowledge and skills, a component of which is reflection. Accordingly, it was suggested by the PhD researcher that an SJT could be developed to serve both the PhD research and the PREFER project.

The PREFER model of professional roles provides a means for engineering students, alumni and academics alike, to navigate the types of jobs which are available to engineers after graduation. The model was developed in collaboration with academics and industry professionals alike to bridge the gap between a students' academic career and their professional one. This was achieved by identifying three professionally relevant roles and a range of professional skills associated with each. A vast amount of literature has explored the skills important for an engineer to succeed in the labour market (Baytiyeh and Naja, 2010; Husain *et al.*, 2010; Warnick, 2011; Han Ahn, Pearce and Kwon, 2012; Ortiz-Marcos *et al.*, 2012; Pons, 2016; Conchado Peiró *et al.*, 2017) but there is a scarcity of research regarding the types of roles that an engineer can fulfil after graduation (Craps *et al.*, 2017). To explore both of the above in detail, the Treacy Wiersema model (Treacy and Wiersema, 1993) was prototyped as the basis of this engineering specific model of professional roles. The Treacy Wiersema model was categorised into three professional roles: *Product leadership*, *operational excellence* and *customer intimacy* - the operational definition of each is provided later. The decision to use this model as the prototype was made based on prior research, utilising structured interviews with industry representatives to decide between two proposed models (Hofland *et al.*, 2015). The Treacy Wiersema model was initially validated in an engineering context by Hofland *et al.* using a cohort of one hundred and twenty-one industry representatives, 91% of which could identify the role model in their own company. A modified DELPHI study was then carried out at TU Dublin, KU Leuven and TU Delft in which twelve expert panels were undertaken with industry representatives. The panels included the industry partners to the PREFER project: ESBI in Ireland, ENGIE in Belgium and Siemens in The Netherlands along with 9 other multinational corporations. Participants were provided with a presentation about the research and introduced to the Treacy Wiersema model, they were then provided with a list of skills drawn from Binder Dijker Otte (BDO) list of professional skills. BDO consulted on the

PREFER project and had expertise in human capital. Their list of skills was developed using Bartram's eight great competences (Bartram, 2005) and included rich descriptions of each skill. The definition for each skill is presented in Appendix A. The PREFER model of three professional engineering roles and the associated skill sets for each of the three roles is presented in figure 1.1 (Craps, Pinxten and Langie, 2019).

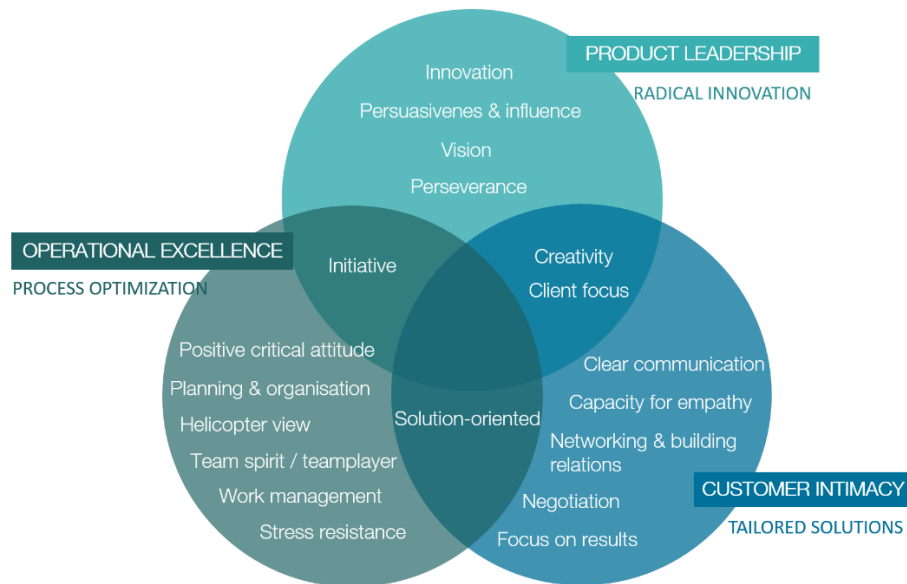


FIGURE 1.1 THE PREFER MODEL OF PROFESSIONAL ROLES

The figure above illustrates the three professional roles. *Product leadership*, which concerns radical innovation, *operational excellence* which concerns optimizing process in terms of cost and time and *customer intimacy* which concerns providing tailored engineering solutions for clients. These skills, associated with each of the three professional roles formed the basis for the development of the SJT items for use in this PhD research.

1.7 SUMMARY

A strong emphasis has been placed on professional skills intervention to address the skills mismatch in engineering by academics across the world over the past three decades, along with the methods of evaluating the efficacy of these interventions. Until now, little has been done to address Downing's

concerns about the dearth of focus on metacognitive skill development in such interventions. This research develops and reconfigures an SJT to make naturalistic observations of engineering students' metacognitive behaviour while working on an SJT in groups. The overall aim of this research is to develop an activity which stimulates metacognitive behaviours in students' and to evaluate the efficacy of that activity using the NOME protocol. These behaviours have been associated with success in STEM related disciplines and more generally with success in academic and non-academic endeavours. This knowledge and set of skills, which can be measured through the observation of student discourse, represent critical behaviours for engineers to be able to demonstrate if they are to succeed in their future careers.

CHAPTER 2: LITERATURE REVIEW

2.1 CHAPTER OUTLINE

Conscious evaluation and control of one's cognitive processes are the result of an under-lying process referred to as metacognition (Brown, 1978). This meta-level control of cognitive process is not essential for all activities, but in the domain of problem-solving and the development of expertise, conscious control of mental functioning is essential to success (Brown, 1977; Brown and DeLoache, 1977). The term metacognition is used interchangeably with the term self-regulation in many accounts, although some regard self-regulation as a sub-component of metacognition (Efklides, 2011). They will be taken as synonyms in the proceeding sections, except where a particular model demands the above distinction. This chapter serves to provide the genealogy and anatomy of metacognitive theory, thereby providing an insight into the theoretical back bone of this research. A metacognitive theory is described as a systematic cognitive framework in which individuals consolidate various cognitive knowledge and regulatory skills (Schraw and Moshman, 1995). Most accounts of metacognition make the distinction between metacognitive knowledge and self-regulatory skills. Metacognitive knowledge on the one hand being defined as knowledge of cognition and self-regulatory skills on the other hand being defined as the ability to regulate one's own cognition. There are additional concepts worthy of attention in each account which will also be discussed. In this chapter, metacognitive theory will be examined by tracing the development of the components which are common to most accounts of metacognitive theory; from their conception to their contemporary use. Following an outline of these components, a number of theoretical models and frameworks of self-regulation will be discussed. Furthermore, this chapter presents the necessary background to the means considered for stimulating metacognitive behaviours, Situational Judgement Test's (SJT's)(CIT) as well as the historical means of stimulating this behaviour – technical problems.

2.2 METACOGNITIVE KNOWLEDGE

Metacognitive knowledge as a facet of a theory of metacognition can be attributed to Flavell (1979). To Flavell, metacognitive knowledge was either knowledge of, or belief about, the factors which may influence the course and outcome of a particular activity. For example, an engineering student might believe, unlike their peers that they should use a particular strategy to solve a particular problem, and so metacognitive knowledge could be categorised as knowledge of both *person*, *strategy* and *task*. Little of Flavell's categories of metacognitive knowledge has been altered in contemporary metacognitive theory, bar providing names to each of three categories. Knowledge of person was named *declarative knowledge* which, in the context of this study, is concerned with a student's knowledge of who they are as a learner and the factors which may influence their understanding (Veenman, Van Hout-Wolters and Afflerbach, 2006). The second and third categories, knowledge of task and knowledge of strategy were named *procedural knowledge* and *conditional knowledge* respectively, the former concerning itself with how a learner might execute a procedural method and the latter concerning itself with how the learner will know how and when to apply a particular method (Kapa, 2001).

2.2.1 KNOWLEDGE OF PERSON (DECLARATIVE KNOWLEDGE)

The person category represents everything an individual comes to believe about their own nature and about other people as instruments of task analysis and performance (Flavell, 1979) . This can be further expanded into inter-individual differences (differences in performance between two or more individuals on a particular task), intra-individual differences (individual differences in performance across multiple tasks) and universals in an individual's ability to perform. For example, a student might believe that they are better at learning in peer-centred environments than in teacher-centred environments, they may also believe that they are better at learning in peer-centred environments than their peers, while believing that universally, all students are better learners in a peer-centred environment. The individual may also believe that they find it difficult to determine if they know something well enough to reach some academic goal, for example, "have I studied thermodynamics enough to answer an exam question on that topic". We will return to this example in section 2.5, on meta-comprehension.

2.2.2 KNOWLEDGE OF TASK (PROCEDURAL KNOWLEDGE)

The task category concerns the information that is available to an individual during a task. The metacognitive knowledge in this category categorises information received about a particular task. This information could be categorised by an individual as being well organised or ill-structured, reliable, or unreliable, detailed or vague and it is these variations that serve as input to determining how performance on a task should be managed. There is an ability inherent in this information in determining what subcategories aid in the effective management of a task and determining the relative difficulty of a task on the basis of these categorisations.

2.2.3 KNOWLEDGE OF STRATEGY (CONDITIONAL KNOWLEDGE)

The strategy category contains a large volume of knowledge in that it takes the knowledge of task and knowledge of person categories as input to form a knowledge of strategy. It concerns what strategies are likely to be effective and ineffective when attempting to perform a particular task. For example, an individual may come to learn that when preparing for a written test, they are more effective at recalling certain information when they write it down and recite it back to themselves. This knowledge of strategy is formulated based on their knowledge of self and knowledge of the task.

2.3 METACOGNITIVE SKILLS

Metacognitive skills are broadly thought of in contemporary literature as:

- *The ability to plan*, which entails selection of the appropriate strategies to complete the task;
- *The ability to monitor* which refers to the learners' awareness of their comprehension and performance;
- *The ability to evaluate* which is a learners' ability to retrospectively analyse their own performance in a particular task and assess the outcome of their learning (Schraw and Moshman, 1995);

- and the ability to *control* which is the ability to pay attention to and modify the three former skills (Biggs, 1987).

Once again, there are nuances to each of these concepts depending on the theoretical perspective being discussed and so a need arises to clarify these concepts before addressing the various models of metacognition.

2.3.1 PLANNING

When asked to create a strategy for completing a task, a learner must identify the relevant information to the task and utilise it to generate new information in such a way that it gets them closer to completing the task (Chinnappan and Lawson, 1996). The process of creating a plan also forces the learner to make optimal use of the information. The tracing of this optimum scenario can result in the consideration of possible alternative solutions to a particular task. The ability to plan ahead and knowledge about the efficacy of that plan are components of what Brown referred to as a “*repository of meta-memorial information*” (Brown, 1977). To better understand the concept of meta-memory, Brown outlines a study in which school children were asked to memorise a phone number, the children were then asked if they would like to dial the number straight away or get a glass of water first. Ninety-five percent of the grade school children dialled the number straight away compared to forty percent of kindergarteners, suggesting an awareness of the pitfalls of waiting before dialling the number on the part of the grade school children while at the same time highlighting a lack of this awareness in younger children. This suggests that meta-memory and planning as a component of self-regulation are developmental, but that is not to say the skill is entirely absent in younger children. Provided the task is sufficiently simple, the skill can be observed in children as young as 3 years old (Wellman, Ritter and Flavell, 1975).

2.3.2 MONITORING

Monitoring and checking the outcome of applying a particular strategy to a problem/task are different from planning as a metacognitive skill paradigmatically as historically, they have been attributed specifically to the process of problem solving rather than being associated with general task performance (Brown, 1977). Brown highlights that children do not adequately check the solutions to problems and have a willingness to live with contradictory

information. This is more prevalent in mathematical problem solving (Holt, 1966) when compared to, for example, finding logical inconsistencies in a passage of a story (Thieman and Brown, 1977). In order to address this issue, the Knowledge Monitoring Assessment (KMA) was developed with the purpose of allowing students to more precisely monitor their prior learning and to distinguish what they know about a problem from what they do not (Tobias, Everson and Laitusis, 1999).

There are conflicting accounts of the definition of monitoring as a metacognitive skill. Accounts of cognitive monitoring which utilise KMA distinguish between *planning*, *evaluation of learning*, *selection of strategies* and *monitoring knowledge* as the core components (Hacker, Dunlosky and Graesser, 2009) and are grounded in the amalgamated model of Brown (1977) and Flavell (1976). Other accounts, which are grounded in the model of self-regulation proposed by Boekaerts (1997), dichotomise cognitive monitoring into *process-monitoring*, *self-testing*, *diagnosing* and *evaluation* (Masui and De Corte, 1999). These models are discussed later in this chapter.

2.3.3 EVALUATING

Evaluation refers to appraising the results of a task performance and may also refer to the evaluation of the quality of the strategy used to perform the task (Schraw and Moshman, 1995). Evaluation as a metacognitive skill did not come from the early work of Brown and Flavell. It was proposed by Schraw and Moshman based on a study by Bereiter and Scardamalia (1987) that tracked the writing proficiency of grade school students longitudinally from grades 7-9. Their findings suggested that students' ability to evaluate and adjust inconsistencies in their writing depended on their chosen writing strategy. They found that good writers use a "knowledge transforming" approach while poor writers used a "knowledge telling" approach – suggesting a link between the ability to plan a task strategy and the ability to evaluate the outcome of the use of that strategy (Bereiter and Scardamalia, 1987).

2.3.4 CONTROL

Control of cognition refers to a conscious ability to change the method employed to plan, monitor or evaluate task performance (Biggs, 1987) and has a number of practical connotations depending on which of the three metacognitive skills it refers to. In action theory, Kuhl (1987) integrates the notion of control of cognition with

control of emotion and motivation. Emotional control refers to generating and fostering positive emotions and reacting in a positive way toward negative feelings, while motivational control refers to strategies employed to preserve initial motivation for completing a task. The conception of cognitive control as a metacognitive skill has been adopted into the contemporary use of a number of models and frameworks of self-regulation (Mccord and Matusovich, 2019), with some models placing greater emphasis on the effect of motivational and emotional control on self-regulation (Boekaerts, 1997; Efklides, 2011).

2.4 METACOGNITIVE EXPERIENCES

At least three of the skills mentioned in section 2.3 were described by Brown (1977) and Flavell (1979). But while Brown referred specifically to *planning* and *monitoring & evaluating* as separable components of metacognition, Flavell discussed these components as dialectic parts of what he termed *metacognitive experience*. Metacognitive experiences are defined as experiences that occur before, during or after performing a task and they can be long or short in length and simple or complex in content (Flavell, 1979). Flavell proposed that these events occurred during conscious thinking, where every step requires careful planning and evaluation. Metacognitive experiences have been somewhat redefined in contemporary literature to include feelings, judgments or estimations of task performance (Koriat, 2000). In particular, an emphasis has been placed on the evaluation of a “feeling of knowing”. In feeling of knowing experiments, participants are asked to rate the likelihood that they will remember a particular item (Schwartz and Metcalfe, 1992). Participants are then asked general knowledge questions to test their memory of that item and the results are correlated. Previous experimental work has shown that there is a strong correlation between a participant’s ability to comment on the state of their knowledge of a particular task and their ability to retrieve information from memory (Metcalf, 1993). Schwartz and Metcalfe (1992) proposed that the cause of this phenomenon was cognitive monitoring of memory, in other words,, the participants knew they could retrieve the correct answer upon request allowing the participant to comment on the state of their knowledge (or ignorance.)

2.5 META-COMPREHENSION

As well as being thought of as a set of discrete knowledge and skills, metacognition can be thought of as an epiphenomenon which stems from a conscious realisation by an individual of their own ignorance. Sieber (1968) referred to this ignorance as *secondary ignorance*, i.e. being unaware of one's own ignorance. Brown (1977), seeking to further this notion, defined meta-comprehension as the ability to ascertain the state of one's own ignorance. A practical example of meta-comprehension can be extracted from teaching practice. Take an engineering student in a classroom scenario being asked to solve a problem relating to thermodynamics. A student raises their hand and says "I don't get it" but is not able to articulate precisely what they do not comprehend. The teacher then seeks to clarify if the student understands the concepts of heat and temperature, arriving at the conclusion that the student had confused the two. In this case, the student did not ask about heat and temperature because the student did not know what they did not understand about the problem.

Meta-comprehension remains an important concept in current research and practice as Krueger and Dunning (1999) suggest that those who suffer from secondary ignorance, or what they refer to as *unskilled* individuals, suffer from a threefold burden. Firstly, those who are unskilled overestimate their own abilities relative to others. Second, they underestimate the abilities of their peers and third, this incompetence robs them of the metacognitive ability to realise the error in their estimations. The skilled individuals are similarly burdened in that those who perform well on tasks often underestimate their own abilities. This psychological phenomenon was coined the *Dunning-Kruger effect* and highlights the fact that individuals make imperfect estimates of themselves and their abilities. The means by which this effect is measured is relatively simple in design. An individual is asked how confident they are in completing a particular task, usually rated on a Likert scale; they are then asked to perform said task which receives a score. The self-assessment and the score are then compared, generally resulting in skilled task performers underestimating their ability and unskilled task performers over estimating their ability (Kruger and Dunning, 1999; Krueger and Mueller, 2002; Dunning *et al.*, 2003).

2.6 MODELS AND FRAMEWORKS OF SELF-REGULATION

As highlighted earlier, at least part of the impetus for studying metacognition can be traced back to the early work of Brown and Flavell on metacognitive knowledge, skills and experiences. However a number of metacognitive models and frameworks have emerged with their own unique focus with regard to self-regulated learning (Schunk

and Greene, 2011), some of which predate the work of Brown and Flavell but nonetheless compliment and support their work. There is debate in education research as to which model is the most accurate reflection of reality (Mccord and Matusovich, 2019) with no clear agreement to date on which aspects of metacognitive theory are most worthy of investigation (Veenman, Van Hout-Wolters and Afflerbach, 2006). This section focusses on models of metacognition and self-regulation, while broader theories of intellectual development lay outside the scope of this research, such as those of Perry (1968), Schommer (1993), King and Kitchener (2010) and Elby and Hammer (2010). In the following section, various models of self-regulation are discussed with respect to those concerned with the cognitive and developmental aspects of metacognition, such as the early work of Vygotsky (1986)¹, Brown (1977) and Flavell (1976) followed by the models that concern themselves with the affective and motivational aspects of metacognition with respect to the work of Boekaerts (1997) and Efklides (2011).

2.6.1 VYGOTSKY & ENGSTRÖM

Vygotsky's work on metacognitive theory focused on how individuals attained mastery of their own cognitive processes. The simple premise for the theory was partly based on Marxian theory. The basis of Marx's work on social structures is in his analysis of the products of labour created within these social structures (Ritzer, 1996). Vygotsky applied Marx's ideas about labour to describe an environment in which learning could be defined as a meaningful activity under which *tools* would be applied to *signs* to generate knowledge, i.e. knowledge is objectivised as a product of pedagogical effort. When Vygotsky refers to signs, he is referring to external stimuli, in particular, symbolic cultural systems. Tools refer to tools of higher mental functioning, which are applied in some cultural system to construct knowledge and understanding about that reality (John-Steiner and Mahn, 1996). There are conflicting views on why Vygotsky used Marx as a basis for his theory. Some recent accounts have suggested that Vygotsky, a Russian psychologist in the 1930's living under an increasingly oppressive and ideological regime was required by the communist party to relate his work to Marxian theory (Aubrey and Riley, 2019). Other accounts suggest that Vygotsky admired Marx's earlier work on defining consciousness as an active constructor of experience that also organised and controlled the individual's behaviour and wished to integrate his ideas into a new theory of

¹ The citation for Vygotsky's early work on metacognitive theory was originally published in Russian, the source used in this thesis is a translation of the original manuscript published by MIT in 1986.

cognitive development (Rohrkemper, 1989). In either case there is no disputing that Marxian theory was a useful basis for Vygotsky to develop his own theory.

Vygotsky wished to set apart cognitive tools from metacognitive tools. To do this, Vygotsky made the distinction between physical tools of labour, which are utilised to create material commodities, from psychological tools of higher mental functioning, which he viewed as self-generated internal stimuli. He posited that these psychological tools are developed semiotically, that is by the use of signs. In particular, he viewed the use of language and various forms of speech as a crucial component for the development of higher mental functioning (Kozulin, 1986). Kozulin points out that speech plays two roles in Vygotsky's theory: first in that it is itself a tool of higher mental functioning that helps organise mental processes and second in that it is one of these mental processes itself. In particular Vygotsky placed a great emphasis on egocentric speech, or talking to one's self out loud, as a constructor of higher mental functioning (Vygotsky, 1986). He viewed this process of egocentric speech as necessary for children to orientate and plan their thought processes. Unlike Piaget (1959), who thought of egocentric speech as a useless accompaniment to a child's activity that vanished as children developed, Vygotsky argued that rather than vanishing entirely from consciousness, that egocentric speech becomes internalised as "inner speech" and retained the same utility in orienting and planning cognitive activities. The research of Levina (1999) further illustrates the importance of speech to the planning of problem solving strategies. In observations of children engaged in problem solving activities, it was observed that egocentric speech was utilised on the most difficult problems the child encountered and highlighted that the use of this mental resource resulted in successful problem solving for the children who used it. Thus, during an attempt to solve a problem, children use egocentric speech to continuously guide and direct their attention, submitting to deliberate control of their cognition.

A second crucial aspect to Vygotsky's theory was the way in which an individual interacted through the use of language to shape and to be shaped by culture and society (Vygotsky, 1978). In particular he emphasised the role of speech in shaping an individual's understanding of the sociocultural environment and how activity in that environment led to the development of higher mental functions. Vygotsky emphasised that language was not only a tool for understanding the social world but a means for individuals to communicate. Interpersonal communication between a More Knowledgeable Other (MKO) and a less knowledgeable individual results in the gradual transfer of higher mental functions. This joint activity is mediated by the use of language, implying that human development is a highly social process. Although Vygotsky did not formalise his theories into a model of self-regulation, his

contemporaries have applied the general features of his theory of development to create a model of how self-regulatory skills are consolidated.

Activity theory is a learning theory that relies on Vygotsky's theory of mediation; that is, that tools and signs are applied to objects to extract meaning and Marx's theory of labour (Engeström, Miettinen and Punamaki, 1999) to generate a theoretical model that posits that social interaction plays a central role in the development of higher mental functions. A generic activity system is presented in Figure 2.1 adapted from Engeström (2011).

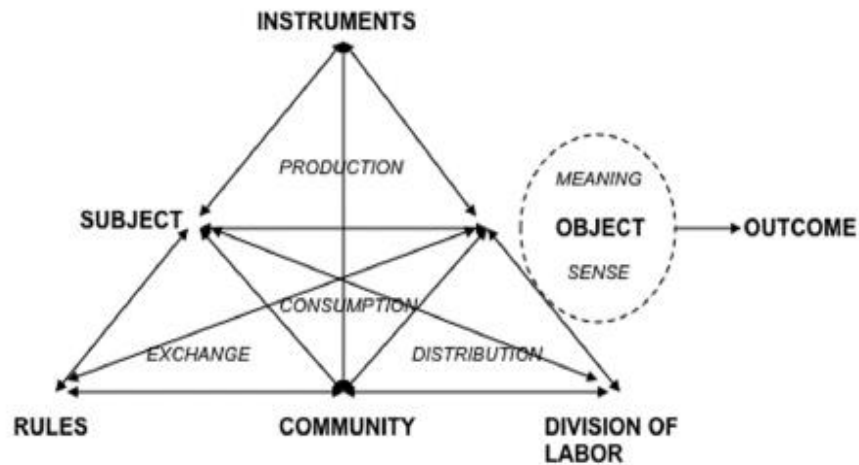


FIGURE 2.1. GENERIC ACTIVITY SYSTEM FROM ENGESTROM (2011)

The primary unit of analysis in Activity Theory is a *joint* activity or practice. In other words, individuals reside in individual activity systems and are defined in terms of the artefacts they have developed within the context of the community and rules that society has built around them. Knowledge is co-constructed by interaction between two or more of these activity systems, mediated by the use of language.

2.6.2 BROWN & FLAVELL

Brown and Flavell placed a great emphasis on metacognitive knowledge and metacognitive skills as the cornerstones of a model of self-regulation (Brown, 1977; Flavell, 1979). As highlighted earlier, the most discussed of these skills are *planning*, *monitoring*, *evaluating* and *control* while discussion about metacognitive knowledge focusses on

knowledge of person, task and strategy., These are referred to as the essence of metacognition in a number of accounts (Biggs, 1987; Schraw and Moshman, 1995; Schraw, 1998). McCord and Matusovich (2019) assembled Brown's and Flavell's components of metacognitive knowledge and skills into a model of self-regulation. Figure 2.2 illustrates the model assembled by McCord and Matusovich (2019).

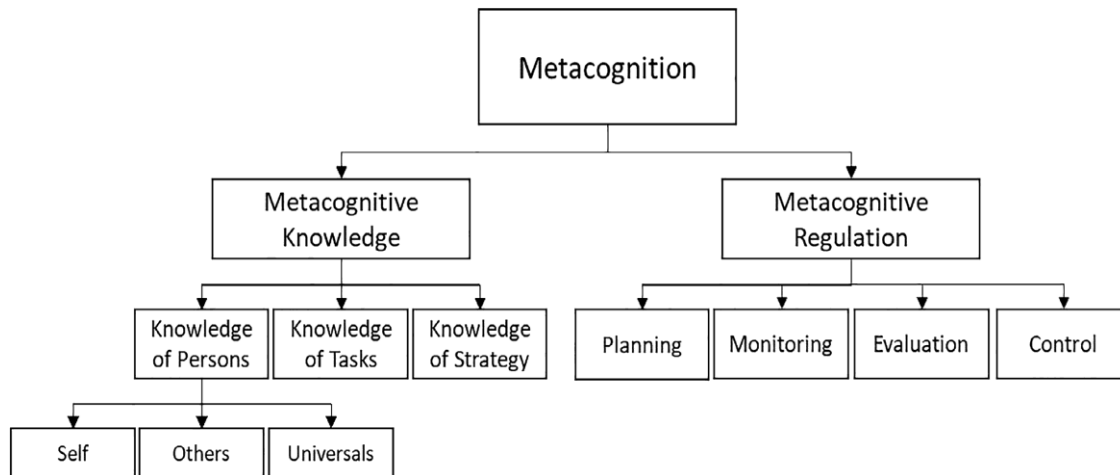


FIGURE 2.2 BROWN-FLAVELL MODEL OF METACOGNITION FROM MCCORD AND MATUSOVICH
(2019)

Based on this theoretical model and on Whitebread's (2013) analysis of self-regulated learning in social and naturalistic contexts, McCord and Matusovich (2019) developed a protocol for the observation of metacognitive behaviours in engineering students. The Naturalistic Observations of Metacognition in Engineering (NOME) protocol utilise the self-regulatory skills and knowledge components of metacognition proposed by Brown and Flavell and associated each of these components with an observable metacognitive behaviour. As part of the development of their protocol, they also identified a number of sub-components within each primary component that further describe the observed behaviour. The first layer of the NOME protocol - the codes - are provided in

table 2.1 for clarity. Each component of metacognitive knowledge and skill is ascribed with a behavioural indicator which are further divided into subcodes and more nuanced behavioural indicators, which are presented in chapter 3.

TABLE 2.1 CODES FROM THE NOME PROTOCOL

Metacognitive regulation	
Behaviour	Description
Planning	Any verbalization or behaviour related to the selection of procedures necessary for performing the task, individually or with others.
Monitoring	...the ongoing on-task assessment of the quality of task performance (of self or others) and the degree to which performance is progressing towards a desired goal.
Evaluation	...viewing task performance and evaluating the quality of performance (by self or others).
Control	...a change in the way a task had been conducted (by self or others) as a result of cognitive monitoring.
Metacognitive knowledge	
Behaviour	Description
Knowledge of persons	A verbalization demonstrating the explicit expression of one's knowledge in relation to cognition or people as cognitive processors
Knowledge of tasks	...one's own long-term memory knowledge in relation to elements of the task
Knowledge of strategies	...one's own knowledge in relation to strategies used or performing a cognitive task, where a strategy is a cognitive or behavioural activity that is used so as to enhance performance or achieve a goal.

2.6.3 THE MASRL MODEL

The Metacognitive and Affective Model of Self-Regulated Learning (MASRL) provides a theoretical framework for understanding the relationship between affect, motivation and metacognition (Efklides, Schwartz and Brown, 2017). For clarity, affect in this context is a generic term used to describe emotions, feelings and attitudes; feelings refer to the experiential aspects of emotion. The MASRL model has two levels, the *person level* and the *task x person level*. The person level contains an individual's self-concept, ability, motivation, affect, metacognitive knowledge, metacognitive skills and control beliefs and this level interacts with the task to create the task x person level. Take the example of a student learning about classical mechanics, that student might have some anxiety about learning classical mechanics. Based on their self-concept of becoming an engineer the student generates a motivational strategy to learn the material. Therefore, the student makes an initial plan to tackle the material based on their previous experiences learning about physics concepts and their knowledge of their own ability, thus self-regulating affect and motivation. This control results in the task x person level of the model, which outlines the process of self-regulated learning from cognition (i.e. learning the material) to self-regulation. The model, adapted from Efklides (2011) is presented in Figure 2.2.

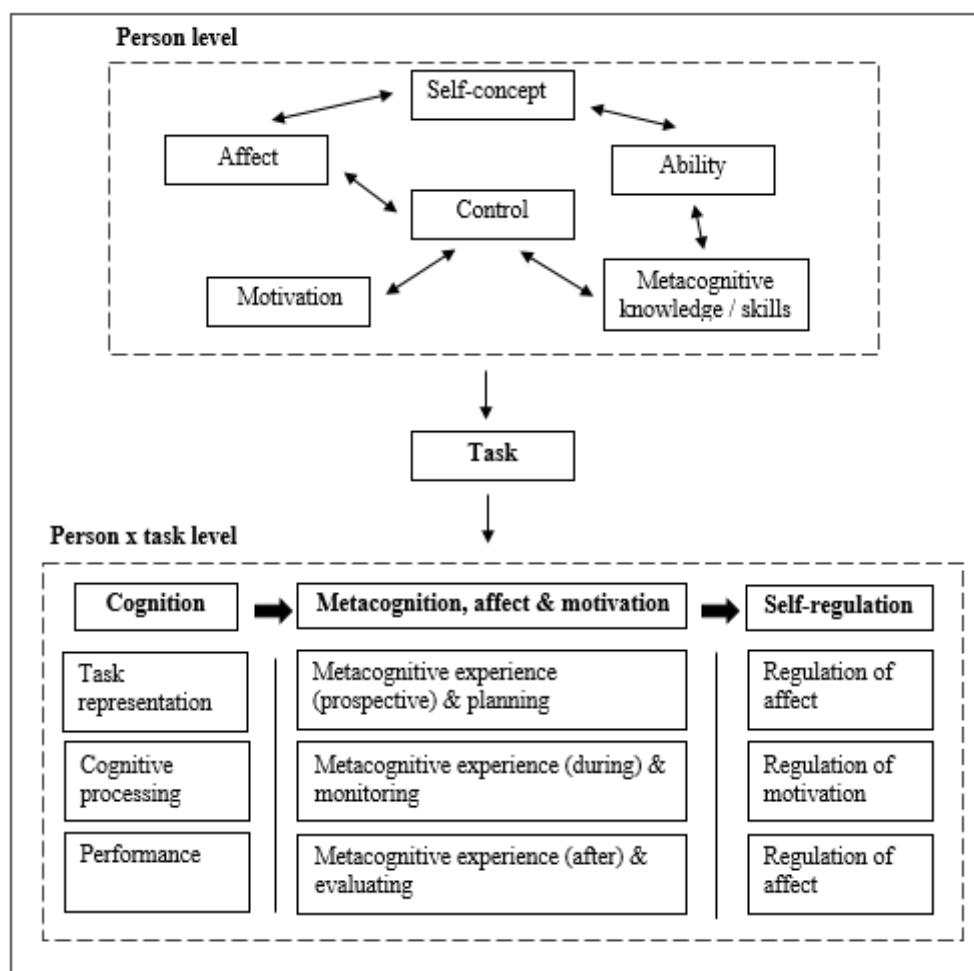


FIGURE 2.3 THE MASRL MODEL OF SELF-REGULATION ADAPTED FROM EFKLIDES (2011)

Efklides remarks that the regulation of affect and motivation is carried out through an affective loop. To put this in perspective, imagine the student who is learning classical mechanics suddenly encountering a concept that they find challenging to understand, the student may become anxious and must create a new affective and motivational strategy in order to complete the task. For example, they may imagine the benefits of being familiar with the material if there was a question on the concept in an examination and the relief they might feel having familiarised themselves with the concept beforehand.

The MASRL model hypothesises a shared phenomenological root between emotion and metacognition, in other words, the MASRL model suggests that both arise to allow an individual to respond to internal conditions or changes in those conditions. It also hypothesises a link between the parts of the brain that are responsible for self-regulation and those responsible for emotion. In particular, emotion and metacognition have been associated with the same areas within the pre-frontal lobes (Maril *et al.*, 2005; Chua, Pergolizzi and Weintraub, 2014). The model leaves a number of questions unanswered, including whether or not an individual keeps track of emotional or metacognitive experiences, or is affect encoded in memory and stored at a subconscious level? Further questions include: Are particular combinations of emotional and metacognitive experiences more pedagogically significant than others? Is the model stable across larger time frames i.e. beyond individual tasks and activities to entire courses? Efklides, Schwartz and Brown, (2017) remark that these questions are yet unanswered and would require large scale longitudinal studies to address.

2.6.4 BOEKAERTS, SCHRAW & HARTMAN

Boekaerts (1997) modelled self-regulated learning as a dichotomous process that involved both metacognitive and motivating factors. The first regulatory components of the model are linked by goals. Cognitive regulatory factors include the ability to mentally represent one's learning goals, to design a plan of action, monitor one's own progress and evaluate the achievement of goals. Motivational regulatory strategies involve mental representation of intentions and linking these intentions to a plan of action and then sticking to a plan of action despite obstacles. The second regulatory components are linked by strategy use. Cognitive strategies entail decoding information, mental rehearsal, elaboration and structuring relevant information and the ability to formulate a procedure for performing a task. Motivational strategies involve the creation of a learning outcome or a learning goal, utilising coping mechanisms to deal with stressors, avoiding procrastination and utilising social resources such as asking peers and instructors for support and guidance. The third regulatory components are linked by domain-specific knowledge. The content domain is composed of the conceptual and procedural knowledge required for a given task, along with any misconceptions about the content area pertaining to the task. The metacognitive knowledge & motivational beliefs are composed of the person's beliefs, attitudes and values related to the task, a strategy utilising those beliefs and beliefs about one's own ability to complete the task.

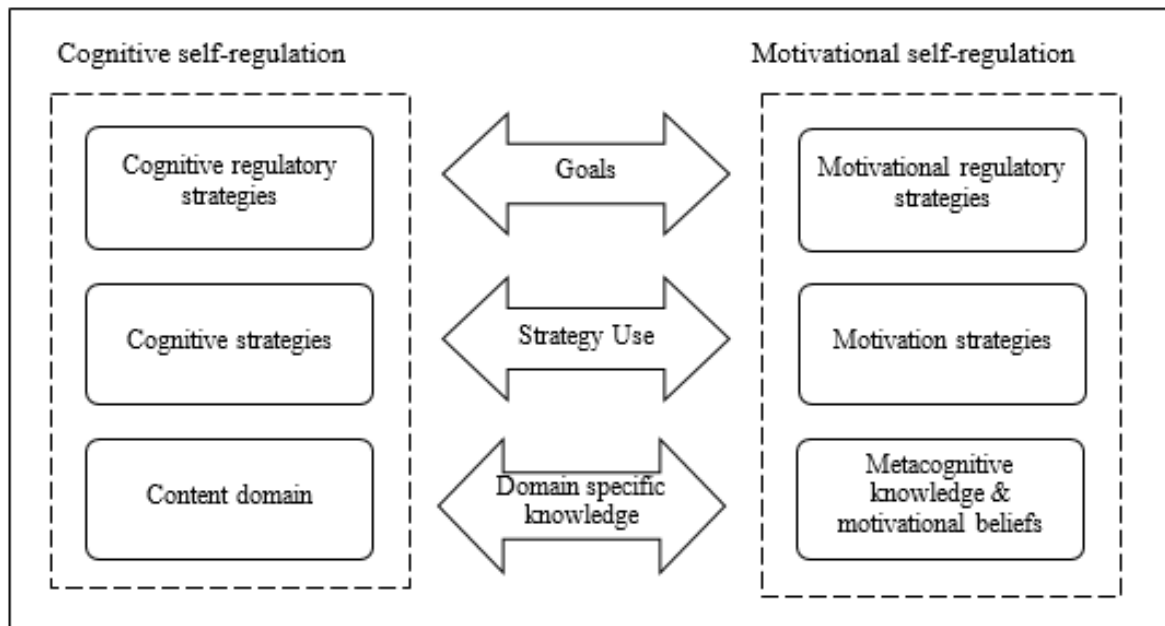


FIGURE 2.4 THE THEORETICAL MODEL OF SELF-REGULATION PROPOSED BY BOEKAERTS

The model was later adapted by Schraw (Schraw, Crippen and Hartley, 2006) which is illustrated in figure 2.5. Schraw's model separated the cognitive and metacognitive factors into distinct elements on the basis that cognitive skills are those required to perform a task while metacognitive skills are those necessary to understand how a task is performed. (Schraw, 1998).

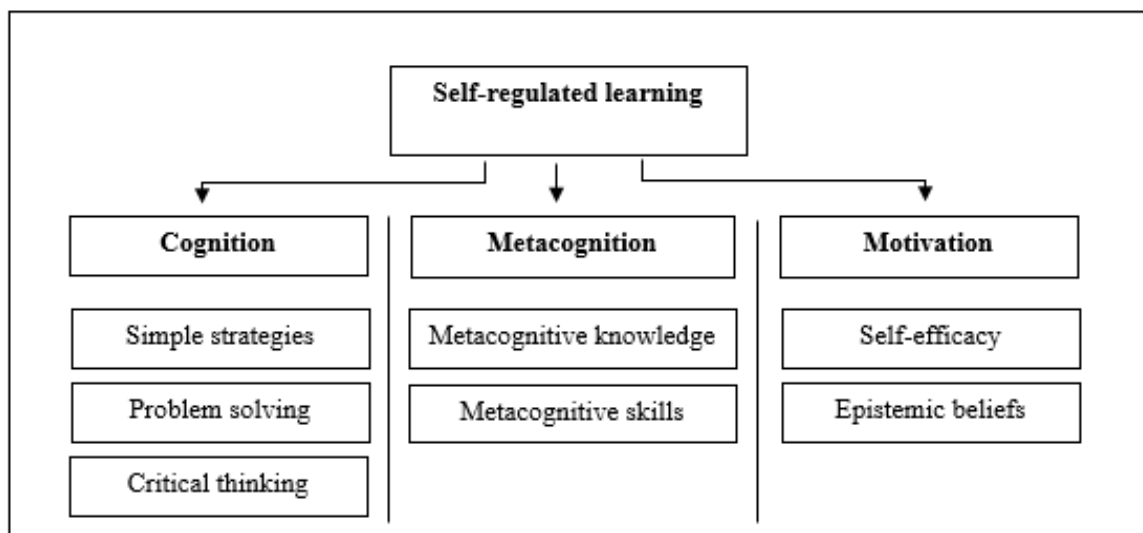


FIGURE 2.5 THE THEORETICAL MODEL OF SELF-REGULATION PROPOSED BY SCHRAW ET AL

Schraw went on to endorse the work of Hartman and Sternberg on the BACEIS model (Behaviour, Affect, Cognition, Environment, Interacting, Systems), working on a book together about metacognitive strategy development (Hartman, 2002). The resulting model, presented in figure 2.6, encompassed Schraws model of cognitive, metacognitive and affective factors, but also extended to encompass the consequences of these systems for human behaviour and the external system in which those behaviours were observed.

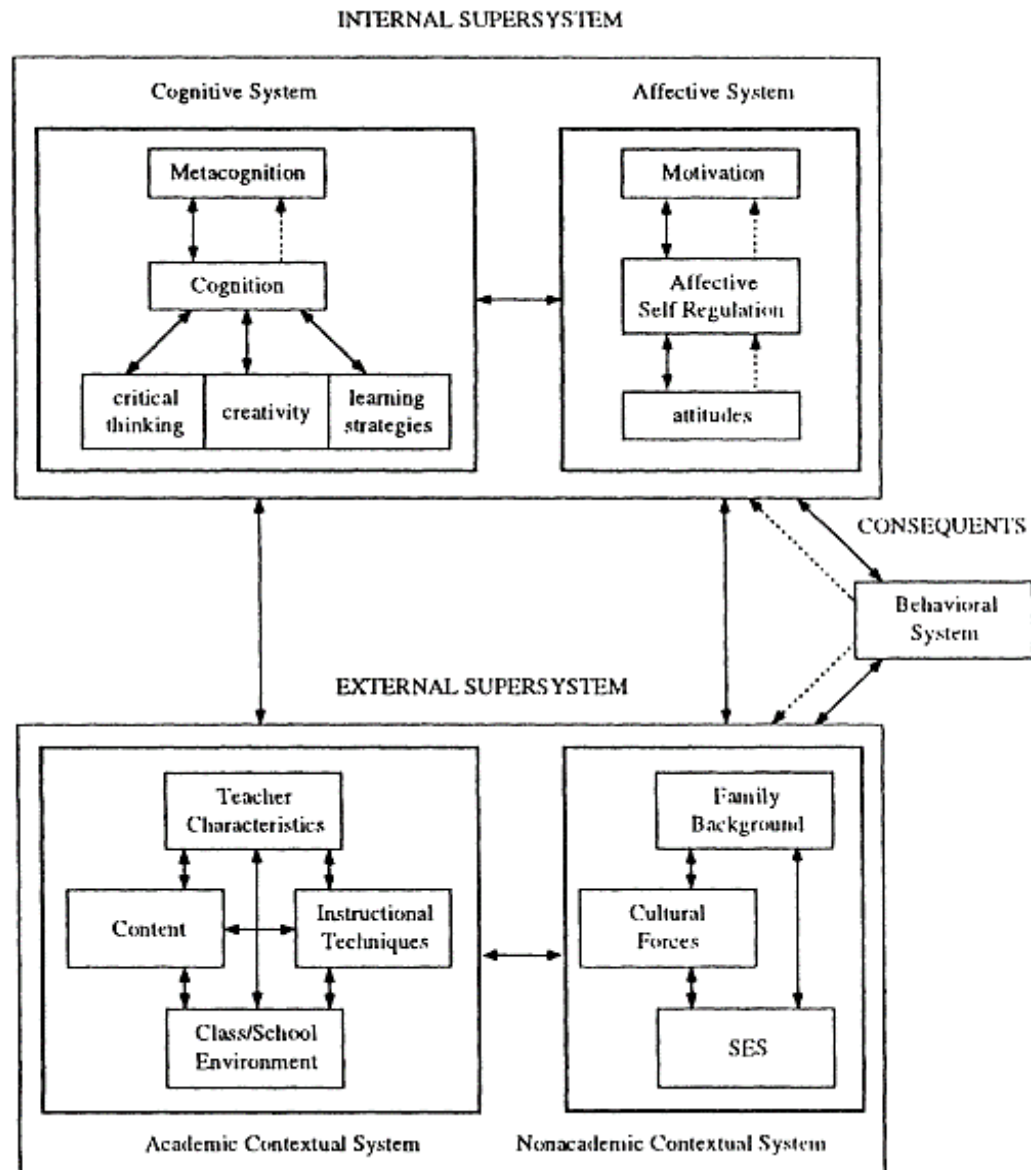


FIGURE 2.6 THE BACEIS MODEL TAKEN FROM HARTMAN (2002)

The model is reminiscent of Vygotsky's principals of tools and signs, with the internal system of cognitive and affective factors representing the available tools of knowledge construction and the external, contextual system comprised of family, teacher, classroom environment and culture representing various signs, which represent the material onto which tools can be applied. The product of this pedagogical labour in Hartman's view is a conscious change in behaviour.

2.7 METACOGNITION AND PERFORMANCE

Academic performance and metacognitive skills are linked (Masui and De Corte, 1999). The relationship between metacognitive knowledge & skills and academic performance is well documented in a number of STEM disciplines at second level. The development of students' metacognitive skills has been related to self-efficacy (Coutinho, 2008), success in academic and non-academic endeavours (Coutinho, 2007) and achievement in mathematics and problem solving (Pennequin *et al.*, 2010).

Otero, Campanario and Hopkins (1992) conducted a study with four hundred and one students from the 9th to the 12th grade, measuring students' ability to monitor their comprehension utilising the Cognitive Monitoring Assessment (CMA). The CMA is a series of sentences with logical inconsistencies throughout. Students are asked to read these sentences allowed and identify these inconsistencies while the instructor makes observations and applied a rubric to determine a score. The study took place across five different schools, examining the correlation between CMA scores and Physics grades, a correlation ranging from .158 in school B to .515 in school D was observed. Similarly for mathematics grades, a correlation of .342 was observed in school B compared to a correlation of .508 in school A. This analysis split the sample into significantly smaller groups than the original sample of four hundred and one students, a larger study would be required to draw generalizable conclusions from the study, however it does present evidence that there is a significant but low magnitude correlation between metacognitive skills and mathematics and physics grades.

In a study of forty eight French elementary school children, using an experimental and control group that identified both low and normal achievers in mathematics, a pre and post-test was carried out following five one hour interventions on the experimental group spanning a seven week period. The interventions ranged from training students to skim read, slow their reading down, activating prior knowledge and draw diagrams during the problem-

solving process. The results of the study indicate that the mean problem solving ability of the control group for both low and normal achievers showed no statistically significant change, while students in the experimental group showed significant improvement in their problem solving abilities. Most notably, students in the experimental group who were considered low achievers showed larger gain scores in the post test than students who were considered normal achievers (Pennequin *et al.*, 2010).

An overview of two other studies of Dutch students examining the relationship between metacognitive skills and mathematical ability was provided by Desoete et al. (2001). In the first study, eighty students in grade three used an instrument composed of the Metacognitive Attribution Assessment (MAA) and the Metacognitive Skills & Knowledge Assessment (MSA) to assess their perceived metacognitive awareness. This was combined with the Kortrijk Arithmetic Test (KRT) which was used to divide the group into below average, average and above average mathematical performers. Through principal component analysis, a strong positive correlation ($r = .67$) was observed between students' metacognitive awareness and their mathematical ability. Specifically, the correlation was observed on three components of metacognition, *global metacognition*, *offline metacognition* and *attribution to effort*. In particular it showed that students who were above average performers had significantly higher mean scores in all three components when compared with average and below average mathematical performers. In the second study, fifty nine grade three students with specific mathematical learning disabilities were provided with three mathematics tests, the KRT, a word problem test (VT) and the Arithmetic number factor test (TTR) along with the MAA and MSA. Three groups were identified: severe, moderate and no mathematical learning disabilities. Once again, strong positive correlation was observed between students' metacognitive awareness and their mathematical ability associated with *global metacognition*, *offline metacognition* and *attribution to effort*.

There is a scarcity of research regarding the relationship between metacognitive skills and the performance of students in STEM disciplines, higher education programmes. Frederick (2005) reported on a study of three thousand five hundred university students' in the USA who took the Cognitive Reflection Test (CRT), a 3 problem (later extended to 8 problems) test that measured the tendency of an individual to override their *system 1* thinking, (which is an automatic and impulsive response) and instead utilise *system 2* thinking, (which requires reflection on the problem) (Tay, Ryan and Ryan, 2016). The study found significant correlations between the CRT and SAT scores $r = .44$, SAT mathematics scores $r = .46$ and the American College Test (ACT) scores $r = .43$. Although the CRT has shown strong correlations with other cognitive ability measures, it can only implicate factors related to reflective

thinking and does not address the metacognitive knowledge and other regulatory skills such as planning, monitoring and control.

A study of seventy undergraduate chemistry students in Turkey who took part in a 10 week problem based learning (PBL) course were administered the Metacognitive Awareness Inventory (MAI) pre and post intervention (Tosun and Senocak, 2013). The MAI is based on the amalgamated model of Brown (1978) and Flavell (1976). It asks a series of “yes” or “no” questions, each aligning to a particular component of metacognitive knowledge or skill. For example, a question aligned to the *planning* subscale of the inventory reads “I ask myself questions about the material before I begin”. Yes responses are assigned a score of one, no responses are assigned a score of zero and the respondent sums their score for each subscale to arrive at a final score for each component of metacognitive knowledge and skill. In the first use of the MAI, Schraw discovered a correlation between performance on the MAI and performance on a reading comprehension test (Schraw and Dennison, 1994). The participants entered the PBL course through two streams, the SSSTEP which contained students with strong scientific backgrounds and the PSCSTEP, containing students who had weak science backgrounds. The results indicate that students from PSCSTEP showed significant increases in their perceived metacognitive abilities after the course, however no such effect was observed on SSSTEP students.

A criticism of the use of the MAI in such a context, or any self-reported measure of metacognition for that matter, is that it is not an absolute measurement of metacognition and relies on students self-reporting. It is a well understood phenomenon that students with poor metacognitive skills give themselves higher scores when asked to self-report on abilities when compared to students with strong metacognitive skills. As mentioned previously, this effect was coined the *Dunning-Kruger effect* (Krueger and Mueller, 2002). The MAI then, is useful for identifying extremes in abilities and comparing those scores to actual task performance, but not as a standalone measurement of metacognitive awareness.

The canonical instruments for the assessment of metacognition have been discussed at some length in this section. As indicated earlier, the limitations of these instruments are in their reliance on self-evaluation of abilities, with the Metacognitive Awareness Inventory (MAI), one of the most highly cited inventory style assessments of metacognition (Schraw and Dennison, 1994; Sperling *et al.*, 2004; Akin, Abaci and Cetin, 2007; Tosun and Senocak, 2013) failing to show a consistent factors structure in a recent systematic review (Craig *et al.*, 2020).

2.8 Stimulating metacognitive behaviour

Blakey (1990) suggests that the most appropriate environment for metacognitive skills to develop are environments in which students are actively involved in the problem solving process and are encouraged to think about the process of problem solving and the goals of that process. Drigenberg and Purzer (2018) highlight the necessity for engineering students to work on *ill-structured* problems to better prepare engineering students for the workplace. Real world problems are rarely well defined and are therefore distinct from the traditional classroom problems that students tend to encounter. Drigenberg and Purzer (2018) provide us with an operational definition of what constitutes an ill-structured problem.

- Ill structured problems are not presented to the student with all the necessary information to solve the problem, requiring the student to gather that information and frame the question.
- Ill structured problems do not have a well-defined method for finding a solution, leaving the decision on how best to proceed in the hands of the problem solver.
- Ill structured problems do not have a single solution, instead there are optimal solutions and sub-optimal solutions based on the assumptions made by the problem solver.
- Ill structured problems cannot be solved with certainty, instead the problem solver must justify the assumptions made to solve the problem.

Ill structured technical problems have been the subject of inquiry in a limited number of studies on grade five and on undergraduate chemistry students for their utility in stimulating metacognitive behaviour (Jacobse and Harskamp, 2012; Tosun and Senocak, 2013). In a previously mentioned study, Tosun and Senocak, (2013) utilised chemistry problems to illicit metacognitive behaviour in students by introducing a series of questions that promoted the use of metacognitive skills during the problem solving process. Six scenarios were developed around topics in an undergraduate chemistry module and provided to seventy students, some with a science background (SSSTEP) and some without (PSCTEP). Students were asked a series of questions such as: *What should we learn to find a solution to the problem? Which resources help us find the necessary information? What are our hypotheses?* The MAI was administered before and after the intervention to both groups of students who took part. The results indicated that SSSTEP students experienced no change in their metacognitive awareness following the intervention, which PSCTEP experienced significant, positive changes in their awareness. The results indicate that the introduction of a scaffolding for the use of metacognitive knowledge and skills was generally effective, provided the student had no scientific background but was ineffective when working with students who did have a science background. In the

study by Jacobse and Harskamp, (2012) forty-two middle school students were provided with mathematics word problems, asked to solve the problem aloud and answer the MSLQ afterward. Applying two methods of interpreting their spoken solutions to the problems - the *think aloud* protocol and the Visualisation and Accuracy (VisA) instrument - the results of the study showed strong, significant correlations between strategy identification and scores on the test items ($r = .57$ & $.48$ respectively), while the results showed poor correlation between the MSLQ and the scores on the test items ($r = .03$). Both of the above studies further highlight the limitations of assessing metacognition using self-reported measures. The study by Tosun and Senocak (2013) highlights that technical problems may not always be an appropriate means of metacognitive stimulation for students already exposed to scientific subjects, while the study by Jacobse and Harskamp, (2012) shows that metacognition can be assessed through the analysis of speech.

In the next sections, a source of ill structured problems that do not require any prior knowledge of physics or mathematics is outlined, problems which may be suitable for stimulating metacognitive behaviour by the observational methods, in particular the observation of students' dialogue as they reason their way through the dilemmas presented in the SJT items.

2.9 SITUATIONAL JUDGEMENT TESTING

The items of an SJT are composed of two principal components (McDaniel and Nguyen, 2001). The first component is called the *item stem*, this is usually set in a professional work environment and involves a conversation between two or more actors. The contexts present a dilemma which is outlined in dialogue by one of the actors. The second component of an SJT item are the potential *item responses* that the second actor can provide to the first actor who presented the problem statement to attempt to address the issue. An example of an SJT item is provided in figure 2.7.

Competency	INITIATIVE	
Case:	<p>Samir is a recently graduated engineer, who works for ‘E-Load’, a company that produces batteries. Samir has been invited to attend a meeting with some of the senior engineers to discuss an ongoing project aimed at redesigning the facility to increase the rate of production by 2%. Although Samir is young and inexperienced, Nathan, one of the project leaders on the project thought Samir would be a good fit for the project. Therefore, Nathan asked him to informally attend a meeting to see if he is interested.</p> <p>They started the project a couple of weeks ago and implemented a new procedure with more sensitive sensors. Before the procedure, the production error was 0.5 percent of the produced batteries. Now, after the implementation, the objective to produce 2% more batteries was achieved, but the percentage of defect batteries has increased to 1.2%.</p> <p>During the meeting Nathan says: <i>“We really need to reduce the percentage of defect batteries, and keep the production rate high. I’m not sure if we will be able to respect the initial planning with the resources we have so I’d welcome all additional support we can get.”</i> Nathan looks at Samir.</p> <p>Samir responds:</p>	
	Instruction: Please rate the appropriateness of each of the following responses:	
	Response 1	<p>“I am a bit hesitant to take too big a stake in the project because I’m a junior and this role is too much of a stretch for me. I think it’s better to divide it among yourselves.”</p> <p>Rather inappropriate</p>
	Response 2:	<p>“I would like to assist you with this project. But as I am a junior engineer, I will need some additional coaching from the senior team members. Under that condition, I’m sure I can provide a meaningful contribution.”</p> <p>Appropriate</p>
	Response 3:	<p>“Maybe I can help to reduce the workload. I will complete any tasks you assign to me. So, if you think I can do this, I want to try it.”</p> <p>Neutral</p>
	Response 4:	<p>“Well, if I was part of this project group I would like to help, but I was just invited for the first time so I don’t feel I’m in a position to make a strong commitment.”</p> <p>Inappropriate</p>

FIGURE 2.7 SAMPLE SJT ITEM ILLUSTRATING THE ITEM STEM AND ITEM RESPONSES

The practice of including SJT’s in the candidate selection process, particularly in job interviews, has become increasingly popular in recent years (Chan and Schmitt, 2005). This section presents the taxonomy of a SJT item, the ways in which SJTs can be developed, how SJTs are scored and how success in SJTs relate to job performance. SJT’s have been used in psychological assessment for almost a century, with the first documented SJT appearing in

the George Washington University Social Intelligence Test (Hunt, 1928). The first section of the test was entitled *Judgement in Social Situations* which contained a number of social situations that presented problems, each followed by four possible solutions to that problem (Hunt, 1928).

Motowidlo, Dunnette & Carter (1990) discussed the use of what they called a *low fidelity simulation* of behaviours for predicting job success. They took an inductive approach to SJT development by using the critical incident technique (Flanagan, 1954) to collect lived experiences from managers in seven companies around the topics of problem solving, interpersonal skills and communication skills resulting in the development of a 58 situation test and a 30 situation test. Then, they asked 150 managers to write a few short sentences about how they would react to those situations and these formed the 4 possible responses to each of the situations on the test. Forty-two managers were then asked to select the relative appropriateness of each response before the pilot study took place. When using the critical incident technique, the length of the incidents usually needs to be shortened and certain incidents need to be excluded. For example, if a situation is deemed too specific - detailing confidential information about a client or the company - or if the situation is in some way profane or inappropriate for forming, it may be excluded. The same is also true when collecting item responses (McDaniel and Nguyen, 2001). In some instances of SJT development, the authors adopt a deductive approach and employ a method of job analysis (Peterson and Jeanneret, 2007) to frame the critical incidents which are collected around specific skill areas. Job analyses typically involve the identification of all of the available jobs within a particular discipline and categorise those jobs based on pre-defined criteria. Previous meta-analyses have found that a job analysis is a good moderator of incremental validity, with SJT's developed using a job analysis having higher validity (.38) than those developed without (.29) (McDaniel *et al.*, 2001).

There is substantial variation in how SJTs instruct the participant to select responses. Some tests ask the participant to indicate the task they *would* most like to perform while others ask the participant to identify the task they *should* perform. The former question is referred to as a behavioural tendency instruction while the latter is a knowledge instruction (Lievens, Sackett and Buyse, 2009). Sackett and Buyse (2009) found no meaningful difference between either type of instruction when they tested 2,184 prospective medical students during their entrance examinations, with 1086 students receiving one set of instructions and 1098 receiving another set of instructions to answer the same SJT. This is likely because regardless of the instruction, people will almost always answer with how they *should* perform. However there are still some important considerations when mitigating against test faking. Asking the participant for only a single most preferred response can result in faking, particularly in high stakes scenarios,

and guessing or failure to engage thoughtfully with the test. A number of strategies have been developed to address this, one of which is to ask the participant to identify a best and worst response, forcing the respondent to reflect on why a response is appropriate or inappropriate rather than simply selecting the optimal response (McDaniel and Nguyen, 2001). This of course introduces ipsativity (Hicks, 1970) to the test, in that a ranking is introduced to the responses. This can lead to issues with reliability analysis as the data collected are far less *granular* i.e a four-response SJT item scored Ipsatively has a theoretical maximum score of 4. A more favourable method of *rating* responses or normative rating, can be employed instead and allows a more granular score to be attached to each item rating and so a four-response SJT item scored normatively on a 5 point Likert scale produces far more variation in score than an ipsatively scored item. This is a general issue faced in all Multiple Choice Question (MCQ) testing, but the use of normative scoring has particular significance to the scoring of SJT's as it allows more nuanced data to be collected from subject matter experts, who's responses may shape the scoring key of particular test items.

A recent study by Cucina et al (2012) compared the use of empirical, rational and hybrid scoring methods for scoring data at various sample sizes. In the context of an SJT, the empirical approach involves the collection of scores from subject matter experts and using their responses as the desired responses to the test. The rational approach involves the researcher using their own best judgement to decide on the most/least appropriate responses and basing the scoring key around that. The hybrid approach takes a rational scoring key and modifies the key based on feedback from subject matter experts, usually by weighting the scores of certain desirable or undesirable responses based on their input. The results indicate that the rational method resulted in the lowest criterion related validities when compared to scoring the same items with both the empirical and hybrid keys, however the rational approach has advantages in that it is more generalizable than an empirical key (Hough and Paullin, 1994).

Patterson (2012) carried out a systematic review of the use of SJTs in the evaluation of a number of non-cognitive factors including empathy, integrity and resilience. The review found that SJTs compared favourably with IQ tests and personality tests in predicting job success and represented a cost-effective means of candidate selection when compared with direct observation through structured interview. In the assessment of candidates' interpersonal skills Lievens (2013, p.182) found "significant added value" in using SJTs over cognitive tests alone in predicting interpersonal skills. Motowidlo, Dunnette & Carter (1990) found poor correlation between test scores and the GPA of participants but significant correlation with interpersonal skills $r = .21$ and negotiation $r = .50$ which were evaluated in interviews with test participants. An SJT developed by O'Connell et al. (2007) shared variance with cognitive ability $r = .33$, conscientiousness $r = .33$ and agreeableness $r = .31$ which are established predictors of job

success and the results are in good agreement with previous findings (Chan and Schmitt, 1997; Clevenger *et al.*, 2001; Whetzel, Mcdaniel and Nguyen, 2008). The above literature seems to suggest that while SJTs are not predictors of academic success they are reliable predictors of ones' job performance.

In addition to Lievens (2013) findings discussed above, the study also found that female candidates significantly outperformed males on the SJT with an effect size of $d = -.26$. Whetzel, Mcdaniel & Nguyen (2008) reported similar gender differences favouring females with small $d = -.10$ effect size. In addition, both O'Connell and Whetzel, Mcdaniel & Nguyen found significant differences in scores based on ethnicity, with substantial black-white mean differences of .38 favouring whites being reported in both papers. If SJT's are to be used in candidate selection, it is important to control for this variation in response pattern (male female and black-white) to mitigate against hiring bias based on SJT scores. One solution to controlling for this variation is to establish norm groups when implementing an SJT such that scores are controlled for age and level of experience and adjusted based on gender and ethnicity so as not to advantage one sub-group or another. One approach to making such adjustments is to control for *elevation* and *scatter*. Elevation is the mean score on the items for a given respondent and scatter is the magnitude of the deviations from this mean. The result of adjusting for elevation and scatter is that extremes in responses are suppressed (Mcdaniel *et al.*, 2011). Non-white individuals are known to provide more extreme Likert scale ratings than their white counterparts (Bachman, O'Malley and Freedman-Doan, 2010) and so suppressing extremes in ratings on an SJT is useful as it results in a more inclusive test (and hiring practice, if the test is to be used for this purpose).

Little research has taken place exposing the relationship between SJT items and metacognition. One recent study, utilising four hundred practicing engineers, compared SJT scores to scores on the Cultral Intelligence Scale (CIS), a self assessment which contains both cognitive, metaocognitive, motivational and behavioural subscales (Jesiek *et al.*, 2020). The study found modest, negative correlations ($r = -.23$) between SJT scores and self assessed scores of metaocgnition. At an item level, SJT items are typically "construct heterogeneous" and may measure multiple constructs (Patterson *et al.*, 2012). It is worth highlighting that the authors of the above paper correlated the scores of twenty-six SJT items with scores on the CIS without addressing the inter-item correlations of the SJT, furthermore their use of self-assessed measures to evaluate metacognition suffers from the same drawbacks as all self-assessed measures in that competent participants will underestimate their metacognitive faculties while incompetence participants will over estimate these faculties (Krueger and Mueller, 2002).

2.10 CHAPTER SUMMARY

This chapter highlights both the depth and breadth of metacognitive theory, signposting pertinent concepts and highlighting pertinent models and frameworks that have been adapted to specific research objectives. The work of Vygotsky and later of Engeström, which focussed on the role of metacognition for cognitive development illustrates the mechanism by which individuals interact with one another and with their cultural artefacts to construct an understanding of the world. Brown (1977) and Flavell (1976) focussed specifically on the knowledge and regulatory skills that constitute metacognitive regulation and the later work of McCord and Matusovich (2019) provide a framework for the observation of metacognition in naturalistic environments. The MARSL model, provides an integrated model of how control of cognition extends beyond the cognitive domain and extends to the affective and motivational domains as well. The work of Boekaerts (1997) and Schraw (1994) focused on the cognitive, metacognitive and motivational aspects of self-regulation, which when integrated with the work of Hartman (2002) highlights the dialectic relationship between the individual's metacognitive knowledge, skills and motivation and the context in which that individual operates to control their actions. Further study of metacognition is paramount given the implication in this literature review that metacognition and academic performance are intrinsically linked and the recent revelation that engineering students metacognitive skills compare unfavourably to students in other disciplines (Lichtenstein *et al.*, 2010).

The SJT was considered as a possible instrument for intervening in the development of students' metacognitive knowledge and skills. Previous research comparing SJT scores and scores on a subscale of metacognition led to misleading findings about their efficacy due to a failure to acknowledge the nature of the constructs within the SJT itself and the limitations of self-reported measures of metacognition. SJT's are a source of ill-structured problems that do not require a prior knowledge of physics or mathematics for students to engage with them - a characteristic which until now has not been given due attention in the literature regarding SJT's or in the literature surrounding the use of ill-structured problems for stimulating metacognitive behaviour. Among the axiological and epistemological considerations of the research design, the proceeding chapter outlines how the SJT was developed, evaluated and reconfigured as a means of developing student's metacognitive skills.

CHAPTER 3: RESEARCH DESIGN

3.1 CHAPTER OUTLINE

The research design chapter begins with an outline of the axiological and epistemological considerations that form the basis for the design of this research. Once these orienting concepts have been explored, the most appropriate methodological approach suitable for answering the research question will be identified. From there, the setting in which the research takes place and the available instruments for answering the research question will be discussed and compared. Finally, the methods employed to answer the research questions and objectives and the methods of data analysis are explained, along with the ethical considerations for the research and its design

As previously stated, one of the aims of this PhD research was to develop an activity that developed and stimulated engineering students' metacognitive behaviour. In particular, to develop an activity that did not require the student to have any prior knowledge of physics or mathematics. The question, which arose from this aim was "*can a SJT be utilised to stimulate metacognitive behaviour in groups of first year engineering students*".

A key objective of the research was to develop, evaluate and test an SJT as a stimulus for metacognitive behaviour. Chapter 3, along with providing the axiological and epistemological underpinnings of this research, outlines the methods employed to achieve this objective.

3.2 AXIOLOGICAL POSITION

Axiologically, this research positions itself within the interpretivist paradigm and places a greater value on qualitative data than on quantitative data. This research attempts to evaluate metacognition through the observation of behaviours, in contrast to the canonical instruments of self-assessed measures of metacognition, which are interpreted through the application of statistical methods. This requires the researcher to consider the quality of the

phenomenon of metacognition, as opposed to its quantity, relying on students discourse as the source of data rather than the quantitative data generated from inventory style assessments of metacognition.

Studies in the social sciences are historically positivist in their approach to understanding social reality (Turner, 1988). But since the 1940's, a number of research methodologies which place greater emphasis on human experience have emerged, many of which are still finding their way into the field of engineering education research (Case and Light, 2011). These methodologies evolved from a paradigm shift towards an interpretivist ontological view of reality, that is to say that knowledge does not exist independently of human understanding; or ignorance. One of the earliest intimations of this shift occurred in the early 20th century, at a critique in the Chicago school of social sciences of a piece of research by Florian Znaniecki entitled *The Polish Peasant in Europe and America*. The primary concern of those in attendance was that the validity of human experience data could be thrown into question without the use of statistical methods - they were concerned that without statistics, they would not be able to adequately explain or justify their claims. Herbert Blumer who was present for the critique of the research remarked that a short '*debate over the type of research needed in social sciences*' took place '*leading to disagreement as to the relative merits of human documents and the associated argument as to so-called "objective" types of data*' (Blumer, 1940, p.582).

The predominant difference between the positivist approach endorsed in the Chicago school and interpretivist approaches which emerged later, was a lack of emphasis on general, theoretical knowledge (which is context invariant). Instead, interpretivist approaches focussed on concrete, practical knowledge (which is context dependant) i.e. a positivist might argue that knowledge is generated by the scientific method, while an interpretivist might argue that knowledge is generated by *scientists* and that there are a range of methodologies for generating that knowledge that culminate in a generalizable result. Using these criteria as distinguishing features of positivist and interpretivist research is not without its pitfalls however. A modern Grounded Theory approach for example, contains elements from both paradigms (Age, 2011). While historically grounded theory was a positivist approach, it has evolved over time to adopt a constructivist epistemological position (Mills, Bonner and Francis, 2006) and exists today as a research methodology that draws on elements of positivism, hermeneutics and pragmatism (Age, 2011). A further convolution of these paradigms is that positivists must stick rigidly to quantitative methods while interpretivist researchers must utilise qualitative methods, that is to say these paradigms have "preferred data types", but this is a poor categorisation. A better categorisation is to say that these paradigms place greater emphasis on one data type or another depending on the approach and it is not to say a predominantly positivist approach cannot draw on

qualitative data but merely that there is far greater value placed on quantitative data in that paradigm. These methodological approaches interconnect and overlap, rather than existing as discrete approaches.

3.3 EPISTEMOLOGICAL POSITION

The goal of this research is to identify if an SJT is a useful tool for the stimulation of metacognition, the success of which is evaluated by the analysis of speech and discourse among students engaged in the dilemmas presented in the SJT items. The early work of Vygotsky on social theory, which promoted speech and discourse as active constructors of metacognitive knowledge and skill (Vygotsky, 1978) and the merits of utilising qualitative data to understand metacognition when compared with the traditional inventory style assessments (Mccord and Matusovich, 2019), lead to an examination of constructivism as an epistemological position for situating this research. Constructivism is an epistemological position within the interpretivist paradigm. Constructivism posits that individuals in a certain society share customs and values which define their culture. These values, customs and norms, are typically passed on within a society in order to make more productive members of that society (Mandell and McCabe, 1992). Constructivists adopt the view that individuals living within such societies construct an understanding of the world around them, i.e. social reality. They adopt the view that knowledge is subjective and depends on cultural and societal rules, the values that an individual holds and how that individual interacts with others and with the social world (Jackson and Sørensen, 2013). The process of shaping and being shaped by culture implies that we inhabit constituted realities in which subject and object, person and environment become inseparable (Cole, 1996).

Constructivism, as well as being described as a cognitive theory of how knowledge is consolidated by the interaction of structures and agents, can be viewed as a means of carrying out research into how social reality is constructed in particular contexts. Silverman (2014) outlines an agenda for constructivist research, providing a preliminary conceptual framework that forms the epistemological positioning for this research:

- Constructivist researchers are interested in the practical activities in which actors are engaged with to construct, manage and sustain the sense that their social worlds are ‘real’ and to look at and listen to the activities through which individuals interact with the features of their social worlds.

The above statement implies that constructivist researchers are concerned with the examination of social actors themselves, but also the examination of the tools that these actors use to shape and reshape their understanding of the social world. In the context of this research, the actors are the first year engineers students and the tools they are using to construct their understanding are metacognitive behaviours, or what Vygotsky called tools of higher mental functioning (Vygotsky, 1986).

- Instead of treating social worlds as either objective parameters or as subjective perceptions, constructivists approach these achievements in their own right. Both inner lives and social worlds are epiphenomenal to the constructive practice of everyday life.

The above point harkens to Bourdieu's (1986) theory of practice, which suggests a dialectical relationship between the social actor and the social world in which one is continually reshaped by the other. This relationship is formalised in the next section, when discussing the theory of how metacognitive knowledge and skills are consolidated.

- The researcher must retain an appreciation of the naturalist' desire to describe *what's going on*, with a decided emphasis on how *what's going on* is reflected in everyday life. Using an explicit action orientation, focusing on interaction and discourse as productive of social reality.

This statement resonates with the work of Vygotsky (1986) on the use of language as a constructor of higher mental functions, but moreover it highlights the necessity for an approach that retains the fidelity of the social phenomenon under examination, a characteristic which is lost when students are asked to self-report on their performance. In this research, discourse analysis is utilised to make a determination as to whether or not metacognitive behaviour is being demonstrated or not, rather than relying on retrospective report, either through the use of interviews or self-assessments.

3.4 DISCOURSE AS A CONSTRUCTOR OF METACOGNITIVE KNOWLEDGE AND SKILLS

Since the goal of this PhD was to examine how an SJT could stimulate this metacognitive knowledge and skills while students were conversing with one another, a framework for understanding how students consolidate this knowledge and skills was required. Vygotsky's work on the use of speech as an active constructor of metacognitive knowledge and skills was never formalised into a theory of how individuals consolidate that knowledge when the

actors and the social structures are in a dialectic relationship; where both are continually shaped and reshaped by one another, however Vygotsky's contemporaries along with work carried out by Bourdieu on a theory of practice serve to bolster Vygotsky's work and make the use of discourse a defensible position for the examination of metacognitive behaviour.

Activity theory is a learning theory that relies on Vygotsky's theory of mediation; that is that tools and signs are applied to objects to extract meaning and Marx's concept of labour, the elements of which are simply 1) a meaningful activity 2) the object you wish to perform the activity on 3) the tools you wish to use on the object (Engeström, Miettinen and Punamaki, 1999). The resulting theory posits that social interaction plays a central role in the development of higher mental functions.

The primary unit of analysis in Activity Theory is a *joint* activity or practice. In other words, individuals reside in individual activity systems, defined in terms of the artefacts they have developed within the context of the community & rules that society has built around them, interact with one another to construct meaning. An activity system representing a student-student interaction is presented in Figure 3.1.

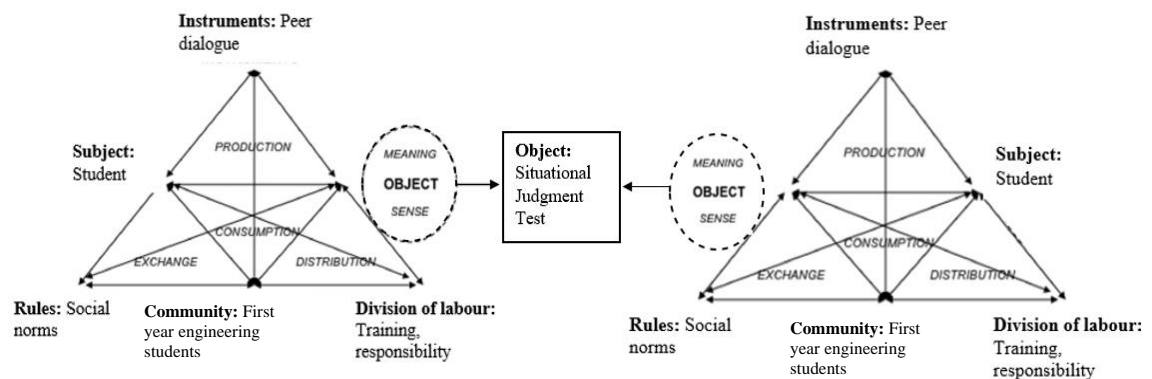


FIGURE 3.1. THE ACTIVITY SYSTEM OF A STUDENT-STUDENT INTERACTION ADAPTED FROM ENGESTROM, (2011)

In this activity system - an education setting - students engage with one another to construct their understanding of some object of their attention. This is a paradigm shift from traditional meaning making in the sense that in a traditional classroom setting, the assumption is that the teacher knows something that has to be learned, while in this system the students are learning something that is not shared by the instructor, but rather constructed by the learner. Existing knowledge and skills are not embedded in such activities, rather it is described as the collective

journey of the learner through the Zone of Proximal Development (ZPD) (Vygotsky, 1978). The ZPD is described as the gap between which a student can solve a problem alone and solve a problem with the aid of a teacher. The function of the teacher is to facilitate this discovery-orientated learning environment, encourage peer dialogue and to use Socratic dialogue to allow students to construct their own understanding (Downing *et al.*, 2009). Moreover, the mediating tool for the construction of this understanding is speech, or rather peer dialogue, a tool for the development of higher mental functions i.e. metacognitive skills (Vygotsky, 1986).

Bourdieu suggested that a person, or rather their *habitus* interacted dialectically with a social structure or *field*, mediated by their social and cultural skills, called *capital* (Bourdieu, 1986). Moreover, in *language and symbolic power*, Bourdieu (1991) makes reference to use of symbolic instruments to better understand the social world. Bourdieu, as a contemporary of thinkers from the Neo-Kantian tradition, saw different symbolic universes, such as art and science, as instruments for constructing knowledge and understanding of the world. He outlined a framework for thinking about symbolic instruments using three key concepts. The first is that of a *structuring structure*, these are instruments or symbolic forms that give us a *method* or *modus operandi* for constructing knowledge about the world. The second is a structured structure, these are objectively real objects in the world that provide us with a *need* or *opus operandum* for generating knowledge. Finally, there are the instruments of domination; such as the division of labour, either by social class or the ideological division of labour into, for example, un-skilled, skilled and semi-skilled labour.

The framework proposed by Bourdieu has many parallels to Vygotsky's social activity theory (Vygotsky, 1978). Vygotsky suggested that one must apply *tools* to *signs*. Tools, in a Vygotskian sense, are the tools of mental functioning that allow us to interact with the physical world, or what Bourdieu would refer to as *structuring structures*, while signs are the symbolic objects that we choose to interact with to construct our understanding, or *structured structures*. The third concept, shared by both Vygotsky and Bourdieu in seemingly high regard is Marx's division of labour, within which learning was defined as a meaningful activity under which tools would be applied to signs to generate knowledge, i.e., knowledge is objectivised. Both Vygotsky and his contemporaries offer a methodological approach to research using the constructivist paradigm. Unfortunately, no such methodological approach is offered by Bourdieu, which is arguably one of the largest criticisms of his work (McLeod, 2005). Nonetheless, the work of Bourdieu serves to bolster the work of Vygotsky and his contemporaries, given the comparability of both theories, they provide a solid foundation for this research which seeks to exploit these peer-peer interactions to develop students' metacognitive knowledge and skills.

Case and Light's (2011) description of emerging research methodologies in engineering education provide a starting point for considerations into a methodology that facilitates the investigation of speech as both a mediator (Bourdieu, 1991) and constructor (Vygotsky, 1986) of metacognition. Ethnography, phenomenography, discourse analysis and narrative analysis were all considered as possible ways of answering the research question. An ethnographic study would require a long term longitudinal study across multiple universities to be considered rigorous (Thomson, Plumridge and Holland, 2003). On the other hand, a phenomenographic study or a narrative study would be better suited to collecting and analysing data about individuals' experiences, rather than collecting data about the interactions between groups of individuals. The theoretical underpinnings of this research place a great deal of value on student interactions and the role played by discourse in mediating the construction of knowledge in such interactions, as opposed to studying students in dialogue with an interviewer or instructor.

Given that constructivists desire to describe what is going on with the highest degree of fidelity (Silverman, 2014), phenomenography and narrative analysis were not suitable approaches to answering the research question, as they required data to be collected in interviews, rather than capturing the metacognitive behaviour as it occurred. Discourse analysis was chosen instead, as it allowed data to be collected through naturalistic observations of the student's behaviour while they were engaged with the SJT. The resulting data – codes and subcodes or metacognitive behaviours - enabled the SJT to be evaluated in terms of its efficacy as a tool for stimulating metacognitive behaviour.

3.5 DISCOURSE ANALYSIS

Discourse analysis as a methodological approach originated in the field of linguistics and, according to the Linguistic Society of America, is primarily concerned with the study of the components of language, such as phonetics, morphology, semantics and the syntax of words (Tannen, 2010). Kittleson and Southerland (2004) examined the role of discourse in group knowledge construction in an engineering design course. The study focussed on a single group of students to identify pivotal student interactions, which in this study, were interactions that resulted in negotiated learning. Data were collected during the groups' problem-solving sessions, resulting in ten sessions being transcribed and analysed. They identified two important factors in group knowledge construction. First is the role of status in the type of knowledge produced. High status individuals, or what might be thought of as individuals with a high degree of social capital, tend to have a greater voice in the knowledge which is produced during these

interactions. The second is the social context in which this knowledge is being constructed. The first of these factors highlight a need to be aware of the effect of having high status individuals in groups on the type of knowledge which is generated and to be aware of the social context in which students are constructing new knowledge.

To provide more background to discourse analysis as a methodological approach it becomes necessary to introduce the concept of structuralism. Alone, structuralism is a hollow concept, as it simply posits that structure is something that matters (Jessop, 2017). Taking the example of society: it can be viewed structurally as being made up of institutions, or as being made up of groups and networks, or as classes, or as societal roles and societal norms (Runciman, 1969). In the work of Foucault, who argued that language had an inherent structure, a more substantive structuralist paradigm was formed that sought to address the debate between structure and agency by examining the semiotics of discourse and speech (Young, 1982).

There are a number of benefits and drawbacks to discourse analysis depending on how the data are collected. The first consideration when collecting qualitative data is an acknowledgment of the researcher's impact on the subjects under examination, sometimes referred to as the 'Hawthorne effect' (Silverman, 2014). There are two contrasting definitions of the Hawthorne effect (Chiesa and Hobbs, 2008). The first definition refers to the introduction of a new stimulus to the work environment which improves workers welfare, resulting in a marked improvement in efficiency. The second definition refers to a tendency of people to change their behaviour when they are aware that they are being watched; in this instance, the latter definition is the one most pertinent to the research as it pertains to the effect of observation on the population being studied. It should be noted that there is controversy surrounding the Hawthorne effect regardless of the chosen definition, with many writers criticising the original Hawthorne experiments for having methodological flaws (Adair, 1984). However, for the purposes of this research it will be sufficient simply to be aware of the effect, as it is not the intention of this research to measure the effect directly. The Hawthorne effect can be minimised through the use of audio recordings as opposed to collecting data by direct observations or by the use of video equipment (Kittleson and Southerland, 2004). However, it cannot be completely eliminated due to the presence of recording equipment as students interact with one another. It was decided that audio recorders would be utilised in this research, as they represented the least intrusive means of collecting the necessary qualitative data. The added benefit of this approach is that the pertinent data are collected during the students' interactions, rather than being collected retrospectively in an interview. Retrospective accounts rely on self-reporting and suffer from losses to the fidelity of the lived experience, relying on what the participant *remembers* happening and not necessarily what precisely happened. Accordingly, and in keeping with the naturalist's desire to

capture what is going on, the approach of recording student's interactions audio-only was viewed as the approach which maximised the fidelity of the qualitative data being collected.

The second consideration to ensure the qualitative data collected using discourse analysis are collected in a rigorous manner (Kincheloe and Berry, 2004) is to be aware of the values that the researcher has and how that may influence their research question, data and analysis, which we may term "research bias" (Silverman, 2014). Bias can be defined as a distortion in the results of a study due to some influence, be it internal or external (Polit and Beck, 2014). Galdas (2017) suggests that studies rejected by journal peer reviewers often contain qualitative data that is too well aligned with the personal agenda of the researcher(s). This issue can arise when the researcher does not critically evaluate their own role and potential bias during the formulation of their research questions, sampling of data and analysis. Therefore it becomes important that the researcher be transparent about their decision making process.

The final means of ensuring rigour in the qualitative data being collected is being able to recognise the truth status of a respondent's account (Silverman, 2014). Truth status can be described as a persons' ability to speak with authority about a subject, where that speech is derived from a body of knowledge that legitimises their claims (Cheek, 2004). This concept has more prominence in the collection of expert accounts, where the participant may hold a position of power in their field and may seek to marginalise and suppress certain knowledge and endorse others. It also becomes more prominent when the sample of participants is small resulting in a highly contextualised account that requires the evaluation of the truth status of the statements being made. This is an important consideration when analysing the discourse of groups of engineering students. To account for students spoiling the data by the use of sarcasm or humour (Calzolari, 2014) notes were taken during the transcription process when the researcher felt that the truth status of a particular statement from a student was in question.

3.6 METHODS

The methods employed to collect and interpret the data are now outlined. A fixed mixed methods approach to the research was chosen from the outset of this research (Creswell and Plano Clark, 2018), as the researcher was aware from the outset that both quantitative and qualitative methods were required to address the research objectives, and qualitative methods would be required to address the research question respectively.

The approach to the research design can be viewed as an explanatory sequential design (Creswell and Plano Clark, 2018) in that multiple methods were applied in succession to address the research objectives and question. The development of the SJT required the application of qualitative methods to evaluate respondents accounts about the content of the SJT items. The roll out of the SJT required the application of statistical tests to make inferences about the data collected from students who took part in this phase of research. Along with qualitative data collected from focus groups with engineering professionals and academics, these data were used to refine the SJT items before seeking to evaluate the SJT as a stimulus of metacognitive behaviour. In contrast, to address the research question about whether or not the SJT was an effective stimulus of metacognitive behaviour, the methods employed to interpret the students' discourse resulted in the production of qualitative data, by application of discourse analysis.

As recommended by Creswell and Plano Clark (2018), when utilising sequential explanatory design, the research should be separated into streams in which the quantitative and qualitative methods are separated. This was achieved by separating the research into four distinct and sequential phases.

- 1) First was the initial development phase of the research, which required utilised focus group discussions with engineering professionals and academics) represented presented on the left-hand side of Figure 3.2.
- 2) Second was the rollout of the SJT to students, which required the application of statistical methods. Presented in the top stream of Figure 3.2.
- 3) Third was the evaluation of the SJT as a stimulus for metacognitive behaviour, utilising the NOME protocol proposed by Mccord and Matusovich (2019), presented in the bottom stream of Figure 3.2.
- 4) Finally, the items which were most effective in stimulating metacognitive behaviour were rolled out as an activity with students, represented by the arrow on the bottom stream of Figure 3.2.

Since, chronologically, the development process precedes all other research activities, it is discussed first before discussing the top stream which occurred in the 2017/18 academic year, followed by the bottom stream occurred in the 2018/19 through 2020/21 academic years.

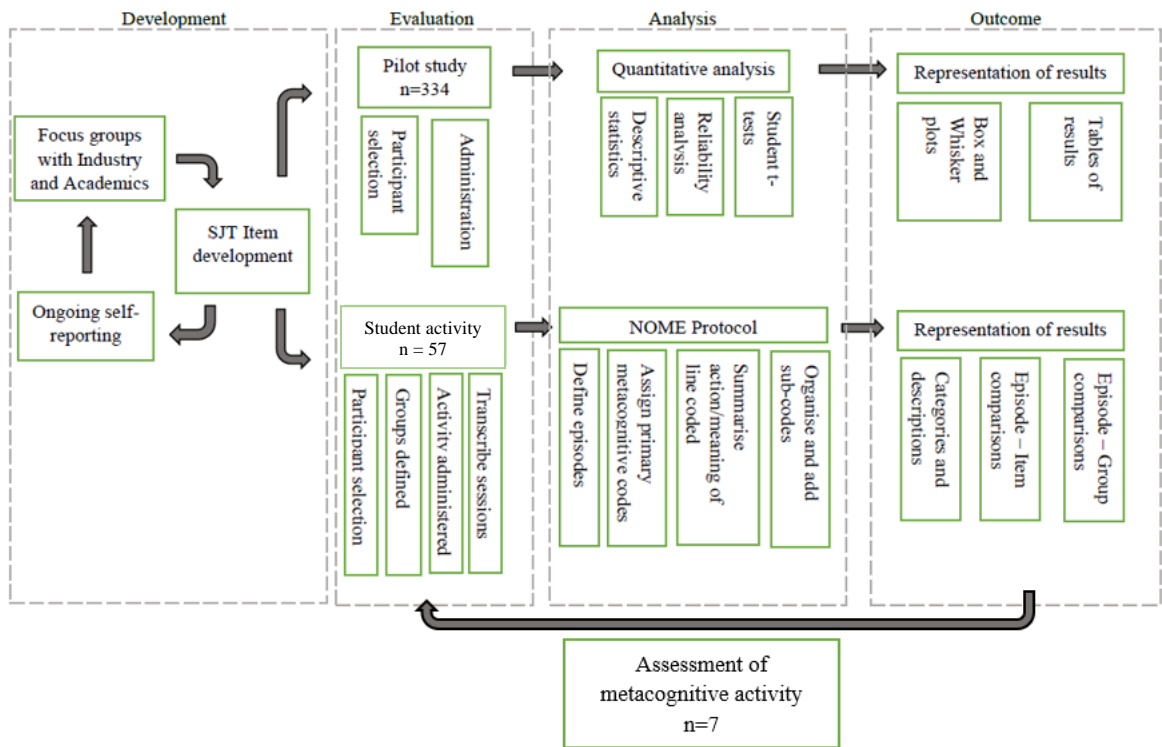


FIGURE 3.2 RESEARCH ACTIVITIES UNDERTAKEN

3.6.1 SJT DEVELOPMENT

The suggestion that an SJT could be used for the purpose of stimulating metacognitive behaviour was proposed by the PhD researcher and it was proposed that the SJT be developed during the PREFER project, which had the goal of developing a reflective tool for students to consider their strengths and weaknesses in a range of professional skills. The decision to develop the SJT was informed by the literature review carried out for this PhD thesis to serve both research purposes. The PhD researcher wrote the SJT item stems and responses, evaluated the items with panels of subject matter experts and conducted all analysis of the SJT outlined in the preceding sections.

The starting point for the development of the SJT was defining a set of professional skills. There is a vast array of methods currently employed to compile a list of skills. Generating a list of skills is typically realised in one of several ways: through systematic review of the literature in order to generate an exhaustive list of skills, then mapping the list to set of outcomes (Cordova-Wentling and Price, 2007), by taking a pre-existing exhaustive list of skills and

mapping them to a set of outcomes (Banik, 2008) or by taking an exhaustive list of skills and narrowing the scope by conducting semi-structured interview with a panel of experts (Nixon, 2005). The studies noted above all utilised the Accreditation Board for Engineering and Technology (ABET) criterion to map the skills, but other frameworks have also been adopted such as the Definition and Selection of Skills (DeSeCo) developed by the OECD (Male et al., 2011) while Cajander, Daniels and Von Kinsky (2011) used a combination of the Australian Council of Education Research (ACER), ABET and DeSeCo to help formulate a list. The final method is to use the learning outcomes of a particular programme as a list (Hofland et al., 2015; Nair et al., 2009). For this research, the third method, taking an exhaustive list and narrowing it using expert panels was used. A list of skills was developed by Binder Dijker Otte (BDO) (a consultancy with a division in Human capital) using a seminal piece of research by Bartram in which 29 validation studies (n= 4861) of his skills framework “the eight great professional skills” were meta-analysed (Bartram, 2005). This list was brought to 13 expert panels (Craps *et al.*, 2018) in Belgium, Ireland and the Netherlands, all of whom employed engineers. Fifty-five panellists took part in the research; forty-seven male and eight female panellists who were predominantly engineers (forty-four engineers, eight HR managers and three engineering managers with HR expertise) comprised the thirteen expert panels.

The outcome of these panels was a set of twenty-three skills and their descriptions. Once these had been identified, these skills were used as the basis for the development of the SJT items. The advantage of this approach was that items could be framed in a particular context by design by basing each item on one of the twenty-three skills that had been identified. Designing the items from scratch also allowed the situations to be kept to an appropriate length; more detailed questions result in higher validity but this must be tempered by keeping the cognitive loading of the items to a minimum (McDaniel *et al.*, 2001). An important design consideration for the SJT items was to have equal representation of gender and ethnicity in the actors in the item stems (a feat which couldn’t be achieved in the expert panels). For example, if the dialogue in the item stem was between a junior engineer and their manager, the manager was not always male and did not always have a western name, to avoid biasing the test toward one gender or one ethnic background. The purpose of this approach was to mitigate against differences in score based on gender or ethnicity due to inherent test biases. For the item responses, four behavioural responses to each item were developed and the level of appropriateness of each response was evenly distributed over the entire test such that the number of inappropriate, appropriate and neutral response categories was even over each of the three tests.

Once the items had been initially drafted, the test was reviewed by a further set of eleven panels, this time made up of academics and industry professionals alike. In total, fifty-three people took part in the panels; thirty-three males

and twenty females. Three panels were academic, made up of lecturing staff from the schools of civil & structural engineering, school of mechanical engineering and school of electrical engineering at TU Dublin respectively, who reviewed the item stems. The items stems were also reviewed by panel from industry, with ESBI, Siemens and ENGIE. Once the items stems had been reviews and the feedback integrated, The item responses were scored by panels from ARUP, Siemens (2 panels), Bosch, and Materialize to generate a scoring key.

3.6.2 ROLLOUT OF THE SJT

Once a revised draft of the SJT items had been created, the test was divided into three, resulting in three tests with between 7-8 items each. It was decided to keep the items grouped by role, rather than randomly assigning items to each test. The rationale for splitting the test was to mitigate against test exhaustion on the twenty three item test, with conservative estimates of eighty minutes to complete the full test (approximately three and half minutes to read and evaluate each item). The tests were brought online using BDO's test platform and links were disseminated to groups of final year undergraduate engineering students and masters students at TU Dublin and KU Leuven. The rationale for selecting final year and masters students was that they represented the students who were closest to joining the labour market. Through their potential exposure to work placements, internships, guest speakers and site visits it was posited that their responses should align well to the responses collected from the panels with industry, and where they did not align well, a mismatch could be identified in their competence. All students who took part in the rollout of the SJT received a feedback sheet that compared their responses on each item to the responses of experts, to provide them with a means of reflecting on their skills. The feedback was sent automatically through the BDO online platform via pdf, a sample of the feedback is presented in table 3.8 The score on the SJT is only an indication of a skill rather than a high-fidelity measurement, there are different ways to interpret the items – they are ill structured problems after all - and so to achieve a better approximation of any one skill, multiple items that attempted to measure that skill alone would need to be developed. Accordingly, the feedback was based on quartiles i.e. if a student scored between 0-24% on an item, they received one type of feedback and if they scored between 25-50% they received another, and so on. Dividing the feedback any further did not seem rational, as the theoretical maximum score on an item was twenty-four and to use a decile range, i.e. ten potential types of feedback per item, seemed excessive given this would draw a distinction between the feedback to a student who scored a zero and a student who scored a four on an item.

TABLE 3.8 SAMPLE OF FEEDBACK TO STUDENTS ON SJT ITEM

Quartile	Feedback
Q1	<p>All the cases you have evaluated are a cross-section of challenging situations for engineers working in an operational excellence role. In this role, the focus is predominantly on product or process optimization. We have compared your assessment of the appropriateness of different responses to these situations with the assessments of some industry experts. The results show that there seems to be quite a big difference between your judgment and that of the industry experts. We observed that more than 75% of your peers were better at assessing the cases. This does not necessarily mean that an operational excellence role is not for you. However, it does mean that there is quite some room for personal development in case you aspire a position in an operational excellence role.</p> <p>We would advise you to gather some experience in an operational environment if you want to develop your skills in this direction. In the rest of the report, you can read more about how and why your assessment of the individual cases diverged from that of experts. This can be an interesting first step in your learning process to become more successful in an operational excellence role.</p>
Q2	<p>We have compared your assessment of the appropriateness of different responses to challenging situations with the assessments of some industry experts. Irrespective of the sector, these situations are representative of what an engineer in an operational excellence role may encounter. When compared to other students, between 50 and 75 percent of your peers were better at judging the level of appropriateness than you. As such, your assessment of the different cases overlaps to some extent with that of industry experts but there still is quite some room for improvement. Given the partial overlap with the industry expert, there is definitely a basic understanding of what it entails to realize efficiency gains in an operational context.</p> <p>We recommend you to gain some working experience in an operational environment if you intend to pursue this path, for example by doing an internship or work placement. In the rest of the report, you can read more about how and why your assessment of the individual cases diverged from that of experts. This can be an interesting first step in your learning process.</p>
Q3	<p>All the cases you have evaluated are a cross section of challenging situations for engineers working in an operational excellence role. In this role, the focus is predominantly on product or process optimization. You seem to have a better understanding of what it takes to do the right thing in an operational excellence role than 50 to 75 percent of your peers. More specifically, your assessment of situations an engineer may encounter</p>

	<p>in an operational excellence role overlaps to a large extent with the experts' assessment of the same situations.</p> <p>Obviously, there is still some room for improvement. By gaining some experience in an operational environment, you will have plenty of opportunities to further sharpen your skills in this respect. In the rest of the report, you can read more about how and why your assessment of the individual cases diverged from that of experts. This can be an interesting first step in your learning process.</p>
Q4	<p>Based on the output of this test, a job in an operational excellence role seems to be well-suited to you. The cases you evaluated are a representative set of situations experienced by an engineer working in an operational excellence role. When it comes to making the right assessment in cases that appeal to increasing efficiency in a particular context, you seem to do a very good job. Your assessment overlaps to a very high degree with the judgment of industry experts. Compared to other students, you have a better understanding than 99 to 75% of your peers when it comes to judging cases in the operational sphere.</p> <p>Please do not consider this feedback as an endpoint but rather use this feedback to further refine your skills. In the rest of the report, you can read more about how and why your assessment of the individual cases diverged (or not) from that of experts. This can be an interesting first step in your learning process.</p>

3.6.3 QUANTITATIVE DATA TREATMENT

In total three hundred and thirty-four final year and masters engineering students took part in the rollout of the test. The resulting data were analysed using inferential statistics. At an item level, where scores on each of the four possible responses could be aggregated, providing a theoretical maximum score of 24, the data were found to be normally distributable, and parametric statistics were utilised (Vidakovic and Kvam, 2007). T-tests were carried out to look for differences in sample means between different items, in order to determine students relative strengths and weaknesses in their evaluation of the scenarios presented in the SJT items. This was achieved by computing the average score on the test and comparing this test average to the item average to look for significant differences. Items with significantly lower mean scores than the test average were identified as areas of professional weakness in the population who took part in the test.

3.6.4 METACOGNITIVE ACTIVITY

At this stage in the research, the first two research objectives, to develop an novel SJT with items tailored specifically to engineering professional scenarios and evaluate the SJT with all stakeholders including students, academics and industry professionals had been addressed. But the overall research question: *“can a SJT be utilised to stimulate metacognitive behaviour in groups of first year engineering students”* and the final two research objectives, to identify the items which best stimulate metacognitive behaviour in engineering students and to deliver a learning resource capable of stimulating these behaviours in engineering students, was yet to be examined. This objectives and question were ultimately achieved and made answerable by using the NOME protocol (Mccord and Matusovich, 2019) to identify metacognitive behaviour in students working with the SJT items in groups. Students recruited for this part of the study were participating in a first-year full time undergraduate project-based learning laboratory and were in the sixth week of a project to design and build a bridge. The rationale for providing the activity in week six (the final week of the project) was that at this stage students would be in the “performing” phase of their group development and therefore maximally predisposed to collaborating on an activity (Tuckman and Jensen, 1977). Participants were drawn from three cohorts of students, the first cohort was examined in November 2019, the second in March 2020 and the third in November 2020. The final group of seven students examined in November were provided with a refined set of items based on the application of the NOME protocol to the discourse of the first two cohorts.

The decision to utilise this particular group of students was a pragmatic decision, as the researcher had a one-hour time slot twice per semester in which to carry out the research. Access to groups of final year students was difficult. Given their focus on their final year projects, examinations and searching for roles in the labour market, it would have been difficult to justify taking one hour of their class-time for the activity. Having both the data from final year and first year engineering students would have made for a useful comparison to evaluate if metacognitive behaviours were more prominent in older, more experienced students, however the answer lay outside the scope of this study.

Each cohort was made up of groups of 4-8 students and in total fifty-seven students across thirteen groups took part. The three cohorts were predefined and mixed based on academic performance up to that stage in their development

and gender. Within each cohort, groups of 4-8 were predefined by the lecturer with the criteria of having at least two female students in each group, where possible. Students were provided with a five-minute presentation outlining the purpose of the activity and instructions on how to evaluate the activity. Students were asked to take turns reading the item allowed within their group, evaluate the responses for the item by providing each with a score from 1-5 and then discussing their rationale with the group for choosing these scores before moving on to the next item. The students' interactions were recorded (audio only) to extract transcripts for subsequent codifying of results.

3.6.5 QUALITATIVE DATA TREATMENT – NOME PROTOCOL

Naturalistic observation is a prominent method in qualitative inquiry, it is used to determine the behaviour of individuals or groups in their 'natural' setting by the direct observation of that group and their behaviour (Angrosino, 2007). There is some disagreement over the role of naturalistic observations. Some authors arguing that naturalistic observation can be used deductively to support theoretical work (Kelly, 1967) while others suggest it should be used exclusively to look at what occurs *in the field* and that such observations do not serve to bridge the gap between theory and practice (Miller, 1977). Naturalistic observations allow the assessment of actual peer interactions (La Greca and Stark, 1986) as opposed to collecting reports retrospectively from teachers or from students' themselves. Accordingly, this method of assessment is considered to be a more rigorous means of assessing social skills in students than socio-metric measures i.e. self-assessment or nominated peer assessment (Foster and Ritchey, 1979).

In this study, the transcripts collected from eleven groups were coded using the Naturalistic Observations of Metacognition in Engineering (NOME) protocol. To account for loss of attention in the latter items and for adjustments in strategy in the beginning of the process an 'A' set of groups received the item sets in forward order, while a 'B' set of groups received them in reverse. As discussed in Chapter 2, The protocol was developed by McCord and Matusovich (2019) based on the work of Whitebread's analysis of self-regulated learning in social and naturalistic contexts (Whitebread and Pino-Pasernak, 2013). The protocol makes use of the theoretical model proposed by Brown and Flavell (Flavell, 1976; Brown, 1977) in which metacognitive knowledge and skills are delineated and expanded into distinct traits. Whitebread, through video-based observations of metacognition,

associated each of these traits with an observable metacognitive behaviour, which are outlined in table 3.9 (Whitebread and Pino-Pasernak, 2013).

TABLE 3.9 WHITEBREAD'S PRIMARY CODES FOR METACOGNITIVE BEHAVIOUR

Metacognitive skills	Definitions
Planning	Any verbalization or behaviour related to the selection of procedures necessary for performing the task, individually or with others.
Monitoring	...the ongoing on-task assessment of the quality of task performance (of self or others) and the degree to which performance is progressing towards a desired goal.
Evaluation	...viewing task performance and evaluating the quality of performance (by self or others).
Control	...a change in the way a task had been conducted (by self or others) as a result of cognitive monitoring.
Metacognitive knowledge	
Knowledge of persons	A verbalization demonstrating the explicit expression of one's knowledge in relation to cognition or people as cognitive processors.
Knowledge of tasks	One's own long-term memory knowledge in relation to elements of the task.
Knowledge of strategies	One's own knowledge in relation to strategies used or performing a cognitive task, where a strategy is a cognitive or behavioural activity that is used so as to enhance performance or achieve a goal.

The NOME protocol was applied to the eleven transcripts collected in this PhD research to identify items of the SJT which stimulated these behaviours to the greatest extent. The sub-codes within the NOME protocol are presented in Table 3.10.

TABLE 3.10 OBSERVED SUB-CODES ADAPTED FROM MCCORD AND MATUSOVICH (2019)

Metacognitive knowledge	Definitions
<i>Knowledge of persons</i>	
<i>Self:</i>	Refers to own capabilities, strengths and weaknesses, or academic/task preferences; comparative judgments about own abilities
<i>Others:</i>	Refers to others' processes of thinking or feeling toward cognitive tasks

<i>Knowledge of task</i>	
<i>Across tasks:</i>	Compares across different tasks (similarities/ differences)
<i>Task difficulty:</i>	Makes a judgment about the level of difficulty of cognitive tasks or rates the tasks on the basis of pre-established criteria or previous knowledge
<i>Knowledge of strategy</i>	
<i>Evaluates effectiveness:</i>	Evaluates the effectiveness of one or more strategies in relation to the context or the cognitive task
<i>Explains procedure:</i>	Explains procedures involved in a particular task
Metacognitive skills	Definitions
<i>Planning</i>	
<i>Collects info:</i>	Collects information or resources necessary to solve the task
<i>Assigns a task:</i>	Allocates individual roles and negotiates responsibilities
<i>Makes a plan:</i>	Decides on ways of proceeding with the task
<i>Homework format:</i>	Works on homework format designated by assignment or instructor
<i>Covered:</i>	Discusses what topics or concepts are included on an will be covered on an exam or project assignment or
<i>Goals:</i>	Sets goals and targets
<i>Control</i>	
<i>Motion or gesture:</i>	Uses physical motion/nonverbal gesture to support cognitive activity
<i>Asks for help:</i>	Asks for help from someone else
<i>Model/representation:</i>	Makes, uses, or refers to a common model/representation to be used to aid cognitive activity
<i>Verbally repeats:</i>	Verbally repeats a strategy to help with understanding
<i>Repeats strategy:</i>	Repeats a particular strategy to check effectiveness
<i>Changes strategy:</i>	Changes strategy as a result of previous monitoring
<i>Helps others:</i>	Helps another person in the group
<i>Effectively :</i>	Suggests and uses strategies to solve the task more effectively
<i>Previous strategy:</i>	Applies a previously learnt strategy to a new situation
<i>Monitoring</i>	
<i>Checks goal:</i>	Checks back to the goal or what needs to be found in the task
<i>Memory retrieval:</i>	Comments on or rates one's memory retrieval
<i>Mental clarity:</i>	Comments on mental clarity/focus

<i>Error-detection:</i>	Detects an errors in a strategy or procedure
<i>Self-commentates:</i>	Talks to oneself out loud for mental dialogue
<i>Corrects others:</i>	Corrects the performance of other(s)
<i>Comments on understanding:</i>	Comments on own understanding
<i>Known/unknown info:</i>	Points out known/unknown information
<i>Self-corrects:</i>	Self-corrects one's own performance
<i>Checks progress:</i>	Checks the progress of oneself or others; reviews progress on task (keeping track of procedures currently being undertaken and those that have been done so far)
<i>Checks understanding:</i>	Checks the understanding of oneself or others; asks for clarification to support cognitive activity
<i>Checks strategy:</i>	Checks a strategy to be used to complete a task
<i>Checks answer:</i>	Checks an answer against the answer of someone else or a given answer
<i>Evaluation</i>	
<i>Correctness/accuracy:</i>	Comments on correctness or accuracy
<i>Reasonableness:</i>	Comments on reasonableness of an answer or strategy
<i>Success/quality:</i>	Comments on success or quality of performance
<i>Progress:</i>	Observes or comments on progress

This method of observation of metacognitive behaviour relies on student discourse. Accordingly a limitation of this method is that it requires speech to be effective. If students do not feel they are entitled to speak, or if a high-status individual dominates the conversation, this method is limited in the conclusions that can be drawn. Mitigating against this is difficult in light of the theoretical underpinnings of this research, which rely on student interaction for knowledge construction. Mediation of this interaction by an instructor upsets this peer-peer dynamic and limits the need for the student to self-regulate their learning. This will be drawn out in greater detail in chapter 6.

3.7 ETHICAL CONSIDERATIONS

A consent form was sent along with a consent document (or web page when students took part online) outlining the nature of the study to all research participants. A power point presentation outlining the nature of the study was

provided and students were permitted time to ask questions before consent forms were distributed. Participants were reminded that participation was anonymous and that they could opt out at any stage of the research. All research for this PhD was carried out with the full approval of the TU Dublin research ethics committee (REC 17-112).

3.7.1 RESEARCH PARTICIPANTS

The inclusion criteria for the discussion panels with industry during the development of the SJT included a condition that the participants were currently employed in industry either as a practicing engineer or as an engineering professional, such as administration and management roles or human resources. The inclusion criteria for the discussion panels with academics included a condition that they were employed as lecturing staff at a higher education institution in Ireland and held a professional engineering qualification. In total, thirty-three males and twenty females took part in these discussions across eleven panels.

The inclusion criteria for the rollout of the SJT to students was that the student currently be enrolled in a third level engineering programme in Europe and that they were in their final year of study, either at on an undergraduate or master's programme. This resulted in the collection of three hundred and thirty-four responses, two hundred and ninety-five males and thirty-nine females took part.

The activity which sought to evaluate the efficacy of the SJT as a stimulus of metacognitive behaviour drew forty-seven male students and ten female students with students required them to be in their first year of an undergraduate programme in engineering at an Irish higher education institution. While the final stage of the research, which sought to rollout the final instrument had the same inclusion criteria as the evaluation, drawing seven participants, six males and one female student. A summary of each cohort is presented in Table 3.11.

TABLE 3.11 SUMMARY OF RESEARCH PARTICIPANTS

Research Stage	Number of participants		Participation	Cohort
	Male	Female		
SJT development	33	20	Voluntary	Engineering professionals/Academics
SJT rollout	295	39	Voluntary	Final year engineering students

Evaluation of SJT as a stimulus of metacognition	47	10	Voluntary	First year engineering students
Rollout of final instrument	6	1	Voluntary	First year engineering students
Totals	395	58		
Grand total	453			

In carrying out the data collection during discussion panels with academics and industry professionals the upmost respect was given to the values of those individuals and of the organisations they represent. Comments about political, religious or other world views not pertinent to the investigation were actively avoided, along with the use of slanderous or foul language. The same was true of discussions with students with the added consideration that a power relationship existed between the researcher and the student, in the case of this research the students engaging with the instruments were in some instances students in a Project Based Learning lab upon which the researcher was an instructor. It was made clear to the students that participation in the study had no bearing on their final grade.

3.7.2 DATA MANAGEMENT

Data collected from pen and paper tests were collected and separated from the consent forms and stored in separate folders in room 364, TU Dublin, Bolton Street, Dublin 1, under lock and key. The data were inputted to an encrypted laptop and the physical copies of the tests and consent forms were destroyed by shredding following a retention period of two years from the date of the test. The online test data were downloaded from BDO servers to an encrypted laptop and the IP addresses of the participants deleted from the data file. Dissemination of the results of the tests was anonymous and was not linked to any individual or their personal data. Participation in the focus groups and panels was anonymous insofar as the names of participants were not recorded and none of the personal data collected from them (such as their current position and level of experience) could be linked to the participant. After the research was completed and the data analysed and published, the data sets were made public on preferproject.eu.

3.8 CHAPTER SUMMARY

The research question and objectives presented in this research were addressed using the mixed methods approach, drawing on a mixture of quantitative and qualitative data to develop and refine the SJT items in order to address the research objectives. Once the objectives of the research had been achieved, the research question as to whether an SJT was an effective stimulus of metacognition could be addressed; through the analysis of students discourse with one another. In the proceeding chapter, the means of stimulating metacognitive behaviour - the SJT - is described in terms of how the above methods were applied to the development and evaluation of the SJT. This chapter is integral to achieving the research objectives, which require the development of a stimulus of metacognition that integrates self-regulatory skills with a set of professionally relevant scenarios, circumventing the requirement of a prior knowledge of physics or mathematics.

CHAPTER 4: DEVELOPING AND EVALUATING THE SJT

4.1 CHAPTER OUTLINE

The data and findings from each stage of the research will be outlined within their respective streams in the chapter. First, the data during the development and evaluation of the SJT will be presented, as shown in the top stream in figure 4.1. The data from the bottom stream, which concerned the metacognitive activity will be presented and discussed in Chapter 5 - Developing and Implementing the Metacognitive Activity.

This chapter will deal predominantly with the outcomes of the expert panels, which were conducted to develop, review and evaluate the SJT. It also deals with the results of the rollout of test, which was carried out with students. The term “expert” is used in this context to mean an individual with industry experience, rather than individuals who are regarded as experts in evaluating SJT items. This chapter describes the research data used to ensure the robustness of the SJT before it could be implemented as a metacognitive resource.

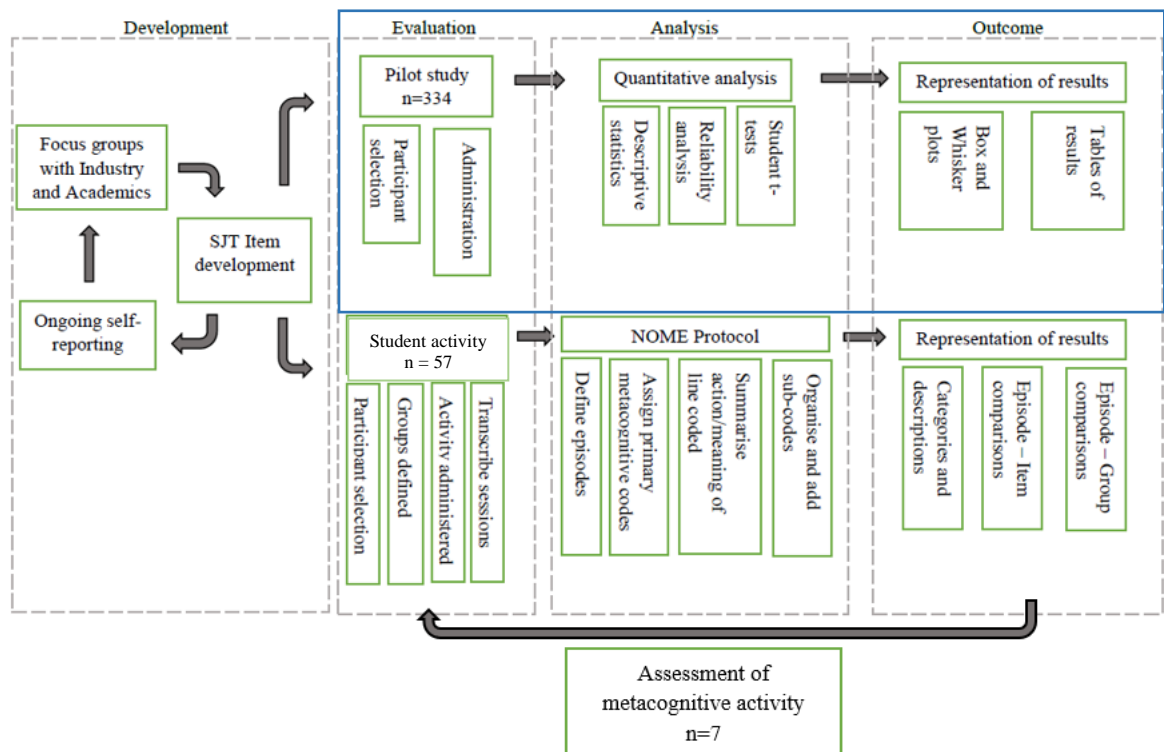


FIGURE 4.1 RESEARCH ACTIVITIES UNDERTAKEN (TOP STREAM)

4.2 THE DEVELOPMENT OF THE SJT

As discussed in the literature review, the conventional purpose of an SJT is to provide a low fidelity measurement of behaviour, with the intent of using the result to select candidates for job interviews. The term “low fidelity” refers to how accurate a replication or copy of something is to the original article or object. In this instance, the term *low fidelity measurement* refers to how accurately an SJT item can predict actual observed behaviour. The SJT developed as part of this research consists of items relating to professional skills, which are in turn related to three professional roles.

As reported earlier, the SJT used in this research was developed through an iterative process of item writing, expert panel review and self-reporting. Once the items had been initially drafted and internally reviewed, they were reviewed in a series of panel discussions with academics and industry professionals. In total, fifty-three people took part in the panels, thirty-three males and twenty females. Of these, fifty-three participants, forty-three were engineers while the other ten participants were made up of five participants from other STEM fields, three human resource professionals and two psychologists.

4.3 INSTRUMENT REVIEW

Once the SJT items had been developed, the items were subjected to a review whereby the opinions of both academics and industry professionals were sought out. In total, fifty-three experts from industry and academia took part in the review of the content and scoring of the test with thirty-four percent female participation in the research. Seventy one percent of the participants were engineers – either practicing or working in academia with the remaining twenty-nine percent being made up of other STEM related disciplines (14%), Human Resource professionals (9%) and non-STEM related disciplines (6%). Fifty one percent of the participants had between zero and five years of experience in their role, while the other forty-nine percent had between six and thirty years of experience. The

qualitative feedback collected in each panel were cross-referenced with one another to identify common points of improvement for the items. An illustration of the evaluation process is presented in figure 4.2.

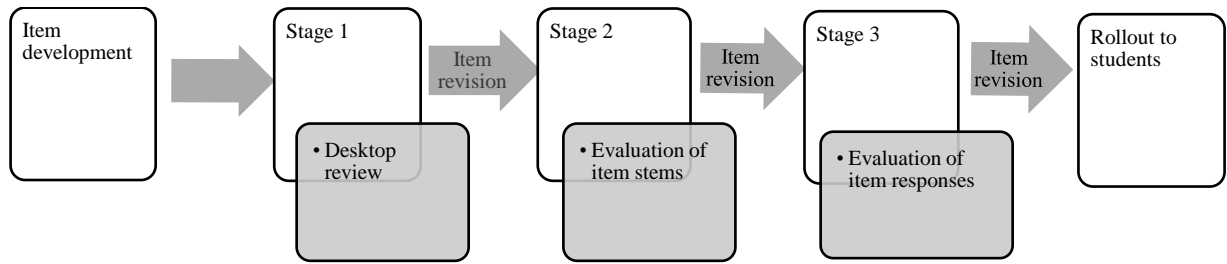


FIGURE 4.2 PROCESS OF EVALUATION OF SJT ITEMS

4.3.1 OVERVIEW OF STAGES

The first stage of the evaluation of the SJT began with a desktop review of the twenty-three test items by staff from TU Dublin and KU Leuven; their qualitative feedback was documented. In the second stage, the test was brought to three expert panels. These panels were comprised of junior engineers, senior engineers, engineering management and HR professionals from ESBI, Siemens and ENGIE. During these panels, the participants were asked to evaluate the item stems to check if the items were suitable representations of the professional skill which it had been related to while their qualitative remarks were recorded. This outcome of these panels is highlighted in table 4.1.

TABLE 4.1 SAMPLE FROM THE SECOND STAGE OF THE SJT EVALUATION WITH INDUSTRY

Item	Siemens	ENGIE	ESB
Positive critical attitude	<ul style="list-style-type: none"> • Fully agree with the case. • The cases matches Operational excellence very well. 	<ul style="list-style-type: none"> • As this was the first item to review, there was some discussion on how it actually works. • There is also an initiative element in this case (Robert asks Sarah), this confused them. • It is not clear what is expected: Being critical could be considered a positive thing 	<ul style="list-style-type: none"> • Case is not aligned to the role or to definition of competence. The case is more about communication to superiors.

		(e.g., R3). • Maybe change appropriateness R3 and R4 (suggestion).	
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The test was brought to three expert panels comprised of lecturing staff at TU Dublin with backgrounds in the engineering industry and psychology from the schools of Civil & Building Services engineering, Mechanical & Design Engineering and Electrical & Electronic Engineering. In these panels, the participants were asked to assign two or three skills to each SJT item to check for alignment between the item and the skill it was written to represent. The participants were provided with the list of twenty-three skills and their definitions, rather than the full list from BDO as this would have added a considerable amount of time to the sessions, which lasted for one hour each. Table 4.2 illustrates an example of the outcome of this process. Taking positive critical attitude as an example, the skill that it was designed to represent was listed by all five participants and so little work would have been carried out in reviewing this item. In instances where the skill did not appear, the skills which did appear predominantly were used as the basis for changing the items. For example, *if* positive critical attitude was to be altered, the elements of the item that hinted to a *focus on results* and *initiative* would have been diminished in the case by altering the dialogue of the actors in the item.

TABLE 4.2 SAMPLE FROM THE SECOND STAGE OF THE SJT EVALUATION WITH ACADEMICS

Positive critical attitude					
Rank	Participant				
	1	2	3	4	6
1	Focus on results	Focus on results	Initiative	Capacity for empathy	Initiative
2	Positive critical attitude	Positive critical attitude	Positive critical attitude	Positive critical attitude	Positive critical attitude
3	Negotiation	Client focus		Team spirit	

The data from the second review stage were compiled and reviewed by the researcher. Following revision of the content of the test items a second review stage began where the four possible responses to the scenarios presented in each item were reviewed in a further four expert panels with junior engineers (<5 years of experience), senior engineers (>5 years of experience), engineering management and HR professionals at *ARUP*, *BOSCH*, *Materialise* and two panels with *Siemens*. The participants were asked to indicate their level of experience and their role along with their scores of the level of appropriateness of *each* item response on a 1-5 Likert scale, their qualitative remarks were also recorded. The scores provided by the experts were compared to the theoretical scoring key established by the researcher. Table 4.3 illustrates an example of the outcome of this process.

TABLE 4.3 SAMPLE FROM THE THIRD STAGE OF THE SJT EVALUATION

Positive critical attitude			
Resp.	Scoring key	Experts	Reason
R1	Rather appropriate	Neutral	"Is there a reason you bought these" - Sassy
R2	Appropriate	Neutral	Combo of 2 & 4 would be best
R3	Inappropriate	Rather inappropriate	
R4	Rather inappropriate	Neutral	

The qualitative remarks were used to alter the responses in instances where there was disagreement between the developer's score and the expert's score as recommended by McDaniel and Nguyen (2001). Taking the above example of positive critical attitude, responses one and two would have been altered in line with the feedback while responses three and four would remain the same. All qualitative data from the evaluation of the SJT are available in Appendix B.

4.3.1 FINDINGS FROM THE EVALUATION PROCESS

The findings from each stage of the evaluation of the SJT items is presented in the proceeding sections, separated by the three test components for clarity. Few items were spared from some form of feedback during this evaluation process, which will be illustrated in the following sections. However rather than explaining the process of evaluation

for each of the twenty-three items, the following sections will highlight how the review process proceeded in a select number of cases, as they encompass the various decisions made about all items during this stage of the research. Given that the test scores on the SJT were computed based on industry representatives' perceptions of what constituted an (in)appropriate response, feedback from industry was taken over academics in cases where conflicting advice about the cases was provided by academics. Additionally, only panellists from industry were invited to provide a scoring key, which academics and industry alike were asked about the structure of the item stem and item responses.

4.3.1.1 PRODUCT LEADERSHIP

Several items related to the product leadership component of the SJT were identified as requiring revision. Referring to table 4.4, the items *vision* and *persuasiveness* were reasonable representations of the skills they represented, receiving two and three first rank endorsements respectively.

TABLE 4.4 ACADEMIC FEEDBACK FOR VISION AND PERSUASIVENESS ITEMS

Rank	Participant					
	1	2	3	4	5	6
Vision						
1	Focus on results	Conceptualisation	Innovation	Vision	Vision	Positive critical attitude
2	Solution orientation	Solution Orientation	Conceptualisation	Positive critical attitude	Conceptualisation	Vision
3		Helicopter quality				
Persuasiveness						
1	Focus on results	Clear communication	Persuasiveness	Innovation	Persuasiveness	Persuasiveness
2	Solution orientation	Negotiation	Networking	Negotiation	Clear communication	Negotiation

3		Persuasiveness				
---	--	----------------	--	--	--	--

Initiative, along with the other four items in the product leadership role did not fare as well in this process as *vision* and *persuasiveness*. Following the above panels with academics, the items from product leadership were reviewed by Siemens and ENGIE in two expert panels. *Persuasiveness*, which received positive endorsement from academics, received a positive endorsement from industry representatives as well, with the expert at Siemens and ENGIE highlighting that the link between the skill and the case was clear: Siemens remarked that it was a “*good case, very clear*” while ENGIE remarked that “*the case is very clear*”. ENGIE did remark on the responses, however. Particularly response 1 and response 4 where they stated that the personal element of response 1 should be removed “*‘you will be gaining my expertise’ - It doesn’t work that way*” and for response 4 where they state that it “*is not neutral but rather inappropriate ‘I am only interested in’ - change into mostly interested*”. Despite evaluating the item responses not being the goal of this panel, their feedback was considered as part of the item review.

Despite the item *initiative* performing poorly in the evaluation in the first set of panels with academics, the panels with industry found the item to be clear, although a little bit short and suggested changes to the appropriateness of a number of responses. Siemens remarked that the “case is clear, initiative is apparent”, while ENGIE remarked the case is “*pretty lightweight*” and could be extended.

The most poorly performing item in this process was *Creativity*. It received no endorsement as the skill linked with the case in the panels with academics, nor did it receive positive feedback in the panels with industry representatives. Siemens remarked as saying that they “*do not see the link with creativity*” and proposed that seeing more of the reasoning for each response may aid in the redevelopment of the item. Based on these remarks and the results of the panels, this item was entirely re-written. The item was re-written in such a way as to convey a willingness to engage and promote creative ideas.

4.3.1.2 OPERATIONAL EXCELLENCE

In this set of items, *positive critical attitude* received positive endorsement from academics, with 5 out of 5 participants endorsing positive critical attitude as being linked to the case, albeit second rank endorsements, as highlighted in table 4.5. Similarly, the item *planning & organising* (which had two versions) received two first rank

endorsements for that skill on the second version of the item, while the first version received none. This made the decision very clear as to which item to carry forward for further evaluation.

TABLE 4.5 ACADEMIC FEEDBACK FOR POSITIVE CRITICAL ATTITUDE AND PLANNING ITEMS

Rank	Participants					
	1	2	3	4	5	6
Positive critical attitude						
1	Focus on results	Focus on results	Initiative	Capacity for empathy	Initiative	
2	Positive critical attitude	Positive critical attitude	Positive critical attitude	Positive critical attitude	Positive critical attitude	
3	Negotiation	Client focus		Team spirit		
Planning & Organising 2						
1	Planning & Organising	Team spirit	Focus on results	Planning & organising	Solution oriented	Positive critical attitude
2	Work organisation		Solution orientated	Work organisation		

All other items considered by the panels of academics fared poorly in this process. Following on from these panels with academics, the items from operational excellence were reviewed by ESB, Siemens and ENGIE in three expert panels. All item stems and responses received extensive feedback from these panels and so all items were brought forward for redraft. Accordingly, no specific feedback pertaining to any items is tabulated here, however all the feedback from this process is published in Appendix B.

4.3.1.3 CUSTOMER INTIMACY

The items *client focus* and *solution orientation* received strong endorsements for the skills they represented, with 4 and 3 endorsements respectively from the panels of academics, as highlighted in table 4.6. All other items received poor skill match ratings and were tentatively considered for review.

TABLE 4.6 ACADEMIC FEEDBACK FOR CLIENT FOCUS AND SOLUTION ORIENTATION ITEMS

Rank	Participants				
Client focus					
1	Client focus	Team player	Positive critical attitude	Negotiation	Client focus
2	Focus on results	Client focus	Focus on results	Client focus	Networking
3	Negotiation		Capacity for empathy	Capacity for empathy	
Solution orientation					
1	Client focus	Solution oriented	Helicopter quality	Stress tolerance	Negotiation
2	Negotiation	Initiative	Initiative	Client focus	Solution oriented
3	Solution oriented		Stress tolerance	Clear communication	Work organisation

Following these three panels with academics the items from customer intimacy were reviewed by ESB and Siemens in two expert panels. Both *client focus* and *solution orientation* received positive reviews in both panels, resulting in these items being exempt from redraft, while the remaining 6 items were brought forward for redraft. These were the only two items of the twenty three items that did not require attention moving in to the item-response evaluation stage. Siemens remarked that *client focus* was an “*excellent case*” and remarked that the “*case was good*” for *solution orientation*. Similarly, ESB remarked that *client focus* was the item “*fits the competence*” and remarked that the “*cases and responses work*” for *solution orientation*.

4.3.2 EVALUATION OF THE ITEM RESPONSES – ESTABLISHING A SCORING KEY

Once the second stage of evaluation was complete and the output from the first six expert panels had been reviewed, the SJT items underwent an extensive redraft, with eighteen items being altered, three items being completely rewritten and two items remaining unchanged. Following this redrafting phase, the items were brought to a five expert panels with Bosch, Materialise, ARUP and two panels with Siemens in order to score the item responses.

The rating for the (in)appropriateness of each item response as determined by the PhD researcher was compared to the rating provided by these expert panels, participants in these panels were also requested to provide their remarks on why they deemed a response as (in)appropriate to serve as a basis for the redevelopment of the responses. The rationale for this was to establish a scoring key for the items based on what industry representatives considered (in)appropriate responses. The following sections detail the process for a select number of items, highlighting the types of decisions that were made during this phase of the evaluation.

4.3.2.1 PRODUCT LEADERSHIP

Overall, the scoring key compared well with that of the expert panel who examined the product leadership component of the SJT. In fact, only a single response across all seven items was poorly aligned to the expert's opinions. The context of the *persuasiveness* item was on an engineer making an investment pitch to potential investors. In response four, he states that he isn't interested in commercialising the product, but would like to licence the product to the investors. As highlighted in table 4.7, the only response which required attention was response 4. One panellist highlighted that the "investor wants a return, so he's investing in the person as well" and suggested that response four be made an inappropriate response.

TABLE 4.7 COMPARISON OF RESPONSE PATTERNS ON THE PERSUASIVENESS ITEM

Persuasiveness			
Resp.	Scoring key	Experts	Reason
R1	Rather appropriate	Rather appropriate	Answers the question
R2	Appropriate	Rather appropriate	Better, value selling. But a fluffy answer
R3	Rather inappropriate	Rather inappropriate	
R4	Neutral	Rather inappropriate	Investor wants a return, so he's investing in the person as well

4.3.2.2 OPERATIONAL EXCELLENCE

For the items grouped to operational excellence, the scoring key determined by the researcher compared favourably with the views of experts. Although less favourably than the scoring key developed for product leadership. In particular for the item *positive critical attitude*, in which a sensor is being installed by a junior engineer who notices the sensor isn't the best quality has the opportunity to voice his concerns to his manager. The expert responses tended towards the centre of the scoring key, in the *neutral* category for both responses two and four.

TABLE 4.8 COMPARISON OF RESPONSE PATTERNS ON THE POSITIVE CRITICAL ATTITUDE ITEM

Positive critical attitude			
Resp.	Scoring key	Experts	Reason
R1	Rather appropriate	Neutral	"Is there a reason you bought these" - Sassy
R2	Appropriate	Neutral	Combo of 2 & 4 would be best
R3	Inappropriate	Rather inappropriate	
R4	Rather inappropriate	Neutral	

This was an undesirable result as the neutral category allowed students to 'sit on the fence' and so the original scoring key for that item was retained. *Positive critical attitude* was evaluated again at another expert panel and similar results were obtained, with the experts endorsing neutral responses for responses two and four. Similar results were observed for the *team player* item, which is designed to expose students to a scenario where there is a personal issue between two colleagues. As indicated in table 4.9, the experts tended towards the middle of the (in)appropriateness scale on responses two and four.

TABLE 4.9 COMPARISON OF RESPONSE PATTERNS ON THE TEAM PLAYER ITEM

Team player			
Resp.	Scoring key	Experts	Reason
R1	Rather Inappropriate	Rather inappropriate	Shouldn't be discussing with Liz or the TL.
R2	Rather Appropriate	Neutral	This is the text book answer
R3	Appropriate	Rather inappropriate	A better response would be to pass it up to management without "naming names"
R4	Inappropriate	Neutral	

In relation to the *team player* item and in contrast to *positive critical attitude*, a clear difference of opinion was observed on response three between the researchers scoring and the experts. In this case, the rationale for their selection was used to alter that particular response.

4.3.2.3 CUSTOMER INTIMACY

Overall the theoretical scoring key compared well with the views of the experts on the customer intimacy item set. Similar effects of experts tending towards the centre of the scoring key and avoiding extreme responses was once again observed, although the majority of item responses aligned well with the theoretical scoring key with the notable exception of *clear communication and networking*.

The *clear communication* item was featured an engineer who had attended a meeting on behalf of a colleague and it was their role to brief their absent colleague on the key actions of the meeting. The experts viewed all responses entirely differently to what was intended by the researcher, as highlighted in table 4.10. Their reasoning was taken on board by altering the scoring key to align with their views.

TABLE 4.10 COMPARISON OF RESPONSE PATTERNS ON THE CLEAR COMMUNICATION ITEM

Clear communication		
Scoring key	Experts	Reason
Rather inappropriate	Rather appropriate	Don't like "is it okay for you", but its ok.
Rather appropriate	Rather inappropriate	This is like taking the work away from her
Neutral	Rather appropriate	Good because you're collaborating
Rather appropriate	Rather inappropriate	The worst, taking all the work away from her

The same was observed for the item *Networking* as highlighted in table 4.11, in which an engineer is sent to a trade show to show off their company's latest involutions and secure leads. Much of the item's operationalisation focusses on the respondent's inclination to actively engage with their audience and so the disparity between the researchers' scoring key and the expert key may be due to the introvert/extrovert personality trait.

TABLE 4.11 COMPARISON OF RESPONSE PATTERNS ON THE NETWORKING ITEM

Networking			
Resp.	Scoring key	Experts	Reason
R1	Inappropriate	Neutral	Neutral, it doesn't add much but also doesn't take away
R2	Neutral	Neutral	You need to signal to people that you are open and available
R3	Rather inappropriate	Rather appropriate	More proactive
R4	Rather appropriate	Appropriate	

The rationale for their scoring were taken on board and used to alter responses one and three as they were considerably different from the scoring key proposed by the researcher.

4.4 ROLLOUT OF THE SJT

After the scoring key had been established and final changes to the responses made, the SJT remained split into its three components for the roll out for the SJT to students. The original plan was to combine the components into a single test, but test exhaustion became the deciding factor in leaving the test divided into its three components, with conservative estimates of 60 minutes being made to read and evaluate all 23 items. A modest number of responses to the SJT were gathered for product leadership (n=59) and operational excellence (n=76) while customer intimacy achieved a more substantial response (n=205), due to a technical error in the email distribution system that resulted in the URL for product leadership and operational excellence not being sent correctly. The distribution of scores for each item were represented in box and whisker plots to facilitate a visual examination of the range of scores on each component of the SJT. Following this visual examination, the mean scores of the items in each component of the SJT was calculated, leading to the identification of several items in each test possessing lower mean scores. A reliability analysis of each test component was carried out using Cronbach's alpha. The purpose of the above analyses was to identify items that required further revision based on students' responses in each case and to further evaluate the robustness of the SJT items.

4.4.1 QUANTITATIVE ANALYSIS

The data generated during the pilot study were processed using a hybrid scoring key (Cucina *et al.*, 2012) which was the result of analysing the qualitative data collected from the six expert panels which evaluated the item responses. The scores key, which attributes scores to each item based on the student's chosen response is illustrated in table 4.12. Taking the example of a student who correctly identifies a response as being appropriate. When the experts also made this judgement, the student receives the maximum score of 6. Similarly, if the student identifies a response as neutral and this was also the judgement made by experts, the student once again receives a maximum score of 6. As there are four item responses per item each requiring a judgement of the level of appropriateness, the maximum score on any item is 24. The meaning of this score therefore is how closely aligned the students' assessment of the level of appropriateness was to the experts' assessment.

TABLE 4.12 THE SCORES FOR EACH ITEM RESPONSE

Expert judged appropriateness of n th response	Student responses to n th response				
	Appropriate	Rather Appropriate	Neutral	Rather Inappropriate	Inappropriate
Appropriate	6	4	2	0	0
Rather Appropriate	4	6	2	0	0
Neutral	1	2	6	2	1
Rather Inappropriate	0	0	2	6	4
Inappropriate	0	0	2	4	6

Item data were tested for normality using the Shapiro-Wilk's test of normality resulting in a rejection of the null hypothesis that these data differed significantly from a normal distribution. Accordingly, all item data were treated using parametric statistics. In particular, the mean score for each test was computed and compared to the item mean score to assess if significant differences existed between them. This difference in score represents a difference in the response pattern of the student when compared with the response pattern of the expert panellists and is interpreted as an area of professional weakness within the population of students who took part in the test.

4.4.1.1 RESULTS FROM PRODUCT LEADERSHIP TEST

The distribution of scores for each item are displayed in figure 4.2, with the mean score represented by the black line on each box plot and the data which fall within the normal distribution represented by the shaded area. A visual examination of the mean score of each item revealed that *Perseverance*, *Client focus* and *Vision* had the lowest mean scores out of the 7 items in the product leadership component and appeared to be significantly lower than the mean scores of the other items.

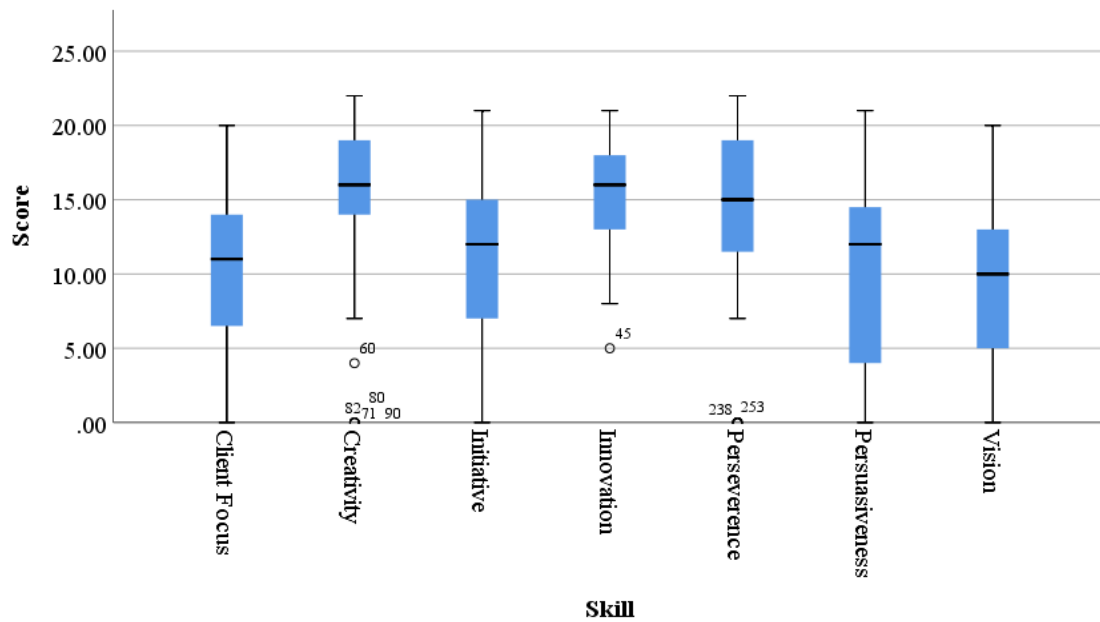


FIGURE 4.2 BOX AND WHISKER PLOT FOR PRODUCT LEADERSHIP ITEMS

To test this hypothesis H_{1a} , the mean scores per item were compared with the test mean using a paired sample t-test. The results presented in table 4.13 indicate that the three items identified in the box and whisker as having the lowest mean score were in fact significantly lower when compared with the student mean scores resulting in a rejection of the null hypothesis H_0 in favour of hypothesis H_{1a} . This suggested that the items *Perseverance*, *Client focus* and *Vision* were all areas of students professional skills that required attention. This is supported by the low item mean score, implying that on average, all student performed poorly on these items. This is in contrast to items such as *creativity*, *innovation* and *perseverance*, which had comparatively high mean scores and retained a large variance in these scores, implying they can still discriminate between high performing and low performing students.

TABLE 4.13 PAIRED SAMPLES T TEST FOR PRODUCT LEADERSHIP ITEMS

Item	Mean	Standard deviation	t	df	Sig
Innovation	3.356	4.788	5.384	58	.000
Creativity	3.153	4.266	5.676	58	.000
Vision	-3.034	4.017	-5.801	58	.000
Persuasiveness	-1.932	3.810	-3.896	58	.000
Perseverance	1.661	3.646	3.499	58	.001
Initiative	-1.034	3.429	-2.316	58	.024
Client focus	-1.814	3.457	-4.030	58	.000

4.4.1.2 RESULTS FROM OPERATIONAL EXCELLENCE TEST

The distribution of scores for each item are displayed in figure 4.3, with the mean score represented by the black line on each box plot and the data which falls within the normal distribution represented by the shaded area. As illustrated in figure 4.3, *planning and organising*, *solution orientation*, *team player*, and *work organisation* had lower mean scores than the other items. It was unsurprising that *work organisation* and *planning and organising* were of similarly low scores as the operationalisation of these items was very similar; in both instances a cognitively loaded item was avoided, for example an item where an optimised schedule had to be created – as this would not fit well within the taxonomy of an SJT item. Instead, responses outlining consistent and inconsistent plans were created and the respondent was asked to rate each of these in terms of their utility for completing a particular task.

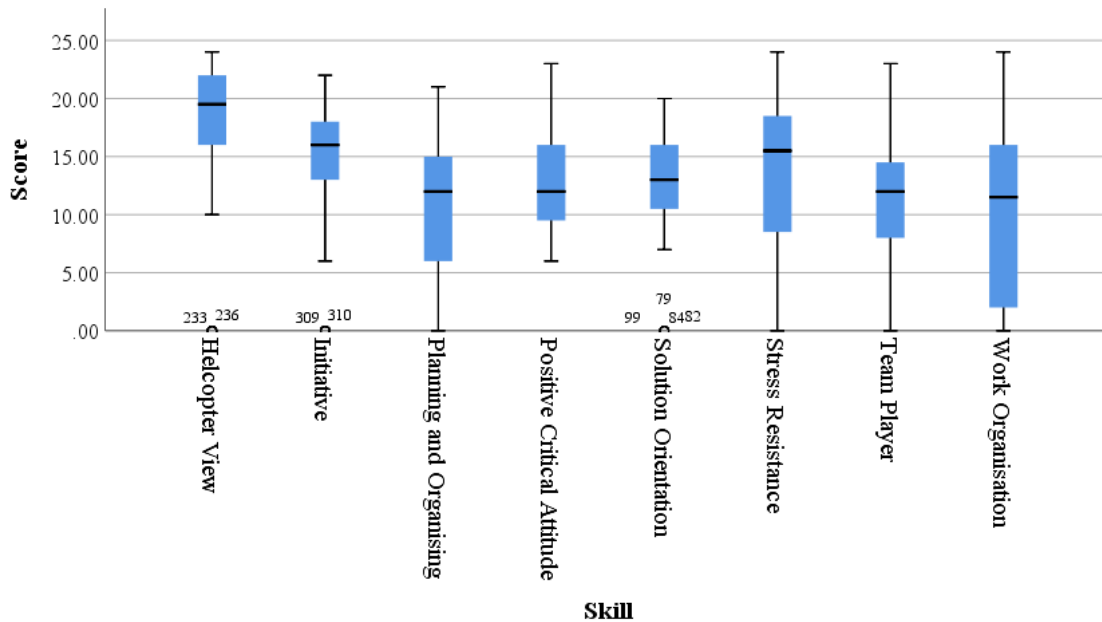


FIGURE 4.3 BOX AND WHISKER PLOT FOR OPERATIONAL EXCELLENCE ITEMS

To test this hypothesis H_{1b} that the above items did indeed have significantly different, the item means were compared with the test mean scores using a paired sample t-test. The results presented in table 4.14 indicate that the four items identified in the box and whisker as having the lowest mean score were in fact significantly lower when compared with the student mean scores resulting in a rejection of the null hypothesis H_0 in favour of hypothesis H_{1b} . The *work organisation* item was of particular concern due to the low mean score, but also the variance in the score. The distribution of scores within the normal distribution presented as the shaded boxes in figure 4.3 illustrate that the tail of the distribution of scores for *work organisation* was firmly placed between and score of 0-5. This was also the case for *planning and organising*, although to a slightly lesser extent, and presented areas of weakness in the students' professional skills that should be addressed.

TABLE 4.14 PAIRED SAMPLES T TEST FOR OPERATIONAL EXCELLENCE ITEMS

Item	Mean	Standard deviation	t	df	Sig
Positive critical attitude	-.1039	5.988	1.255	76	.879
Solution orientation	-.0649	4.072	.859	76	.889
Team player	-1.662	4.287	-.689	76	.001
Helicopter view	4.402	4.139	5.342	76	.000
Initiative	1.324	3.529	2.125	76	.002
Work organisation	-2.389	5.373	-1.170	76	.000
Stress resistance	.441	5.053	1.588	76	.446
Planning and organising	-2.363	4.032	-1.448	76	.000

4.4.1.3 RESULTS FROM CUSTOMER INTIMACY TEST

The distribution of scores for each item are displayed in figure 4.4, with the mean score represented by the black line on each box plot. As illustrated in figure 4.4, a visual examination of the mean scores reveal that *Clear communication* and *networking* had lower mean scores than the other items. Hypothesising that these means were significantly different the other items H_{1c} a more detailed examination was carried out using a paired sample t test.

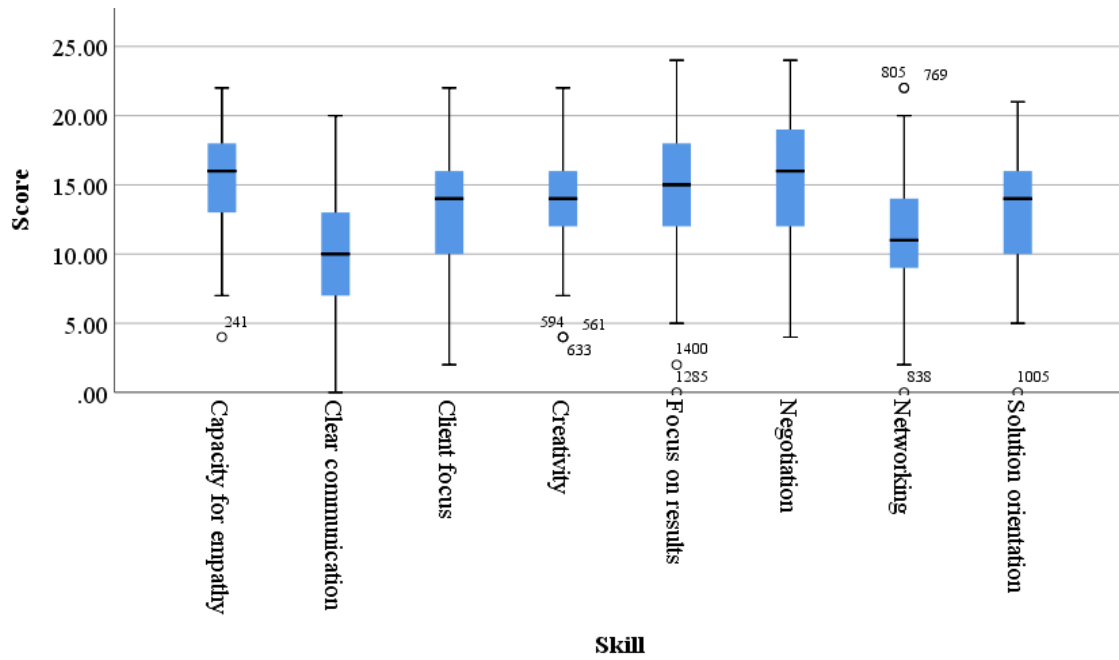


FIGURE 4.4 BOX AND WHISKER PLOT FOR CUSTOMER INTIMACY ITEMS

The results of the paired sample t test of the customer intimacy items revealed that *Clear communication* and *networking* had significantly lower means scores when compared with the test mean, resulting in a rejection of the null hypothesis H_0 in favour of the alternative hypothesis H_{1c} .

TABLE 4.15 PAIRED SAMPLES T TEST FOR CUSTOMER INTIMACY ITEMS

Item	Mean	Standard deviation	t	df	Sig
Client focus	.848	5.099	1.55	204	.018
Capacity for empathy	1.921	3.907	2.46	204	.000
Clear communication	-3.448	4.179	-2.873	204	.000
Creativity	.307	3.141	.739	204	.163
Networking	-2.224	3.453	-1.748	204	.000
Solution orientation	-.326	3.460	.149	204	.178
Negotiation	1.531	4.304	2.124	204	.000
Focus on results	.970	3.725	1.483	204	.000

In light of the mean score on *Clear communication* being significantly lower than the test mean, this skill was identified as skill that required training in the population of students that were sampled. *Networking* had similarly low scores however this item may be a candidate for review rather than being interpreted as an area for students to work on. The *networking* item was operationalised in a way that tests whether a respondent will proactively networking by approaching potential clients or take a more passive approach and so it is posited that this item is personality-loaded and may be testing the introvert-extrovert trait. The interpretation of the data therefore is that participants on average tend toward introversion and that the score is not simply a reflection of the item being difficult to evaluate.

4.4.2 RELIABILITY ANALYSIS

After the collection of data from the roll out of the test had been collected, an analysis of the reliability of the SJT was carried out. The purpose of a reliability analysis is to determine the relationship between scores on individual items. In this context it was carried out to determine if the test items in a particular role were well related. The

formula used was the Tau equivalent reliability formula, more commonly referred to as “Cronbach’s alpha” (Cronbach, 1955)

The reliability of SJT’s are difficult to determine by conventional means. At an item level, they are typically “construct heterogeneous” and may measure multiple constructs (Patterson *et al.*, 2012) in simple terms they may not measure a single skill, but may measure several, interrelated skills at once. First, taking Cronbach’s Alpha as the lower bound of the true reliability of a test; a coefficient that is a function of the degree to which scores on the items of the test are inter-related, the values of the coefficient can range from .43 and .94 when used to measure the reliability of an SJT (Mcdaniel and Nguyen, 2001). This is a rather large range of values that may be explained by two factors which are not mutually exclusive; the items of an SJT are rarely construct heterogeneous by design and/or the length of the test both play a role. To take an example, a test that focuses on measuring communication skills alone (or at-least measure multiple facets of communication in the same format) would likely achieve high levels of internal consistency due to higher inter-item correlations, while a test that contained items that attempted to measure multiple skills would likely have a lower internal consistency value as the inter-item correlations would be posited to be low. Test length also has a strong influence on internal consistency and even construct heterogeneous tests that attempt to measure multiple skills, provided they are of sufficient length, can be shown to have high values of internal consistency (Cortina, 1993).

The topic of what an SJT measures is a hotly debated topic, however several meta-analysis have revealed that SJT’s measure several related constructs including 3 of the Big 5 personality traits and general intelligence depending on how the test has been designed (Mcdaniel and Nguyen, 2001; Mcdaniel *et al.*, 2001; Whetzel, Mcdaniel and Nguyen, 2008). SJT’s are best viewed as *methods* that can measure a wide variety of constructs (Chan and Schmitt, 1997; Weekley and Jones, 1999). Taking Cronbach’s alpha to be the lower bound of the true reliability of the tests, the internal consistency of the product leadership test was found to be .496, for operational excellence it was found to be .225 and for customer intimacy it was found to be .272, based on standardised items. This was partly due to the number of observations made per role, as reliability tends to be covariant with the number of items in the scale (Cortina, 1993) and partly due to the inter-item correlations, which form the basis of the Cronbach’s alpha calculation.

4.5 CHAPTER SUMMARY

In summation, this chapter outlines the work that was carried out to develop and evaluate this SJT. In the development stage, all items were initially drafted and internally reviewed to make semantic and grammatical changes before presenting them to stakeholders, both academic and industrial. Following the evaluation of the item stems, the item responses were evaluated with industry stakeholders and a revised scoring key was developed. The test in its three constituent parts was piloted with engineering students in their final year undergraduates and masters courses, which lead to the identification of a number of items which the majority of the student's struggled to evaluate effectively. It is important to note that the final stage of evaluating the SJT, the pilot study, occurred in tandem with much of the research presented in chapter 5 about utilising the SJT as a stimulus of metacognitive behaviour.

CHAPTER 5: DEVELOPING AND DELIVERING THE METACOGNITIVE ACTIVITY

5.1 CHAPTER OVERVIEW

This chapter outlines the final stage of the research, in which the final version of the SJT was implemented as a stimulus of metacognitive behaviour. To achieve this, the SJT reported in chapter 4 was provided to students, who were allowed to read and openly discuss the items and their chosen responses in groups of 4-6. This process lead to the identification of several SJT items that were deemed fit for purpose for stimulating metacognitive behaviours. Those items were then provided to new groups of in an in-depth study of student behaviour while they interact with the items. This chapter outlines the results of the application of the chosen coding strategy to analyse the collected transcripts, the outcome of which lead to the development of a new learning resource for stimulating metacognitive behaviours in first year engineering students.

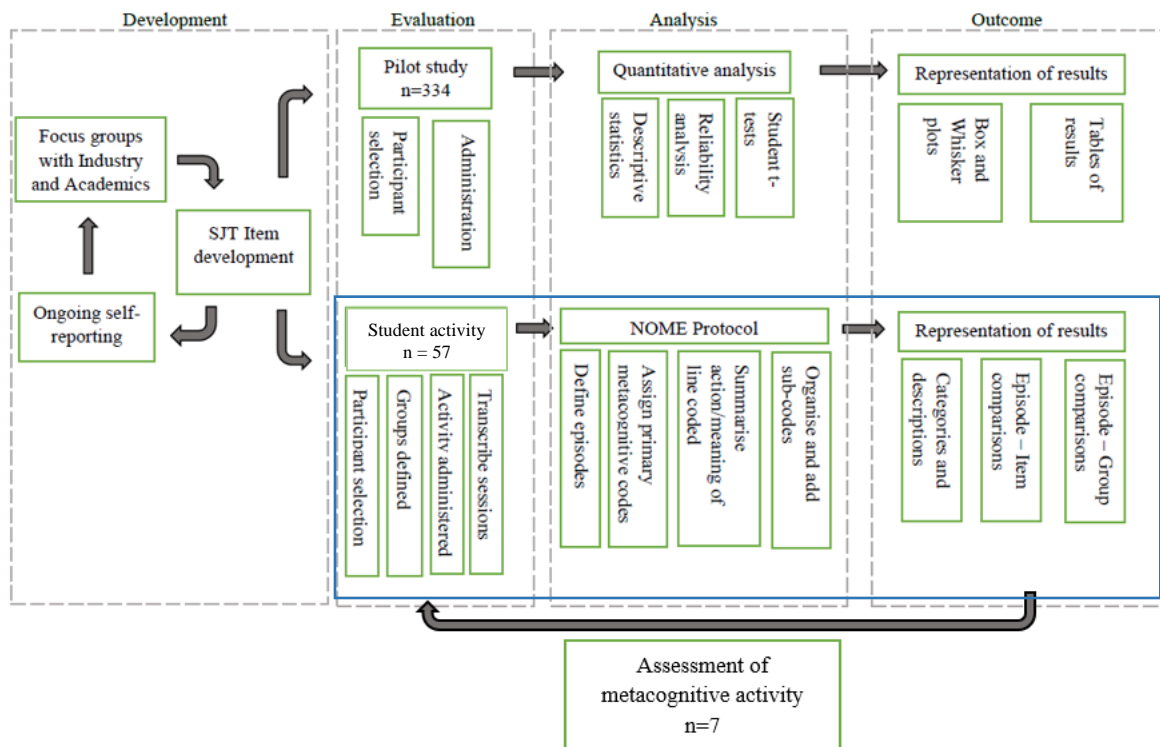


FIGURE 5.1 RESEARCH ACTIVITIES UNDERTAKEN (BOTTOM STREAM)

5.2 EVALUATING THE SJT AS A STIMULUS OF METACOGNITIVE BEHAVIOUR

Students were recruited for the evaluation of the SJT as a stimulus of metacognitive behaviour through a first-year full time undergraduate project-based learning laboratory in the sixth week of a project to design and build a bridge. A description of the sample can be seen in table 3.1. Students were provided with a five-minute presentation outlining the purpose of the activity and instructions on how to evaluate the activity. Students were asked to take turns reading the item allowed within their group, evaluate the responses for the item by providing each with a score from 1-5 and then discussing their rationale with the group for choosing these scores before moving on to the next item. The students' interactions were recorded (audio only) to extract transcripts for subsequent codifying of results. Two recordings of the students dialogue were corrupted and so the coding strategy could not be applied.

TABLE 5.1. DESCRIPTION OF SAMPLE UTILISING SJT TO STIMULATE METACOGNITION

Group	Location	Gender	Nationality	Duration of session	Timing and activities
1A	On campus, November of the 2019/20 academic year	Male	Irish	52 minutes	2:00 PM Friday, Received the Product Leadership item set
		Male	Irish		
		Male	Irish		
		Male	Irish		
		Male	Non- national		
2A	On campus, November of the 2019/20 academic year	Male	Irish	33 minutes	2:00 PM Friday, Received the Customer Intimacy item set
		Male	Irish		
		Male	Irish		
		Male	Non- national		
		Male	Irish		
3A	On campus, November of the 2019/20 academic year	Male	Irish	30 minutes	2:00 PM Friday, Received the Operational Excellence item set. Recording corrupted
		Male	Irish		
		Male	Irish		
		Male	Irish		
		Male	Irish		

4A	On campus, November of the 2019/20 academic year	Male	Non-national	40 minutes	2:00 PM Friday, Received the Operational Excellence item set
		Male	Non-national		
		Female	Irish		
		Female	Irish		
5A	On campus, November of the 2019/20 academic year	Male	Irish	32 minutes	2:00 PM Friday, Received the Customer Intimacy item set
		Female	Irish		
		Female	Non-national		
		Male	Non-national		
		Male	Irish		
1B	On campus, March of the 2019/20 academic year	Male	Irish	26 minutes	2:00 PM Friday, Received the Operational Excellence item set
		Male	Irish		
		Male	Non-national		
		Female	Irish		
		Female	Non-national		
2B	On campus, March of the 2019/20 academic year	Male	Irish	41 minutes	2:00 PM Friday, Received the Product Leadership item set
		Male	Irish		
		Male	Irish		
		Male	Irish		
		Male	Non-national		
		Male	Irish		
3B	On campus, March of the 2019/20 academic year	Male	Irish	21 minutes	2:00 PM Friday, Received the Product Leadership item set
		Male	Non-national		
		Male	Irish		
		Female	Irish		

		Female	Irish		
4B	On campus, March of the 2019/20 academic year	Male	Irish	33 minutes	2:00 PM Friday, Received the Operational Excellence item set
			Non-		
		Male	national		
		Male	Irish		
		Female	Irish		
		Female	Irish		
5B	On campus, March of the 2019/20 academic year		Non-	27 minutes	2:00 PM Friday, Received the Customer Intimacy item set
		Female	national		
		Male	Irish		
		Male	Irish		
		Female	Irish		
6B	On campus, March of the 2019/20 academic year	Male	Irish	22 minutes	2:00 PM Friday, Received the Operational Excellence item set
		Male	Irish		
		Male	Irish		
		Male	Irish		
7B	On campus, March of the 2019/20 academic year	Male	Irish	25 minutes	2:00 PM Friday, Received the Operational Excellence item set. Recording corrupted
			Non-		
		Male	national		
		Male	Irish		
		Male	Irish		
		Male	Irish		

5.2.1 CODING STRATEGY

The coding strategy adopted for the analysis of the transcripts from the pilot study was a four-stage process as illustrated in figure 5.1. The episodes were defined as instances where a metacognitive behaviour was exhibited, this could include making a plan to read the items aloud, students thinking aloud or having a dialogue about the reasonableness of a response pattern. The codes, extracted from Whitebread (2013) for identifying metacognitive behaviour, are provided in Table 5.2. Episodes in each transcript were identified in two categories, on-task item

related and on-task non-item related metacognitive behaviours. The rationale for creating these categories was the acknowledgement by the research that metacognitive behaviours could occur informally (when students are between items) and formally (when they are working on an item). On-task item related behaviours were initially coded with the item name and on-task non-item related behaviours were coded with an asterisk to differentiate them when counting the number of item-related behaviours. An example an on-task non-item related behaviour can be found when students are between items, when students are determining who will read the next item. This would be identified as a planning behaviour and coded and sub-coded as *planning, makes a plan*. This behaviour does not relate to any particular item, but it does relate to the activity.

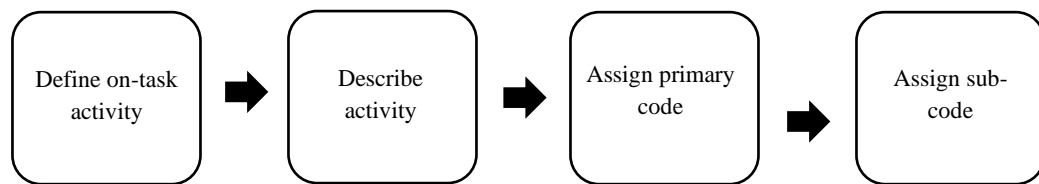


FIGURE 5.2 CODING STRATEGY FOR NATURALISTIC OBSERVATIONS OF METACOGNITION

After the episodes had been identified and the relevant dialogue between the respondents recorded, the dialogue was described to provide a rationale for coding that dialogue as the exhibition of a metacognitive behaviour. Once this rationale had been provided a code and sub-code was assigned to categorise the behaviour as an example of metacognitive knowledge using the sub-codes provided by McCord and Matusovich (2019). A full description of each of these sub-codes is provided in Table 8.10 in Appendix B while a sample of the coding process is provided here, in table 5.3. The set of codes provided in the NOME protocol were comprehensive and no behaviour was identified that did not map easily to the codes. In fact, the only issue with the protocol was under-utilisation of certain codes, as certain behaviours were not observed.

TABLE 5.2 SAMPLE OF THE CODING PROCESS

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
	Respondent 1: Will I read?	Respondent makes a plan by suggesting to read the item out loud for the group	Planning	Makes a plan
	Respondent 2: So is this . . is this based off what we would say or what would be an appropriate response	Respondent checks that they understand the answering strategy	Monitoring	Checks understanding
	Respondent 1: Yeah, so did he say like 5 . . . so you give 1 if it's bad, 5 if it's good?	Respondent checks that they understand the answering strategy	Monitoring	Checks understanding
	Respondent 3: I think we just rank them		Monitoring	Comments on understanding
	Respondent 1: I think that he said you can give them all 5 if they're all good responses		Monitoring	Comments on understanding
Client focus	Respondent 1: Yeah, so 'I suggest that you extend my contract' . . . I will work extra hard	Respondents evaluate the reasonableness of response 3	Evaluation	Reasonableness
	Respondent 3: I think the third one he gives the choice to the client like, and all the information like, you know			
	Respondent 1: Yeah and allow him to make an informed decision			
	Respondent 3: Exactly			

Client focus	Respondent 1: Did you say put 5?	Respondent checks that they understand the answering strategy	Monitoring	Checks understanding
	Respondent 3: 5			
Client focus	Respondent 3: Because for the first one you could argue that that's what the client wants but then you could say the second response you could say that's what's best for the client . . so the client might not know about . . this person is better suited for . .	Respondents evaluate the reasonableness of response 1	Evaluation	Reasonableness
Client focus	Respondent 1: Yeah exactly, so now that's like a 3, it's okay . . both of them a 3 . . yeah? Okay	Respondent checks that they understand the answering strategy	Monitoring	Checks understanding

5.2.2 ORGANISATION OF CODES & SUB-CODES

The coding strategy was applied to eleven transcripts as two groups were omitted due to a file corruption of the audio in one case (Group 3A) and due to the audio being of poor quality in another (Group 7B). The codes and sub-codes were then organised by group, to examine the types of metacognitive behaviour that were dominant in the activity and then by item, to examine which items were stimulating the most metacognitive behaviour. The outcome of this process identified several factors which influenced the students' interaction during the activity, including group composition and the presence of "high status" individuals. Furthermore, it highlights the efficacy of particular items in eliciting metacognitive behaviour which were carried forward into the final activity with students.

5.2.3 CODES ARRANGED BY GROUP

The application of the coding strategy to the transcripts shows that the two most common metacognitive behaviours were monitoring and evaluating task performance, while the least common behaviours were planning an approach and controlling cognition. These findings are in line with the findings of McCord and Matusovich (2019) who found that student's on-task behaviour focussed on monitoring and evaluating problems. Similarly, the metacognitive knowledge type behaviours were coded infrequently compared to the metacognitive skill type behaviours, which was also an outcome of the work of McCord and Matusovich.

Groups showed varying degrees of engagement with the activity, as indicated by the sum total of all codes identified per group in table 5.4. The least engaged of these groups were groups 2A and 4B. Group 2A received the Customer Intimacy items while group 4B received Operational Excellence items and so the item set is not an explanatory factor in their lack of on-task metacognitive behaviour. Group 2A got off to a slow start in terms of the level of meaningful discussion that was taking place about item responses, however by item three they appeared to get to grips with the procedure and were discussing their responses more openly. The group did rely heavily on consensus with some members asking for prompts on what the "accepted" responses pattern was. Respondent four, a non-national male student provided little input to the group.

TABLE 5.3 METACOGNITIVE BEHAVIOURS CATEGORISED BY CODE

	Groups										
Behaviour	1A	2A	4A	5A	1B	2B	3B	4B	5B	6B	Totals by behaviour
Knowledge of person	0	0	1	2	0	0	0	0	0	0	3
Knowledge of strategy	0	1	7	1	0	0	0	0	1	0	10
Knowledge of task	2	1	0	1	1	0	1	3	0	1	10
Planning	0	2	0	5	1	3	0	0	1	2	14
Monitoring	9	5	9	4	24	7	11	5	10	5	89
Evaluating	10	9	9	11	22	14	15	9	18	14	131
Control	0	1	0	1	0	0	1	0	1	0	4
Totals by group	21	19	26	25	48	24	28	17	31	22	

A similar effect was observed in Group 1A. This group was made up of four Irish males and one international male student. The discussion was largely dominated by respondent one and two for the first two items, with the participants consistently interrupting one another before they could justify their chosen responses. After this, the discussion opened up to participant three & four and less interruption was observed for the remaining items. Participant five, the male from Kuwait had very limited input to the conversations. Based on observations made by the researcher, he was engaged in the process of selecting responses however he did not actively engage in deliberating on the responses. The above may be evidence that having a single non-national male in a group of Irish males is not conducive to active participation by all participants. This does not account for group size, students age and experience or the personality traits of the respondents. However, it may be taken simply as best practice not to include a single non-national student in a group composed of Irish male students.

TABLE 5.4 METACOGNITIVE BEHAVIOUR PER PARTICIPANT AS A PERCENTAGE OF THE TOTAL

CODES IN EACH TRANSCRIPT

	Respondent					
Group	1	2	3	4	5	6
Group 1A	33	20	14	21	12	
Group 2A	46	30	17	7	0	
Group 4A	39	38	8	15		
Group 5A	21	26	22	13	18	
Group 1B	36	34	20	7	4	
Group 2B	49	7	9	22	9	5
Group 3B	26	11	18	45	0	
Group 4B	80	11	6	3	0	
Group 5B	53	19	28	0		
Group 6B	21	15	23	40	2	

As for group 4B, who had similarly low levels of coded activity, a likely cause of the lack of engagement by the group was the domination of the conversation by respondent one, an Irish male student. An analysis of the transcript revealed that 80% of the coded dialogue in the transcript could be associated with the comments made by respondent one. The same was observed for group 6B, who had similarly low levels of coded behaviour. In this group respondent four, an Irish male, took charge very quickly and moderated the discussions reasonably well by ensuring all group members were happy with the scores. However, he was in most cases the one proposing these scores and then allowing others to come in with alternative scores. This was a group of all Irish male students and so a large deviation in the assigned scores wasn't to be expected, however the approach taken by the group certainly would not have facilitated the expression of differences in opinion given the dominant behaviour of respondent 4. This lack of peer interaction in groups 4B and 6B certainly had an impact on the exhibition of metacognitive behaviour during the task and these results highlight the role of high-status individuals in group knowledge construction. Based on the observations made, these high-status individuals appear to be made up entirely of Irish students, predominantly males. In contrast to these results, there were some groups with a diverse set of individuals who performed well on this task.

Group 1B, which was made up of two Irish males, one female international, one male international and one Irish female student, performed significantly better on this activity relative to any other group. Forty-eight instances of metacognitive behaviour were identified, the highest number of coded behaviours of any group, and although the distribution of codes per student was not evenly distributed, it was far more distributed than any other 'B' groups' discussion. Similar results were recorded for group 5B. This group was made up of one Irish female, one Kuwaiti female and two Irish males, sticking a fifty-fifty balance both in gender and in national and international students. Their group has the second highest number of coded behaviours, second only to group 1B, who were, for the most part, equally well balanced in terms of gender and nationality. As for the distribution of codes per participant in group 5B, fifty-three percent of the coded behaviour can be attributed to participant one, an Irish female, while no coded behaviours were recorded for participant four, the international female student. This again highlights the role of high-status individuals in group discussion and also further highlights who feels that they are entitled to speak during these group discussions. It is important to consider the limitations of the above findings at this stage, as group dynamics are highly complex, and this was not the intension of this research to explore group dynamics in detail. Accordingly, the above findings are limited by not considering the effects of group size, which varied from 4-6 individuals, their personality traits, in particular the role of introversion on their level of input and their age and level of experience, which may also affect their perceptions of their entitlement to speak during the activity.

A further finding of this analysis was the order in which the metacognitive behaviours occurred, an examination of the students' processes of determining an appropriate response pattern did not follow an optimum pattern of behaviour to arrive at their conclusions. The optimum order of events for successful problems solving is be *planning*, *monitoring* and *evaluating* (Brown, 1977). In other words, students would first decide who might read the case and discuss a strategy for evaluating the case (planning), during the evaluation they would monitor their understanding by asking clarifying questions and checking their understanding (monitoring). Finally, having arrived at a suitable response pattern evaluate that response pattern in terms of its' effectiveness as a solution to the item and check that their strategy was "correct" by discussing the item with their peers (evaluation). Control type behaviours would come in the form of identifying (by monitoring their progress) that their strategy for choosing the response pattern was incorrect and altering their approach going forward. This was not the observed order in which students utilised their self-regulatory skills, in most instances, the planning phase was skipped entirely and issues with students' understanding of the way to evaluate the items would come to the fore when they were monitoring their progress. This result may suggest that students do not have the transcendental metacognitive skills to realise that planning is

an effective strategy to generate a response pattern to these items when they work in groups. The same result was observed by Mccord and Matusovich (2019), in their study, they found students exhibit very little planning behaviour and spend their time monitoring their performance and evaluating their solutions. Two explanations of students lack of ability to problem solve effectively are possible. One is that students - through their formal education up until first year of university - have not been provided with ample opportunity to develop effective strategies for problem solving (Griffin, 2014). The second is that students who are effective problem solvers in one domain, such as mathematics problem solving, do not possess the transcendental metacognitive skill to apply their knowledge of strategy to the SJT items (Boekaerts, 1997).

5.2.4 SUB CODES ARRANGED BY GROUP

A further analysis of precisely which behaviours were stimulated was undertaken by examining the sub-codes from each group, which have been abbreviated in tables 5.6 and 5.7. Table 5.6 provides the sub-codes for metacognitive knowledge while table 5.7 provides the sub-codes for metacognitive skills. The results of the analysis of the sub codes indicate that while the majority of these sub-codes were used by one group or another, that the quantity of these sub-codes by comparison to the metacognitive skills sub codes is small.

TABLE 5.5 METACOGNITIVE KNOWLEDGE SUB CODES ARRANGED BY GROUP

Behaviour	Group										Totals
	1A	2A	4A	5A	1B	2B	3B	4B	5B	6B	
<i>Knowledge of persons</i>											
Self (KS)	0	0	0	0	0	0	0	0	0	0	0
Others (KO)	0	0	0	2	0	0	0	0	0	0	2
<i>Knowledge of task</i>											
Across tasks (KAT)	0	1	0	1	1	0	1	2	0	1	7
Task difficulty (KTD)	2	0	0	0	0	0	0	1	0	0	3
<i>Knowledge of strategy</i>											
Evaluates effectiveness (KEE)	0	0	2	1	0	0	0	0	1	0	4
Explains procedure (KEP)	0	0	0	0	0	0	0	0	0	0	0

The most frequently coded of these sub-codes were KAT and KEE. KAT was applied as a sub-code when a student, as per the definition of the sub-code “compares across different tasks (similarities/ differences)” i.e., when students compared and contrasted different responses to the item in order to determine the optimal response pattern. An example of this code is found in the transcript of group 4B, respondent one remarks on the *solution orientation* item: “*I thought response 2 and 4 were the best, but I’d say that 2 is a little bit more aggressive*”. The student compares the reasonableness of responses two and four, displaying a knowledge of task. KEE was coded on four occasions in the transcript, this code refers to a respondent’s ability to “Evaluate the effectiveness of one or more strategies in relation to the context or the cognitive task”. In the context of the SJT item this took the form of student’s evaluating the efficacy of one or more response strategies before attempting to apply them to the item, this is in contrast to retrospectively assessing how effective the strategy was, which is coded and sub-coded under ESQ. An example of KEE is drawn from group 4A, respondent two, who remarked on the item *positive critical attitude*: “*He shouldn’t be like “I think you should”, it’s better for him to say his opinion and if there are cheaper ones [sensors] out there not to say it*”. In this instance, the student sought to correct the strategy of the actor in the case, displaying knowledge of strategy.

Overall students’ tendency to draw on their prior knowledge of problem-solving processes was quite minimal. This may indicate that students did not see the generality of the strategy they would employ in traditional problem solving and seek to apply that strategy to these problems as well. It may also suggest that students did not require prior knowledge to complete these items, suggesting that SJT items are more appropriate than technical problems when seeking to observe skills-type behaviors, rather than knowledge type behaviors in first year students.

As for the sub-codes ascribed to the metacognitive skills behaviors, a contrast is apparent between planning & control type behavior and monitoring & evaluation type behavior. The PCI and PRS were the only sub-codes that occurred frequently enough to merit any discussion. PCI is coded when students identify critical pieces of information in the case that will help them select an appropriate response pattern, while PRS is coded when the student listens to the strategy proposed by another student and repeats that strategy for mental clarity. An example of PCI is drawn from group 2A, respondent one, who remarks on the *networking* item “*so, what’s the best way to*

engage with the crowd” and proceeds to read the case aloud. In this instance, the student identifies a goal and then proceeds to collect the necessary information, demonstrating planning behavior.

The substantial lack of control behavior may be linked to the lack of planning behavior. In the context of this activity, control behavior relates to re-formulating and internalizing a particular strategy, while planning relates to the initial formulation of the strategy to begin with. If students don’t adequately formulate a strategy, then there is no need to clarify that strategy by exhibiting control type behavior.

TABLE 5.6 METACOGNITIVE SKILLS SUB CODES ARRANGED BY GROUP

Behaviour	Group										Totals
	1A	2A	4A	5A	1B	2B	3B	4B	5B	6B	
Planning											
Collects info (PCI)	0	2	0	2	0	0	0	0	0	1	5
Assigns a task (PAT)	0	0	0	0	0	0	0	0	0	0	0
Makes a plan (PMP)	0	0	0	1	0	0	0	0	1	0	2
Homework format (PHF)	0	0	0	0	0	0	0	0	0	0	0
Covered (PC)	0	0	0	0	0	0	0	0	0	0	0
Goals (PG)	0	0	0	0	0	0	0	0	0	0	0
Control											
Motion or gesture (CMG)	0	0	0	0	0	0	0	0	0	0	0
Asks for help (CAH)	0	0	0	0	0	0	1	0	0	0	1
Model/representation (CMR)	0	0	0	0	0	0	0	0	0	0	0
Verbally repeats (CVR)	0	0	0	0	0	0	0	0	0	0	0
Repeats strategy (CVS)	0	0	0	0	1	3	0	0	0	0	4
Changes strategy (CCS)	0	1	0	1	0	0	0	0	0	0	2
Helps others (CHO)	0	0	0	0	0	0	0	0	0	0	0
Effectively (CE)	0	0	0	0	0	0	0	0	0	0	0
Previous strategy (CPS)	0	0	0	0	0	0	0	0	0	0	0
Monitoring											
Checks goal (MCG)	0	0	0	0	0	0	0	0	0	0	0

Memory retrieval (MMR)	0	0	0	0	0	0	0	0	0	0	0
Mental clarity (MMC)	0	0	0	0	0	1	0	0	0	0	1
Error-detection (MED)	0	0	0	0	0	0	0	0	0	0	0
Self-commentates (MSC)	0	1	0	0	0	0	0	0	0	0	1
Corrects others (MCO)	1	1	0	0	1	0	0	0	0	0	3
Comments on understanding (MCU1)	0	0	0	1	1	1	0	0	2	0	5
Known/unknown info (MKU)	1	2	4	1	2	0	0	0	0	0	10
Self-corrects (MSC)	0	0	1	0	1	0	0	0	0	0	2
Checks progress (MCP)	0	1	3	0	4	2	5	1	4	1	21
Checks understanding (MCU2)	3	1	0	1	4	1	6	1	4	0	21
Checks strategy (MCS)	0	0	1	1	3	0	0	0	0	0	5
Checks answer (MCA)	0	0	0	0	8	2	1	3	0	4	18
Evaluation											
Correctness/accuracy (ECA)	0	0	1	1	0	0	0	0	0	0	2
Reasonableness (ER)	8	8	5	11	7	12	11	9	18	14	103
Success/quality (ESQ)	2	1	2	3	5	1	4	0	0	0	18
Progress (EP)	0	0	1	0	1	0	0	0	0	0	2

Regarding the monitoring & evaluating behaviours, a far more substantial collection of sub-codes was gathered in comparison to the planning & control behaviours. In particular students were successful in identifying knowns (MKU) and unknowns during the process of formulating their responses and using that information in their discussion with one another to choose the level of appropriateness for a particular response. Respondent one in group 2A remarked of the *team player* item: “. . . [Response] three I was on the fence about, [response] two I gave it a three, it’s kind of not one or the other because it would depend on friendships and relationships”. Here, the student identifies some unknowns in the information provided in the case that could have been useful in providing their response pattern - demonstrating planning behaviour. In addition, students

Students also demonstrated that they could check their progress in evaluating the items (MCP), check that they understood the context of the item (MCU1) and check that their response pattern made sense (MCA), by discussing their responses with their peers. Multiple examples of MCP can be found in the transcript of group 3B. On completing an item, respondent one remarks “*okay, is everyone satisfied? . . . Okay, so second one*” demonstrating monitoring of task. This is also an example of a code that was not associated with on-task item related behaviour, but rather it represented on-task non-item related behaviour. MCU1 was also frequently coded across groups. Respondent 2 in group 3B remarked of the item *vision* “*I have them read, but what does the second part of the first one mean?*” demonstrating an awareness of their lack of understanding and seeking clarity on the meaning of the case. As for MCA, an example drawn from group 6B highlights one of the ways students would check for consensus about their chosen level of appropriateness for a response, respondent four, having evaluated response three says remarks “*Ehhh, [response] 3? Neutral? Kind of neutral?*” demonstrating a desire to check their answer with those of their peers.

The final set of sub-codes relate to the evaluation of the students’ chosen responses. This conversation focussed on the evaluation of the success/quality (*ESQ*) of their chosen responses in dealing with the professional and their evaluations of the reasonableness of the response in relation to how likely a response was to be spoken in reality (*ER*). In the item *vision*, which is about effective waste management, respondent three in group 3B, referring to one possible response remarks that “*It would just get congested*”, which is a remark about the quality of the response, coded as *ESQ*. By comparison, respondent one in group 3B referring to the *vision* item states “*I think [response] 4 is actually the most sustainable, you’re actually looking to what you can do about the waste, not just trying to hide it*” which is about evaluating the reasonableness of a chosen response.

This process of evaluation consumed much of the students’ time working on the items, with significantly less attention paid to planning their responses, which may have reduced the amount of dialogue in the evaluation stage, had they understood their response strategy from the beginning.

5.2.5 CODES ARRANGED BY ITEM

On task item related behaviours were then organised to evaluate which professional scenarios were most suited to be carried forward to the final activity with students. The aim was to identify the most consistent coded items. To

achieve this, the ‘A’ groups received the item sets in forward order, while ‘B’ groups received them in reverse to account for loss of attention in the latter items and for adjustments in strategy in the beginning of the process, codes were then compared across groups who received the same set of items to establish which items were coded most frequently.

5.2.5.1 PRODUCT LEADERSHIP

Group 1A and groups 2B & 3B received the items in opposing order to one another. Regardless of the order received, *innovation*, *initiative* and *client focus* stimulated the least metacognitive behaviour among the students who received the product leadership items. By comparison, the most coded items were *creativity* and *vision* which received consistent coding regardless of the order they were received. The underlying reason for these items being less effective is ambiguous. The research posits that the items which stimulate more discussion amongst the students are harder to evaluate, forcing students to apply metacognitive skills to reason through the case. Regardless of the underlying reason for items being more or less effective, given that the goal is to develop a learning resource for students to stimulate these behaviours, the underlying reason for this stimulation lies outside the scope of this PhD research.

TABLE 5.7 METACOGNITIVE BEHAVIOURS FOR PRODUCT LEADERSHIP

Product Leadership	Group 1A	Group 2B	Group 3B	Totals
Innovation	2	2	3	7
Creativity	4	6	3	13
Vision	5	4	4	13
Persuasiveness	2	3	5	10
Persistence	4	2	2	8
Initiative	1	2	1	4
Client focus	2	2	4	8

5.2.5.2 OPERATIONAL EXCELLENCE

Group 4A and groups 1B, 4B & 6B received the items in opposing order to one another. Regardless of the order received, *Positive critical attitude* and *planning & organising* stimulated the least metacognitive behaviour among the students who received the operational excellence items. One may be tempted to look at the scores and select *work organisation* as an item to bring forward to the next stage, however the frequency for which it was coded can be attributed almost entirely to a single group and considering the relatively low frequency the item was coded in by the other group, this item was excluded from consideration. The most consistently coded items were *helicopter view*, *stress resistance* and *solution orientation* and so these three items were considered for the next stage of research.

TABLE 5.8 METACOGNITIVE BEHAVIOURS FOR OPERATIONAL EXCELLENCE

Operational Excellence	Group 4A	Group 1B	Group 4B	Group 6B	Totals
Positive critical attitude	3	2	0	0	5
Solution orientation	2	2	5	4	13
Team player	0	4	2	4	10
Helicopter view	5	3	4	3	15
Initiative	0	9	1	2	12
Work organisation	2	15	1	1	19
Stress resistance	5	5	2	3	15
Planning & organising	1	4	1	3	9

Groups 2A & 5A and group 5B received the items in opposing order to one another. Regardless of the order received, the majority of the items in the customer intimacy item set were coded infrequently for metacognitive behaviour bar *networking* and *client focus*, which received consistent coding across the three groups who evaluated them.

TABLE 5.9 METACOGNITIVE BEHAVIOURS FOR CUSTOMER INTIMACY

Customer intimacy	Group 2A	Group 5A	Group 5B	Totals
Client focus	4	2	4	10
Capacity for empathy	1	5	1	7
Clear communication	4	2	2	8
Creativity	2	2	3	7
Networking	3	4	5	12
Solution oriented	0	5	0	5
Negotiation	2	2	3	7
Focus on results	4	1	4	9

5.3 THE METACOGNITIVE LEARNING RESOURCE

The items carried forward for re-evaluation were *creativity*, *vision*, *helicopter view*, *stress resistance*, *solution orientation*, *networking* and *client focus*. The rationale for selecting only seven items was formulated by analysis of group 2A, 4A, 5B and 6B transcripts. In these transcripts, by item number six, students began to become aware of the time it was taking to evaluate the items and would check ahead to see how many items remained to be answered. The rationale for keeping seven items (rather than six) was so that students had an example item in the beginning to familiarise them with the process of reading and answering an SJT item. The seven items mentioned above were the most consistently coded items across each of the groups that answered them. That is to say, they were coded frequently across multiple groups of students, regardless of the order that they were provided into the students. An example of an item that was coded frequently but not consistently was *work organisation*, which was coded fifteen times in one group, but only once or twice in the other three groups which answered the item. Therefore, this item was not considered for the metacognitive learning resource. In contrast, the item *helicopter view* was coded fifteen

times in total across four groups, but it was coded, five, three, four and three times respectively by each group, making it a far more consistent item than *work organisation*, accordingly, the networking item was added to the metacognitive learning resource.

5.4 DELIVERY OF THE METACOGNITIVE LEARNING RESOURCE

Due to COVID 19 restrictions in semester one of the 2020/21 academic year, the mode of delivery and the groups of students that were selected to take part in the activity changed. It was originally intended to run the activity in the final week of the design project, the same week as the students who took part in the initial study of the learning resource (where key items were identified that stimulated metacognitive behaviour). However, due to the delay by Ireland's body for managing university applications, the Central Applications Office (CAO), in offering students' places in third level courses, the university semester was shortened by two weeks' reducing the length of design project that this research was carried out on to just 5 weeks. Without a final week to run the activity and without face-to-face interaction either between students or with the instructor, the design of the final delivery of the activity was altered. Instead of providing the activity to pre-determined groups of students, the activity was provided to the project managers of each group, as the researcher had access to these students online in week 2 of the design project. The activity was run online through the Virtual Learning Environment (VLE) *Brightspace*. The procedure remained identical, in that students were asked to sign consent forms, provide demographic data and read, evaluate and discuss their ratings of each of the four responses in groups. The audio from each session was recorded in Brightspace, transcribed and coded using the same coding strategy used in the pilot of the activity.

Group 1C, described in Table 5.11 received the test items online through Brightspace. Participant 1, An international male student took the role of moderator. It was unclear in the beginning who would take the lead as no one was nominated for this role in keeping with the method used in the pilot study. The discussion was stunted in the beginning as students got to grips with the first two items, however after two items the level of discussion saw increase significantly.

TABLE 5.10 DESCRIPTION OF SAMPLE FOR FINAL METACOGNITIVE ACTIVITY

Group	Location	Gender	Nationality	Duration of session	Timing and activities
1C	Online, November of the 2020/21 academic year	Male	Irish	59 minutes	2:30 PM Friday, Received the revised set of items
		Male	Irish		
		Male	Irish		
		Male	Irish		
		Female	Irish		
		Male	Non-national		
		Male	Non-national		

5.4.1 EPISODES ARRANGED BY ITEM

The items Creativity and Helicopter View saw limited discussion as participants got to grips with the process of reading, evaluating and discussing their responses, however by the third item - Stress resistance - students began to demonstrate significantly more self-regulatory behaviour. Participant 1 moderated the conversation well and exhibited a number of planning and monitoring behaviours along with collectively evaluating the task strategies presented to them in the item. Sixty-one percent of the codes can be associated with dialogue from this participant, although this dialogue was not viewed as domineering by the researcher, in fact the participant seemed to be consciously aware of their level of input when they remarked at the end *“Sorry I talked a lot ha ha”*, to which respondent 5 remarked *“I don’t think so”*.

TABLE 5.11 METACOGNITIVE BEHAVIOURS FOR FINAL ITEM SET

Customer intimacy	Group 1C
Creativity	4
Helicopter view	2
Stress resistance	8
Vision	8
Solution orientation	9
Client focus	9
Networking	13

5.4.2 EPISODES ARRANGED BY CODE & SUB-CODE

Taking a closer look at which metacognitive behaviours were exhibited by Group C, table 5.11 illustrates the codes and sub-codes recorded from the transcript. Participants spent most of their time evaluating the reasonableness of their response strategy, with participant 1 acting as the moderator and checking that all participants were prepared to move on to the next item progress following their deliberations. As for monitoring behaviour, the majority of this behaviour was answer checking, where participants would ask one another why another participant chose a particular response pattern, some self-commentary was also observed in the form of self-correction and self-commentary. Only a single instance of control behaviour was observed, as a student re-read a passage of text out loud to clarify their own understating; what Vygotsky would have termed egocentric speech.

TABLE 5.12 METACOGNITIVE BEHAVIOURS BY CODE AND SUB-CODE

Behaviour	Total
Evaluating	32
<i>Reasonableness</i>	26
<i>Checks progress</i>	6
Monitoring	22
<i>Checks progress</i>	4
<i>Checks answer</i>	12
<i>Checks understanding</i>	1

<i>Comments on understanding</i>	3
<i>Self-corrects</i>	1
<i>Self-commentates</i>	1
Control	1
<i>Verbally repeats</i>	1

Overall these items when provided together compared favourably with the items from the pilot in stimulating metacognitive behaviour in students. The volume of discussion generated in the activity was substantially higher than in any other session, with a total of 3683 words being transcribed during the session. By comparison the longest transcript during the pilot phase was group 1B, with a transcript totalling 1516 words. This in-depth discussion may have been the result of the regulatory behaviour of participant one, who frequently asked participants to clarify their reasoning, resulting in substantial self-regulatory behaviour being stimulated. It may also be due to the items themselves, as these were previously shown to be the most suitable candidates for stimulating this behaviour.

Like a number of the groups who piloted this activity, a high-status individual emerged in the group who dominated much of the conversation. Furthermore, much of the dialogue focussed on evaluating the responses, while no attention at all was paid to the planning behaviours. The limitations of these results are discussed in chapter 6 in relation to the research methods employed to collect this data.

CHAPTER 6: CONCLUSIONS

6.1 CHAPTER OVERVIEW

The process of developing the SJT raises several points of discussion regarding whether the research objectives were achieved, along with how the test should be used in future research. Eight of the twenty-three items of the SJT had significantly lower mean scores than the remaining thirteen items. These items, which were related to *perseverance, client focus, vision, planning and organising, solution orientation, team player, work organisation, clear communication* and *networking* all represent potential skill deficits in the population of final year and master students that were tested.

The SJT items which were identified as stimulating the most metacognitive behaviour when coupled together, formed a highly effective learning resource for students to stimulate their metacognitive skills. A number of findings have emerged regarding the use of SJT's as stimulus for metacognitive behaviour. These findings mainly concern which items stimulate this behaviour. When used as a stimulus of metacognition, particular test items were identified as more effective than others in stimulating metacognitive behaviour amongst students. The items *creativity, vision, helicopter view, stress resistance, solution orientation, networking* and *client focus* were consistently coded for metacognitive behaviour. These findings are discussed in relation to the research question, methods of data collection and theoretical underpinnings, in support of these findings.

6.2 THE DEVELOPMENT AND EVALUATION OF THE SJT

A reminder of the first two research objectives is useful for discussing the implications and the limitations of the methods used in the development and evaluation of the SJT. The two objectives which are pertinent to this discussion are to:

- Develop an SJT with items tailored specifically to engineering professional scenarios (RO1)

- Evaluate the SJT with all stakeholders including students, academics and industry professionals (RO2)

The first of these objectives, which is an overarching objective, is discussed towards the end of this section. Before that, the evaluation of the SJT items and the research objective pertaining to that goal are discussed. Regarding the research methods employed to evaluate the SJT items and preparation of those items for their future use as stimuli of metacognition, the process of evaluating the SJT with all stakeholders, including students, academics and industry representatives provided the necessary checks and balances to the researchers' biases. This was particularly evident in the evaluation of the item responses, where a direct comparison was drawn between the researcher's opinion about what constituted an appropriate response and the views from professional engineers and Human Resource professionals. The iterative process of evaluating and altering the SJT added to the robustness of the SJT as an instrument for evaluating the relative strengths and weaknesses of the students who took part in the rollout of the test. The use of expert panels with industry and discussions with academics lead to the development of an SJT that contained scenarios and responses that were a much stronger reflection of the engineering profession than could have been developed by the PhD researcher alone.

Overall, the methods employed to evaluate the SJT items sit well with the epistemological position and theoretical underpinnings of the research. The use of expert panels to evaluate the items is compatible with the view that discourse is both a mediator (Bourdieu, 1991) and constructor (Vygotsky, 1986) of knowledge. The discourse amongst the participants and with the researcher in the panel was utilised to modify the test to make the test as true a reflection of professional reality as possible. This process of knowledge construction can be modelled using Engeström's (1999) activity system. As illustrated in figure 6.1, new knowledge is generated about the SJT through discourse between the researcher and the panellists.

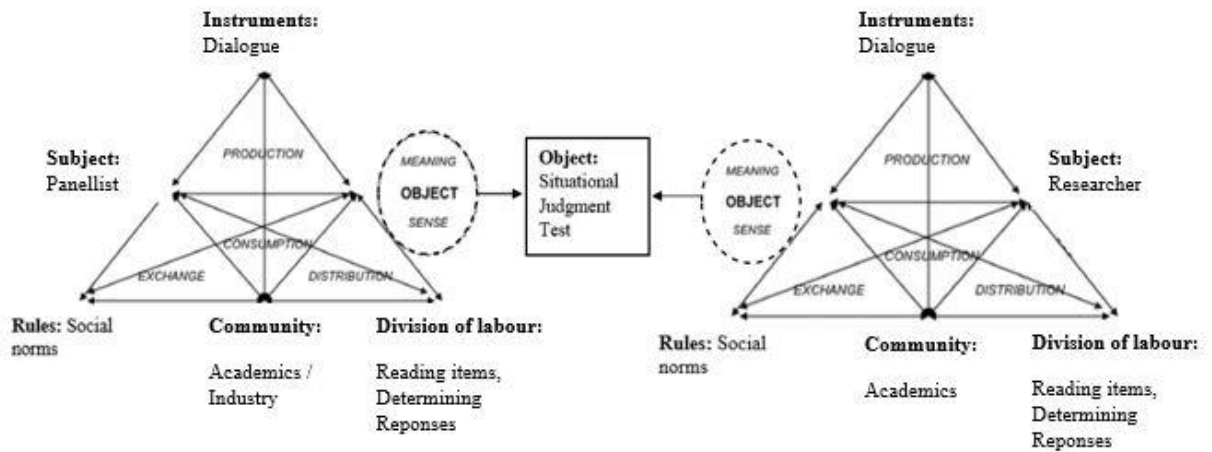


FIGURE 6.1 ACTIVITY SYSTEM OF EXPERT PANELS ADAPTED FROM ENGESTROM (2011)

As for the panels with industry professionals and academics which were carried out to evaluate the item stems and to determine a scoring key for the SJT respectively, the benefit to this approach was not limited to receiving pertinent input and feedback on the item stems and responses; it also created buy-in with two key stakeholders' - academics who could run the tests and industry professionals who recruit engineering graduates. There are potential drawbacks to the methods, however. In developing the scoring key, expert responses were compared with the researchers scoring key and alterations were made using these expert opinions at the discretion of the researcher.

This assumption that academics and industry professionals are content experts in a wide range of professional skills is a limitation to the applicability of the test results. To have a true benchmark of performance in these professional scenarios, norm groups need to be developed that account for gender and ethnic variations in response patterns. Lievens (2013) found that female candidates significantly out-performed males on an SJT with an effect size of $d = -.26$. Both O'Connell et al (2007) and Whetzel, Mcdaniel & Nguyen (2008) reported similar gender differences favouring males with modest $d = -.27$ and small $d = -.10$ effect sizes respectively. In addition, both O'Connell and Whetzel, Mcdaniel & Nguyen found certain groups of people and so to be useful as benchmarks of student ability or as candidate selection tools norm groups must be established to take account of gender and ethnic differences in response pattern. Specifically, research into gender and ethnic differences using this SJT or another need to control for *elevation* and *scatter*. Elevation is the mean score on the items for a given respondent and scatter is the magnitude of the deviations from this mean. The result of adjusting for elevation and scatter is that extremes in responses are

suppressed (Mcdaniel *et al.*, 2011). This is useful because ethnically black individuals are known to provide more extreme Likert scale ratings than their white counterparts (Bachman, O'Malley and Freedman-Doan, 2010). This ensures a fair comparison to expert scoring patterns is achieved and that response patterns are compared on a like-for-like basis. The basis of such adjustments would require a sample of students substantially larger than that collected in this research, as a representative sample of each sub-group would need to be attained to establish norm groups.

As for the methods employed in the rollout of the SJT with students, the resulting quantitative data proved invaluable in identifying which aspects of engineering the students were strong in, and which areas would require further intervention (either by the student themselves or through formal training) in order to better align to labour market expectations. The value of this data when compared with self-assessments of student ability in a range of skills is clear, as students often make poor estimations of their own ability (Kruger and Dunning, 1999; Krueger and Mueller, 2002; Dunning *et al.*, 2003) and therefore having a tool that allows students to be scored in specific professional areas and subsequently reflect on their strengths and weaknesses through the feedback reports is a far more valuable resource to their development than a self-assessment. All students who took part in the SJT were provided with individual feedback reports that showed a breakdown of their responses compared to the responses provided by experts in the field and provided some practical advice on how to improve these skills in the future.

6.2.1 ADDRESSING RESEARCH OBJECTIVES ONE AND TWO

With regard to RO1, to develop an SJT with scenarios tailored to engineers, this research objective was achieved through the evaluation process, in which the views of industry representatives and academics were consulted in an iterative process of writing and reviewing both the item stem and the item responses. With regard to the research objective RO2, which sought to evaluate the SJT with all stakeholders, including industry, academia and students, the research objective was mostly achieved. However, further research regarding the content of the items and responses might include round-table discussions with students in a similar fashion to the expert panels to explore how they interpret the items. This would entail the researcher being present and actively involved in the conversation, in contrast to the role of the researcher in the delivery of the metacognitive activity, where the researcher was merely an observer. In addition, the data collected from the rollout of the SJT with the sample of three hundred and thirty-four students and the inferences made about that data could have been utilised to make

further alterations to the test. However, a pragmatic decision was made that once the outcome of the expert panels had been taken on board, that the rollout of the SJT would run in tandem with the pilot of the metacognitive activity.

6.3 METACOGNITIVE ACTIVITY WITH STUDENTS

The final two research objectives concerned using the SJT in a metacognitive activity with students. Specifically, they sought to identify items of the SJT that stimulated metacognitive behaviour in students and to deliver a learning resource capable of stimulating such behaviour. Similarly to RO1, RO4 was the overarching objective while RO3 served as the means of delivering on that objective.

- Identify the items which best stimulate metacognitive behaviour in engineering students (RO3)
- Deliver a learning resource capable of stimulating these behaviours in engineering students (RO4)

The process of allowing students to discuss the SJT items in groups and determine effective response strategies fits well with the epistemological views and with the underpinning theory of this research. Allowing students to mediate and construct their understanding of the SJT items while making naturalistic observations of their behaviour is good reflection of Silverman's (2014) agenda for constructivist research. In particular:

- Constructivist researchers are interested in the practical activities in which actors are engaged with to construct, manage, and sustain the sense that their social worlds are 'real' and to look at and listen to the activities through which individuals interact with the features of their social worlds. This statement implies that constructivist researchers are concerned with the examination of social actors themselves, but it also the examination of the tools that these actors use to shape and reshape their understanding of the social world.
- The researcher must retain an appreciation of the naturalist' desire to describe *what's going on*, with a decided emphasis on how *what's going on* is reflected in everyday life. Using an explicit action orientation, focusing on interaction and discourse as productive of social reality.

The above points are emphasised in the research in two ways. Firstly by making naturalistic observations of students' and their interactions with one another as they work through the SJT items, the fidelity of their interactions can be retained by making direct observations, rather than relying on retrospective self-report, such as interviews, and secondly by examining their discourse while working on the SJT items, the researcher was able to study the students' use of language as a tool for constructing their understanding of the items (Vygotsky, 1986).

6.3.1 DISCOURSE ANALYSIS

The process of identifying the items which stimulated metacognition and indeed delivering a learning resource capable of stimulating these behaviours, relied on the use of discourse analysis. A decision was made to record students' interactions while working with the SJT in their groups using audio-only. This decision was made to minimise the Hawthorne effect, specifically the effect of modifying student's behaviour because they were aware they were being observed. In contrast to recording video, which would arguably have a more significant impact on the student behaviour, the audio recordings provided much the same data required to apply the NOME protocol. The exceptions to this is the code *Control Motion or gesture*, which was originally coded during video based assessments of metacognition (Whitebread and Pino-Pasernak, 2013). A decision was made that minimising the Hawthorne effect for the sake of a single code was a worthy trade-off. The use of audio-based recording combined with the use of the NOME protocol proved a highly effective means of describing students metacognitive behaviour when compared with video-based observations, given that only a single code was lost. It is worth considering that much of the empirical research which utilised naturalistic observations were conducted on school-aged children (8-10 years old) (Stoneman, Brody and Mackinnon, 1984) and pre-school children, including toddlers and infants (Samuels, 1980; Corter, Pepler and Abramovitch, 1982; Whitebread and Pino-Pasernak, 2013). Until 2019, when McCord and Matusovick (2019) published their work on observing university students while they worked in study groups, the practice of making naturalistic observations of university students was relatively unheard of; apart from studies which focussed on other aspects of student social interaction, such as their alcohol consumption in social settings (Geller, Russ and Altomari, 1986). This thesis represents the second occasion in which research seeking to observe metacognition in engineering students has been published, and the first study of its kind to utilise items from an SJT to stimulate this behaviour.

The model proposed by Engestrom, Miettinen and Punamaki (1999) proves useful when describing the discourse between students as they exhibit metacognitive behaviour to make sense of the SJT. In this regime, students' use peer dialogue to mediate their interactions, these linguistic exchanges are determined by the social norms of the individual and by the context in which the dialogue occurs; in a group of their peers.

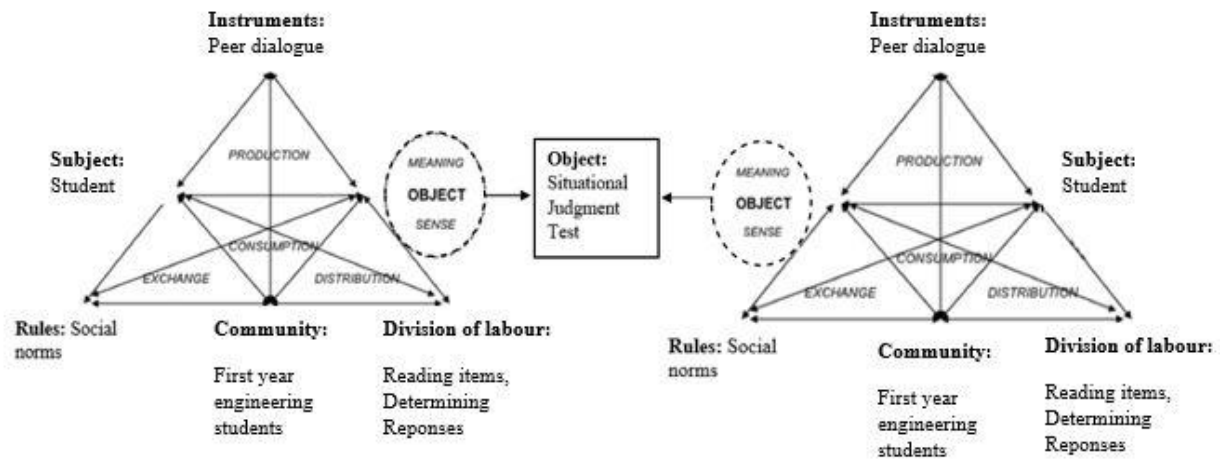


FIGURE 6.2 ACTIVITY SYSTEM OF STUDENTS ENGAGED IN THE METACOGNITIVE ACTIVITY ADAPTED FROM ENGESTROM (2011)

Some limitations of discourse analysis, particularly the use of the NOME protocol for the analysis of student's discourse is that it relies on student speech to make observations of metacognition. Four participants in the initial study to identify items which stimulated metacognitive behaviour had no coded discourse during the activity.

TABLE 6.1 PROPORTION OF METACOGNITIVE BEHAVIOUR PER PARTICIPANT AS A PERCENTAGE
OF THE TOTAL CODES IN EACH TRANSCRIPT

	Respondent					
Group	1	2	3	4	5	6
Group 1A	33	20	14	21	12	
Group 2A	46	30	17	7	0	
Group 4A	39	38	8	15		
Group 5A	21	26	22	13	18	
Group 1B	36	34	20	7	4	
Group 2B	49	7	9	22	9	5
Group 3B	26	11	18	45	0	
Group 4B	80	11	6	3	0	
Group 5B	53	19	28	0		
Group 6B	21	15	23	40	2	

To address this limitation, it becomes necessary to identify who feels entitled or unentitled to speak in these group discussions, or what might be referred to as the “high status” individuals (Kittleson and Southerland, 2004). In all four cases the student with zero coded dialogue was an international student. In group 2A, a male student, in group 3B a male student, in group 4B a male student and in group 5B a female student. These groups were the only groups made up of 4 Irish students and 1 international student, which would suggest that this is a sub-optimal grouping of students if all students are to take part in the linguistic exchange. Furthermore, in groups where there was a disproportionate number of codes associated with a single group participant, such as group 2A, 4B and 5B, the student dominating the conversation was an Irish male student. As highlighted in chapter 5, the optimal mixture of students to distribute this dialogue more evenly and to maximise the metacognitive behaviour being exhibited is a group with two international students and or two female students alongside 2-3 Irish male students. Group 4A and 3B both had two female students and their dialogue was frequently coded for metacognitive behaviour: twenty-six and twenty-eight codes respectively. Compare this with group 2A, a group of all male students with just one international student where seventeen codes were identified and it becomes clear that female participation has a positive effect of the demonstration of metacognitive behaviour. There is an exception to this in group 4B which

had two female students, however participant 1, an Irish male accounted for 80% of the dialogue in the transcript and may explain this anomaly.

6.3.2 THE METACOGNITIVE LEARNING RESOURCE

The items *creativity*, *vision*, *helicopter view*, *stress resistance*, *solution orientation*, *networking* and *client focus* were consistently coded for metacognitive behaviours both in the initial activity with students and in particular when combined together in the final activity with students. Lessons learned during the delivery of this activity include the need for a sample item at the beginning of the activity or a “burner item” to familiarise students with the process of reading evaluating and discussing the items without compromising the seven items which stimulate these behaviours to the maximum degree. Future interventions into students’ metacognitive behaviour should include one such item in the beginning of the activity. Furthermore, in line with the Vygotskian view of the role of the educator, the educator should have no involvement in process or reading, selecting and deliberating over the responses, the role of the educator is to create the initial conditions for learning to occur and observe these behaviours being demonstrated in a way that has a minimal impact on the students. This, in the experience of the researcher is the best way to illicit metacognitive behaviour; by relinquishing power and placing it in the hands of the students.

In addition to the practical limitations of implementing the activity, there are also limitations in the activities ability to elicit metacognitive behaviour in the correct sequence. Ideally, students’ would begin an item by first drawing on their metacognitive knowledge to frame the problem. Next, they would plan their approach, monitor their progress on-task and finally evaluate the effectiveness or correctness of their approach. In reality, students typically overlooked the problem framing step and did not attempt to make a consistent plan for approaching the problem. Instead, they would simply read the case, monitor their understanding and discuss and evaluate their solutions with one another. Of course these are first year students and not skilled problems solvers. A continuation of this research may look at the coded behaviours of final year engineering students or even of engineering academics in order to establish if skilled problem solvers apply their metacognitive knowledge and skills optimally. Furthermore, there may be a need to introduce a scaffolding to the activity to better frame the activity for students, without the need for instructor intervention. Previous research into the application of a metacognitive support during the problem solving process found that providing support in the evaluation phase of the problem solving process lead to more accurate problem solutions (Kapa, 2001). In the case of this research, there may be scope to introduce support in the planning

phase of the problem-solving process to enable students to exhibit planning behaviours, which are at a deficit by comparison to the monitoring and evaluating behaviours.

6.3.3 ADDRESSING RESEARCH OBJECTIVES THREE AND FOUR

Research objective three (RO3) to identify the items which best stimulate metacognitive behaviour in engineering students was achieved. A clearly discernible set of items *creativity*, *vision*, *helicopter view*, *stress resistance*, *solution orientation*, *networking* and *client focus* were consistently coded for metacognitive behaviours. This is further confirmed when the effect of combining these items is considered. Despite the dominant behaviour of one participant in group 1C the items outperformed all other items in terms of their ability to stimulate metacognitive behaviour, particularly when compared to how those same items performed when they were grouped with alternate items in the initial study that identified these key items. The exception to this are the first two items *creativity* and *helicopter view*. As these were the first two items that the students encountered this could be explained by students' lack of awareness of the approach to evaluating the items and as stated earlier, a "burner" item would help mitigate against this. As for research objective four (RO4) to deliver an activity capable of stimulating metacognitive behaviour in engineering students, this objective was partially achieved. As mentioned above, there may be scope to introduce a scaffolding for students to exhibit planning behaviours, as these behaviours were not frequently observed during the pilot or in the final implementation of the activity. This was beyond the scope of this research, as the purpose of this research was to determine if SJT's could be used as stimulus *at all*, while further research may find the best way to leverage SJT's to stimulate students to elicit metacognitive behaviours in the desired order.

6.4 ADDRESSING THE RESEARCH QUESTION

The research question, which was to determine: "*can a SJT be utilised to stimulate metacognitive behaviour in groups of first year engineering students*", was achieved. The activity which was developed around the use of the SJT as a stimulus of metacognitive behaviour resulted in the consistent coding of metacognitive skill-type behaviours, as opposed to knowledge-type behaviours, suggesting that the metacognitive activity required little to no prior knowledge for students to engage with the material. This lack of required knowledge, which is required

when dealing with mathematics and physics problems, means the metacognitive activity presented in this research ensures that students who lack this knowledge early in their studies can still develop tools of self-regulation despite their understanding of mathematical and physical principals.

However, further research should focus on getting students to exhibit a greater degree of planning behaviour, as this is a necessary prerequisite for effective problem solving (Brown and DeLoache, 1977). In addition, the effect of group composition cannot be ignored and it is important that as much as possible, that groups of students undertaking this activity are balanced in terms of both gender, nationality and size, given the empirical evidence presented in this research that groups with two female students and two non-national students consistently outperform groups of male Irish students when working on the SJT. The limitation of this finding is the complex nature of group dynamics, the researcher did not consider the personality type, age & experience, or group size, as this was outside the scope of the research question, however the findings can be taken as best practice when implementing the metacognitive learning resource in groups of first year engineering students. Furthermore, when implementing the activity, an item should be provided as an example at the beginning of the exercise so that students can get to grips with the process more quickly and clarify any misconceptions they may have from the outset of the activity. To add further rigour to the research process, the researcher should consider having a second individual apply the codes and subcodes to each transcript to check for inter-rater reliability, this was the approach taken by and represents a limitation of this research study, as the PhD researcher could not rely on external assistance in assigning codes and subcodes.

6.5 THESIS SUMMARY

This research work aimed to add to engineering education scholarship in three ways. Firstly, to provide an engineering specific SJT to enable educators to identify areas of relative strength and weakness in students' professional judgements. To better prepare them for their future careers. Secondly to use the insights generated from the development and evaluation of the SJT to provide a resource for engineering educators to stimulate students' metacognitive behaviour. To provide them with the skills to self-regulate their learning. Thirdly, this research aims to offers fresh insights into how engineering student's exhibit metacognitive behaviours when working in groups.

This research supports the model of metacognition proposed by Brown(1977) and Flavell (1976), in particular the application of the NOME protocol to the discourse of students engaging with the items of the SJT support metacognitive skills as constructs and the generalisability of the Brown-Flavell model to non-technical problem solving processes, with the caveat that such processes require significantly less metacognitive knowledge for students to engage with them (Mccord and Matusovich, 2019).

Over the course of this PhD, the researcher evaluated and ultimately reconfigured an SJT to make naturalistic observations of metacognition in first year engineering students. This thesis adds to our understating of how students' exhibit metacognitive behaviour in groups using SJT's as a source of ill-structured problems. Metacognition has been linked with student self-efficacy, success in STEM and success in academic and non-academic endeavours alike. They are key skills that can be measured though observation and improved by providing students with a suitable learning environment where they can demonstrate those behaviours in groups.

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APPENDIX A: SKILL DEFINITIONS & SJT ITEMS

7.1 SKILL DEFINITIONS

TABLE 7.1 SKILLS DEFINITIONS PROVIDED BY BDO

Skill	Definition
Solution-oriented	...thinks in terms of solutions, does not ignore problems and does not unnecessarily consider a given situation a problem.
Helicopter quality	...can take important decisions and assess the consequences of these decisions in terms of both space and time.
Vision	...develops and carries out an idea of the future. He/she can distance him/herself from day-to-day practices. He/she identifies facts, trends and future developments and places them within a broader context and long-term perspective of his/her own field of work, specialty and/or organisational unit.
Creativity	...approaches problems from different angles, contributes new and original ideas and solutions, and breaks through established thinking patterns.

Positive critical attitude	...reflects on the methods, techniques and strategies used by the company. He/she questions them in a positive manner.
Planning and organisation	...determines goals and priorities effectively. He/she indicates the time, activities and resources needed to achieve goals.
Work organisation	...can work according to an efficient and practical method, either by him/herself or with a group.
Focus on results	...is focussed on translating - concretising - goals and achieving results in accordance with timeframes, standards and agreements.
Innovation	...has and encourages new, original ideas, working methods and applications. He/she focusses on future innovation in strategy, products, services and markets with an inquiring and inquisitive mind.
Clear communication	...communicates using the proper language and in a clear manner adapted to the situation and the target person or audience, both verbally and in writing.
Persuasiveness	...obtains buy-in for ideas and proposals by making the right arguments - at the right time and in an appropriate manner.
Negotiation	...achieves goals in consultation with other interested parties. He/she can come to an agreement without losing sight of both parties' interests in a manner that leads to agreement and acceptance by both sides.
Capacity for empathy	...listens to and thinks along with others. He/she acknowledges the feelings and needs of others, puts him/herself in others' shoes and consciously deals with different backgrounds and interests.
Networking	...seeks and maintains contacts and cooperation with colleagues, clients and other potential relations that are important for the goals of the organisation or organisational unit.
Client focus	...attunes his/her own actions to the feelings, needs and wishes of internal and external clients, even when these are not directly expressed.

Team spirit/team player	...makes an active contribution to a collective result (organisational goal) or to the resolution of problems or conflicts. He/she also does this when the collaboration concerns a subject that is not of direct personal interest.
Stress tolerance	...can continue to function well with a heavy workload and despite unexpected setbacks.
Initiative	...undertakes actions on his/her own initiative and makes proposals. Instead of waiting, he/she takes the lead, anticipates, seeks and sees opportunities, identifies bottlenecks and acts accordingly.
Perseverance	...brings a launched task to a successful conclusion within a reasonable timeframe, despite difficulties.

7.2 SJT ITEMS: PRODUCT LEADERSHIP

TABLE 7.2 SJT ITEMS PRODUCT LEADERSHIP

Competency	INNOVATION
Case:	<p>Thomas is a software engineer who works for the Government Department of Health. Thomas is in charge for the security of patient records of hospitals and other health services. An important challenge for the department is to ensure data security during the transfer and exchange of personal details between stakeholders of different healthcare services.</p> <p>Peter, the head of the Department, recently visited an international conference of the World Health Organization (WHO) on this topic and has picked up the idea to use blockchain technology (i.e., an incorruptible digital ledger of transactions that can be programmed to record not just financial transactions but virtually everything of value) to keep record of all healthcare actors who opened and consulted the medical file of an individual patient.</p> <p>Peter is eager to share this new idea with his colleagues and at the team meeting, he says: <i>“At a meeting of the WHO, I was introduced to a new blockchain application to track medical patient records. As the</i></p>

	<p><i>technology is still young, it might be a bit risky, but I personally think this is an interesting new avenue in the e-health domain. Thomas, what do you think?"</i></p> <p>Thomas replies:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	<p>"That sounds great, Peter! I believe we shouldn't stick to what we have but make our system more future-proof. Although there are some risks attached and it is unexplored territory, I can look into it. "</p>	Appropriate
Response 2:	<p>"It sounds interesting but I would invest too much time in it. I suggest we explore the technology for a short time but I don't think it will outperform the system we have now."</p>	Neutral
Response 3:	<p>"I prefer to stick to the system that we have in place. It is secure and such a radical shift would erase all the hard work that we have put into our current system. As we haven't done this before, I would be careful with it."</p>	Inappropriate
Response 4:	<p>"Although there are quite some risks involved, I think it is worthwhile to explore this. With your approval, I can maybe spend a couple of weeks exploring the potential of this blockchain technology. "</p>	Appropriate

Competency	CREATIVITY	
Case:	<p>Christine is a mechanical engineer who works at a testing facility of a 3D printing company that focuses on structural applications in the construction sector. Each year, the company organizes a one-day seminar to keep colleagues updated on the most recent developments in this rapidly moving field. For the first time this year, it will be online streamed as a webinar.</p> <p>Supported by a small team, Christine is in charge of putting together a programme for this year's seminar. At the first brainstorm meeting, Christine asks the team for ideas for speakers they can contact.</p> <p>Justin says: <i>"It may sound crazy but at an art expo last weekend I saw an artist creating 3D printed structures inspired on natural shapes of leaves and waves. On her website, I saw a video of a presentation of her in a nearby cathedral and she seems to be an inspirational speaker!"</i></p> <p>Christine replies:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	"Thanks for bringing this up, Justin. I think it is an excellent idea to show our colleagues contemporary applications of the technology. It may spark them to incorporate some ideas into our designs".	Appropriate
Response 2:	"It sounds interesting but I would predominantly focus on applications with direct relevance for our field. If we can't find someone else, we can still use it as a fall back option."	Neutral
Response 3:	"I'm not sure if this will be interesting for most of our colleagues. They might not get anything useful out of this presentation and I'm afraid it will reflect badly on people's perception of the seminar."	Inappropriate
Response 4:	"I would prefer to focus first on content that is better tailored to the construction domain. However, it may be something we can consider as an inspiring closing session."	Rather Appropriate

Competency	VISION	
Case:	<p>Kelly is a researcher who specializes in sustainable waste management solutions. She attends a conference of a well-known research magazine "R&D Magazine". There she participates at a roundtable discussion during which different people share their knowledge and ideas. The theme of the discussion is 'How can the cities of the future contribute to sustainable development goals?'.</p> <p>The chairman of the table opens the discussion by presenting the following case: <i>"In the city Riversdon, the company C-lean collects and processes the trash in the city. A couple of months ago, C-Lean has put seven large waste containers under the surface, at strategic places in the city. Each container is connected with 10 trash bins. So, when somebody throws something in a trash bin, the trash ends up in the large containers via underground pipelines. This approach means a huge saving on waste collection because not all trash bins (70 in total) need to be emptied individually and on a daily basis. What is your opinion about this project?"</i></p> <p>Kelly responds:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	<p>"The field of innovative waste processing is much more advanced than this. The city could invest in more progressive technology such as electric waste collectors, solar powered bins: mini containers that crush the waste to reduce the volume and introducing incentives to recycle."</p>	<p>Rather Appropriate</p>
Response 2:	<p>"I think this system is way too sensitive to defects and congestion. It has not been thoroughly thought through. I assume the savings in time to empty the trash cans will be lost by fixing the system that will break down frequently"</p>	<p>Rather Inappropriate</p>
Response 3:	<p>"I am interested to know how the end-user evaluates the project. In the end, the main objective of such a project is to increase the convenience for the citizens of Riversdon."</p>	<p>Inappropriate</p>
Response 4:	<p>"This approach originates from the idea 'we see more waste, so we have to provide a better way of processing it.' I think the city should try to be more forward thinking and could have invested in waste reduction projects."</p>	<p>Appropriate</p>

Competency	PERSUASIVENESS	
Case:	<p>David is a researcher at a major university. His research involves developing new materials that mimic human skin for use in the medical field and he has quickly become one of the world's foremost experts in this novel area. Having applied for a patent on the new material, he approaches a panel of investors to secure funding to commercialize the material. During a presentation to the investors, David explains how the new material works, how it could be produced at the best price and how it could potentially benefit end users.</p> <p>One of the investors, Simon, seems particularly interested in the product and asks David <i>"David, why should I give you the investment when there are already a number of similar products on the market or - in other words - what makes this product truly unique?"</i></p> <p>David responds:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	"The major selling point of this product is the patented technology, indicating the novelty of the product. Also, you will have to worry less about competitors copying your idea in the middle long run"	Rather Appropriate
Response 2:	"Simon, I truly believe in this product. After years of solid research and successful clinical results, I feel it is time to scale up. The material could become a game- changer compared to current technologies.	Appropriate
Response 3:	"The main reason you should invest in the product is that it will help to save patients' lives. If you're not interested in that, there are plenty of other investors who may be willing to. "	Rather Inappropriate
Response 4:	"To be honest Simon, I am more interested in the research. I have less interest in commercializing this product any further, but I would like to license the product to you for a fee as I believe you could transform the idea into a profitable business."	Neutral

Competency	PERSEVERENCE	
Case:	<p>Since a couple of months, Eva works at the product development department of a large athletic footwear maker. The department intends on developing a new line of shoes that substantially decreases the risks of back injury. Eva's manager has asked her to read 250 medical records from people with back injuries. These were deliberately chosen because they represent a comprehensive cross-section of all back injuries that could be related to athletic footwear. It is important that this review is fully completed before the design stage, which is scheduled to take off in one month.</p> <p>Eva's task is to synthesize the nature of the injury, the treatment and the result in one big data file to inform the development process.</p> <p>Eva is having lunch with Layla, a colleague from the same department. Eva says: <i>"I'm sick of the reading these reports and putting the data in a big file. I've processed 150 of these document in 2 weeks. Having to process 100 more records is really an unpleasant outlook."</i></p> <p>Layla answers: <i>"That must be tough! What are you going to do now?"</i> Eva replies:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	"I think I will send my findings to my manager and ask her if I can stop processing reports and start the design phase."	Rather Inappropriate
Response 2:	"I will just continue until I'm finished. I know it's a necessary part of the project but it isn't a fun part. I'll have to get through it."	Rather Appropriate
Response 3:	"I will tell my manager how I feel about this work. I hope she knows a way to share the burden with somebody else."	Neutral
Response 4:	"I have already processed 150 reports, I think I've got everything I need and I will report this to my manager. I don't think this type of work is appropriate for an engineer."	Inappropriate

Competency	INITIATIVE	
Case:	<p>Jenny is participating at a graduate programme at the Research and Development department of a large energy company. Their research is mainly focused on the further development and optimization of their production park (wind, sun, biomass, energy storage ...).</p> <p>Jenny is currently contributing to a project that aims to make energy supply more flexible with a main focus on smart grids, energy storage and demand side management.</p> <p>While she's on her way to work, Jenny receives a phone call from Rajiv, a friend and former classmate. Rajiv says: <i>"Hey, Jenny. I just wanted to let you know that Mr. O'Reilly, a senior researcher at a leading think tank on energy transition, will be giving a TED talk in our city. He's been doing extensive research on smart and flexible energy consumption. He comes all the way from New York. I'll attend his lecture, let me know if you want to come too."</i></p> <p>Jenny replies.</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	"Thanks for letting me know, Rajiv. I'll attend the TED talk. If it's ok for you, I'll also invite some colleagues."	Rather Appropriate
Response 2:	"That is a great idea, Rajiv. Can you send me the date and venue? If the week doesn't get too busy, I will try to attend."	Neutral
Response 3:	"I have a better idea: I will send an email to our team leader and propose to her to invite Mr O'Reilly for an in- company presentation."	Rather Appropriate
Response 4:	"Thanks for inviting me, Rajiv. But Mr O'Reilly's expertise is on smart and flexible energy consumption. I haven't started my research on that topic yet, so I will pass for now."	Inappropriate

Competency	CLIENT FOCUS	
Case:	<p>Adam is an IT-engineer at SoftCookies who has been developing a new operating system together with his team. The operating system aims to be the safest, most intuitive and most efficient on the market. Pilot studies have been running for several weeks now.</p> <p>Today Adam has a meeting with June, an independent software tester, to discuss her experience with the new operating system. June starts giving her feedback: <i>“I really loved working with the system. The system does what it promises: it’s safe, it’s efficient and it’s very intuitive which I really like. However, when I initiated an update, I noticed that it takes quite some time and is not as intuitive as the rest of the system. I can imagine this is quite a job when you don’t have the IT-background like I do for example.”</i></p> <p>Adam responds:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	“I understand you are saying that there is a risk that people won’t take the time to update. This is valuable feedback, we need to emphasize the importance of this update. They really should take the time to keep the system up to date.	Rather Inappropriate
Response 2:	“Thank you for your feedback. I will examine what other options we have to make it more intuitive for the end-user. I’ll have a look at the consequences for the design of the operating system.”	Appropriate
Response 3:	“Updates need to be simple enough to ensure that users continue to benefit from our hard work. When users don’t update, thus exposing issues, the software becomes less and less reliable and secure, as well as missing out on new features.”	Neutral
Response 4:	“That’s indeed a downside. I think it’s very important that we support the end-user through the update process. We should provide the operating system with a clear and unambiguous manual, so that the end user will quickly find his way in the updates.”	Rather Appropriate

7.3 SJT ITEMS: OPERATIONAL EXCELLENCE

TABLE 7.3 SJT ITEMS OPERATIONAL EXCELLENCE

Competency	POSITIVE CRITICAL ATTITUDE	
Case:	<p>Sarah is a senior automation engineer at a brewery which is currently being fitted with a new stainless steel tank for storing the finished beer. The tank requires several control systems, including temperature and humidity sensors.</p> <p>Robert, one of the junior engineers, has asked Sarah if he can install the sensors. He says he has done this before during an internship in another brewery. Sarah has asked him to be careful because the sensors are fragile and expensive. If they are not mounted correctly, they may break.</p> <p>When Robert unpacks the sensors, he notices that the sensors that Sarah has purchased are indeed more fragile than the ones he worked with before. Moreover, he knows they are more expensive and less sensitive.</p> <p>Sarah sees that Robert is carefully studying the sensors. She asks if everything's ok.</p> <p>Robert replies:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	"I think you should reach out to the vendor. During my internship I used a sensor that I found to be very reliable and they are cheaper than what I'm about to install."	Rather appropriate
Response 2:	"May I ask why you chose these particular sensors? I think I know a cheaper and more reliable sensor. With your permission, I can look into that if you like."	Appropriate
Response 3:	"There are much better and cheaper sensors on the market. I don't know who's advised you to buy these but I can tell you it's a rip-off."	Inappropriate
Response 4:	"I'm trying to find out how to install these sensors. The sensors I've worked with before, were another type and I want to make sure I don't accidentally break them."	Rather inappropriate

Competency	SOLUTION ORIENTATION	
Case:	<p>Ben is a logistics engineer at a fast growing company specialized in ecologic insulation materials for the construction field. The company has bought a larger building in a nearby location as the lease on their current building is about to expire. The rental agreement for their current office building expires in one week. Not moving out on time is considered to be a breach of contract and this will trigger legal action by the property owner.</p> <p>Ben is in charge of moving the large amount of stock to the new location. He contracted a specialized moving company. This firm had been chosen because they committed themselves to moving the whole stock in a single day, limiting delays in production to one day. It is an expensive contract but as the demand is high, the company cannot afford too much downtime.</p> <p>Ben's colleague walks into his office and says: <i>'I just got a phone call from the moving company. There is a technical problem with one of the three trucks they were planning to use. A spare part has been ordered but as this spare part has to be tailor-made, it will take two weeks to repair the truck. Therefore, they will need three days instead of one. What do we do?'</i></p> <p>Ben replies:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	"I'll have a look at the contract. I'm sure there will be a fine if they don't live up to their promise. I'll make sure our legal department makes them pay!"	Rather Inappropriate
Response 2:	"I'll give them a call and suggest that they rent a truck for the day or ask another moving company to assist them. I really want to find a way to avoid rescheduling the move."	Appropriate
Response 3:	"We will have to postpone the move until their truck is repaired so the move will only take one day as originally planned. I hope the property owner doesn't mind we move out later than planned."	Rather Inappropriate

Response 4:	<p>“They cannot just change the duration of the move... Problems can always happen but it is their responsibility to find a solution. I’ll call them to tell them they need to solve this.”</p>	Neutral
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Competency	TEAM PLAYER	
Case:	<p>Felicia works as a construction engineer in a real estate company that specializes in building mega constructions such as dams, skyscrapers, and complex bridge structures, etc.</p> <p>The engineers from Felicia's company collaborate intensively with a real estate company to build a state-of-the-art airport in the United Arab Emirates. Felicia gets along very well with Carl, one of the engineers from this other company with whom she collaborates intensively. They are both junior construction engineers.</p> <p>Today, Felicia is having dinner with Carl. During dinner, Carl says: <i>'I really like working with you and so do my colleagues. But, honestly, no one from our team likes working with your colleague Liz. Even though she does not have any more expertise or seniority than us, she is often very critical without offering any solutions. A lot of colleagues think she can be very rude and insensitive. They don't feel comfortable working with her.'</i></p> <p>Felicia responds:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	<p>"Thanks for sharing this, Carl. I will definitely take this up with our team leader. I'm sure he will take it up with Liz. It is his task to solve this."</p>	Rather inappropriate
Response 2:	<p>"I had no idea that this was your perception about Liz. But I can imagine that this is how she comes through if you don't know her that well. Why don't you discuss this with her? I'm sure she'll be open to this feedback."</p>	Rather appropriate
Response 3:	<p>"I don't think Liz is aware of this. Good that you mention it. I will discuss this with Liz - without naming you, of course. If she does not change her approach, I'll discuss this with the team leader."</p>	Appropriate
Response 4:	<p>"I think this is just a difference in personalities. Liz can be very straightforward indeed. Once you're used to this, you will see she has no bad intentions."</p>	Inappropriate

Competency	HELICOPTER VIEW	
Case:	<p>Keisha is a junior project manager for a construction firm. This is her first project and she has been tasked with managing the construction of an extension to a public hospital.</p> <p>Keisha is doing a walk of the building site and inspecting the concrete pillars which hold the building up. She discovers from her inspection that 28 of the 36 pillars were built using the wrong type of concrete and that they must be replaced.</p> <p>Keisha meets with Billy, one of her colleagues and says <i>“Hey Billy, I’m going to call Tom, the site representative for the construction company who were tasked with building the pillars and talk to him about the issues we’re having, can I use you as a soundboard before the call? I was going to say:”</i></p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	<p>“Tom, the pillars you built seem not to be in line with the project description. I’m afraid we cannot continue like this. I’ll need an estimate of the time and cost to tear down the old pillars and replace them. When can your team be back on site?”</p>	Appropriate
Response 2:	<p>“The pillars are built from the wrong concrete. I’m not confident that they can support the building going forward. We can’t continue building the floors of the hospital until they are replaced with the correct concrete pillars. I need you back on site as soon as possible.”</p>	<p>Rather Appropriate</p>
Response 3:	<p>“Tom, I need you back on site to take a look at these pillars, they’re not what was agreed in the project description and I’m seriously considering calling in the companies’ lawyers.”</p>	Inappropriate
Response 4:	<p>“Tom, I need you back on site to remove these pillars, I’m not overly concerned with costs or time constraints on the project, at the moment my primary concern is with public safety.”</p>	<p>Rather Inappropriate</p>

Competency	INITIATIVE	
Case:	<p>Samir is a recently graduated engineer, who works for 'E-Load', a company that produces batteries. Samir has been invited to attend a meeting with some of the senior engineers to discuss an ongoing project aimed at redesigning the facility to increase the rate of production by 2%. Although Samir is young and inexperienced, Nathan, one of the project leaders on the project thought Samir would be a good fit for the project. Therefore, Nathan asked him to informally attend a meeting to see if he is interested.</p> <p>They started the project a couple of weeks ago and implemented a new procedure with more sensitive sensors. Before the procedure, the production error was 0.5 percent of the produced batteries. Now, after the implementation, the objective to produce 2% more batteries was achieved, but the percentage of defect batteries has increased to 1.2%.</p> <p>During the meeting Nathan says: <i>"We really need to reduce the percentage of defect batteries, and keep the production rate high. I'm not sure if we will be able to respect the initial planning with the resources we have so I'd welcome all additional support we can get."</i> Nathan looks at Samir.</p> <p>Samir responds:</p>	
	Instruction: Please rate the appropriateness of each of the following responses:	
	Response 1	<p>"I am a bit hesitant to take too big a stake in the project because I'm a junior and this role is too much of a stretch for me. I think it's better to divide it among yourselves."</p> <p>Rather inappropriate</p>
	Response 2:	<p>"I would like to assist you with this project. But as I am a junior engineer, I will need some additional coaching from the senior team members. Under that condition, I'm sure I can provide a meaningful contribution."</p> <p>Appropriate</p>
	Response 3:	<p>"Maybe I can help to reduce the workload. I will complete any tasks you assign to me. So, if you think I can do this, I want to try it."</p> <p>Neutral</p>
	Response 4:	<p>"Well, if I was part of this project group I would like to help, but I was just invited for the first time so I don't feel I'm in a position to make a strong commitment."</p> <p>Inappropriate</p>

Competency	WORK ORGANIZATION	
Case:	<p>Antoine is a junior electrical engineer, who works for Melo Pharma, a company that produces medication against cancer. Due to an epidemic of the flu, a lot of colleagues are absent from work. Antoine will have a busy week to get everything done.</p> <p>It's Monday afternoon. Nick, the manager of the department calls Antoine. He is working on an important optimization project to install a new system for scanning barcodes on their medication. It is a flagship project with high stakes for the company. Nick says over the phone: <i>"I'm currently working on the configuration of the sensors on the production line and still need an engineer with knowledge of a specific product. I immediately thought of you. The team meeting will take place this Wednesday. I know this is short notice, but your expertise would be very helpful. I can send you all the specs of the sensors right now so you can adequately prepare for the meeting. This will give us a significant head start. Could you prepare the meeting and participate in this project?"</i></p> <p>Antoine responds:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	<p>"I'm glad you reach out. It's very busy here, but this is a unique opportunity to contribute to this flagship project. I will confer with my colleagues to re-allocate some tasks to ensure I can do the project."</p>	Appropriate
Response 2:	<p>"It's a great opportunity and even though it is very busy now, I will arrange it. If needed, I'll do some overtime to make it work."</p>	Rather appropriate
Response 3:	<p>"Thanks for reaching out, Nick. However, I don't have the time to do the meeting, let alone prepare it profoundly. I will ask someone else to attend the meeting."</p>	Rather inappropriate
Response 4:	<p>"Sounds like a great opportunity. Of course I can prepare this meeting. Most of the colleagues will be back next week and then they can catch up on the work. You can count on me."</p>	Inappropriate

Competency	STRESS RESISTANCE	
Case:	<p>Kevin is an IT engineer in F.O.O.D., a catering company with a brand new delivery platform. Because of this new delivery platform, the CEO is very preoccupied with the online image and publicity of the company.</p> <p>The company has a very dynamic website where staff from the marketing department can post content without interfering from IT. On a daily basis, the website has about 800 visitors and is hosted by an external provider. The contract with the hosting provider includes a clause that they will temporarily provide more bandwidth if F.O.O.D. warns them beforehand about an expected increase in the number of visitors.</p> <p>Over the past weeks, Kevin has been extremely busy with the migration to a new server system. It was a stressful period with a lot of unexpected difficulties and this really puts a strain on the IT team.</p> <p>That afternoon, Rick, the head of the IT, rushes into Kevin's office and says: <i>"Kevin, our website is down! This is very bad timing! Apparently, marketing just launched a competition whereby the visitors of our site could win a dinner party for 10! People are complaining on social media... Can you quickly fix it because this is bad publicity!"</i> Kevin looks at the website statistics and sees that the site has up to 10 times more traffic than usual.</p> <p>Kevin replies.</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	"It's a shame for the bad publicity but I really can't spend time on this website incident right now as the server migration has higher priority. We will need to establish a procedure to avoid this in the future."	Rather Inappropriate
Response 2:	"It's very busy now but let's quickly publish a message online that the website is down due to an unexpected high number of visitors. I'll try to contact our hosting service to solve this."	Appropriate
Response 3:	"Let's suspend the competition and relaunch it tomorrow. I'll make all preparations to make sure everything goes smoothly tomorrow."	Rather Appropriate
Response 4:	"The marketing department should have warned me beforehand so I could request more bandwidth. They know this. It's their responsibility. Given that I'm in the middle of this important migration, I really can't deal with this now."	Inappropriate

Competency	PLANNING AND ORGANISATION	
<p>Case:</p> <p>Katrina works at a large 3D printing company with more than 700 employees. The company specializes in printing medical implants and prostheses. In this domain, innovations succeed each other at a high pace. As a consequence, there are often several dozens of prototypes being used for research to display to investors. They are also used for marketing purposes at medical showcases. Partly due to the exponential growth of the company, the product development department lost track of the existing prototypes. Currently, over 400 (beta) versions are circulating in the different implant divisions. As a result, quite a few of both older and more recent prototypes got lost lately.</p> <p>The manager Product Development calls Katrina and says: <i>“Hey Katrina, I want to ask you something. I would like you to locate all prototypes, make an inventory, and uniquely label them through a tracker system. It is essential that the tracker system is future proof and is scalable to our large organisation. With the input of the different implant divisions, this process should enable us to flag outdated models and to know where each prototype is at each moment. Do you think you can do that?”</i>.</p> <p>Instruction:</p> <p>Response 1:</p> <p>Response 2:</p> <p>Response 3:</p> <p>Response 4:</p>	<p>Please rate the appropriateness of each of the following responses:</p>	
	<p>“Maybe we should keep an inventory from all prototypes that will be produced as from today but not spend too much time on tracing the old ones?”</p>	Inappropriate
	<p>“Yes, I can certainly do that. Maybe you could ask the communication department to put a message in the internal newsletter to request all staff members who have a prototype to contact me.”</p>	Neutral
	<p>“Yes, I would gladly help you out on this one. I suggest taking this up during the summer, when a lot of colleagues are on leave, so this does not interfere with their work”</p>	Rather Inappropriate
	<p>“I will send a message to each team leader to ask them to let me know before the end of the month which prototypes they have. I’ll label them at a time when it does not disrupt their work.”</p>	Appropriate

7.3 SJT ITEMS: CUSTOMER INTIMACY

TABLE 7.4 SJT ITEMS CUSTOMER INTIMACY

Competency	CLIENT FOCUS	
Case:	<p>Kenneth works as a senior consultant for a consultancy firm. Over the last 9 months, he has been working with a client to design an organization wide IT system. Within a month, this project will come to an end. Kenneth enjoys working with the client. He gets a lot of appreciation and he likes the dynamic organizational climate.</p> <p>That morning, he receives an email from Laura, his manager at the consulting firm: <i>“Hi Kenneth, your client has just asked me to extend your contract with them for another 6 months so you can help them implementing the IT system. I’m not sure how to respond. I think Sarah has more experience with implementation, even though she is a junior profile (and hence selling her services is less profitable for us). You have less experience with implementing systems like this but the client is satisfied with your performance so they asked me to put you on the project. Should I extend your contract? Or should I introduce them to Sarah?”</i></p> <p>Kenneth replies:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	<p>“I think we should extend my contract if that is what the client wants. And I personally don’t mind working with this client.”</p>	Inappropriate
Response 2:	<p>“Even though I really like working with this client, I think you should offer them Sarah’s services. Her profile meets the clients’ needs better than mine.”</p>	Rather Appropriate
Response 3:	<p>“I would be transparent with the client and share the two options with them so they can make an informed decision.”</p>	Appropriate

Response 4:	<p>“I suggest that you extend my contract. I will work extra hard to acquire the necessary skills in the field of IT system implementation in the short run.”</p>	Neutral
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Competency	CAPACITY FOR EMPATHY	
Case:	<p>Bob is a project leader at “Bluebot”, a company that builds customized robot arms for the automotive industry. Recently, the company started to focus more on robotics for the production of electric cars. Bob and his team are now building robotic arms for Automania, a car company that just started mass-producing their first electric car, called the e-tronic.</p> <p>Automania is facing serious pressure to get their production facility up and running. As a consequence, they are closely involved in the design of the robotic arm and have been asking for a lot of last-minute customizations which has resulted in a lot of delays and overtime at Bluebot.</p> <p>Today, a team from Automania visited Bob’s team to check on their progress. During the visit, the client asked for even more customizations. Bob wrote down all change requests. After the client left, he discusses the list with the team. Everybody agrees that this puts the planning under a lot of pressure. One of the staff members asks Bob what he’ll do. Bob replies:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	<p>“I will call the client to tell him that our building team is already doing a lot of overtime. In addition, we will get behind on schedule. I will explain that it’s just not possible to implement the adjustments he’s asking for.”</p>	<p>Rather Inappropriate</p>
Response 2:	<p>“I will try to align their needs with what our team can realistically deliver. I will inform them how each additional adjustment will affect the delivery date and associated costs. They can then decide if the customizations are worth the delay.”</p>	<p>Appropriate</p>

Response 3:	<p>“To keep the planning on track, we cannot do all the customizations they are asking for. I will call the client and tell him that all their requests are difficult to realize within this timeframe. I will ask him to pick a couple of customizations.”</p>	Neutral
Response 4:	<p>“I will call the client and tell him that we understand the urgency and will do our very best to work as well and as fast as possible to get this done in time. But I’ll also explain that what he asks is not self- evident for our team and that we will definitely get some delays.”</p>	<p>Rather Appropriate</p>

Competency	CLEAR COMMUNICATION	
Case:	<p>Mason works at "TRFC", a company that designs innovative mobility solutions. His job is to set up collaborations to bring the new products to the market. The R&D department recently developed a traffic management system that uses real-time data from traffic cameras and from road users to enable a smooth traffic flow in and around the city. The aim is to install a continuous information exchange between various parties (traffic officers, road user and traffic lights).</p> <p>Mason is looking for city councils that are willing to pilot the system. The aim of the pilot phase is to collect data and to thoroughly test the system in real life circumstances.</p> <p>He just got back from a first meeting with Maddy who is responsible for mobility at NewCity. Mason's colleague, Jennifer, prepared the meeting since she would originally represent the company in this meeting. Due to circumstances she couldn't make it to the meeting and Mason took her place. The meeting was a great success and Jennifer calls Mason for a quick 1 minute update as she's running to another meeting.</p> <p>Mason summarizes the meeting as follows:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	<p>"The meeting just finished, I think I connected very well with Maddy on a personal level. I will copy you when I send the minutes of this meeting to Maddy. Is that okay for you?"</p>	<p>Rather Inappropriate</p>
Response 2:	<p>"Maddy is interested in joining the pilot study to collect data and go through the system. Next step is to have another meeting in 3 weeks with her to go through the details."</p>	<p>Rather Appropriate</p>
Response 3:	<p>"I think she is interested in a collaboration. I will send you the report from the meeting. If you have any other questions you can always call me."</p>	<p>Neutral</p>

Response 4:	<p>“We talked about the outline of the project and she seemed really interested. Of course, we still need to discuss the practicalities but as a first meeting, this couldn’t have gone any better. I will send you the report of the meeting today.”</p>	<p>Rather Appropriate</p>
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Competency	CREATIVITY	
Case:	<p>Derek works at a startup company. The company designs software and appliances to build 'smart homes'. Their clients are mainly project developers who buy the company's products and services to design and build the smart interiors of houses and apartments. The organization has 3 teams: the software developers, the hardware developers and the sales team.</p> <p>During today's team meeting says John, the company's founder and CEO that he has read that studies say that the innovation rate of companies is higher if staff has a good understanding of the expertise of departments other than their own. Based on these insights, he requires that all staff members follow one training or attend one conference related to the field of expertise of one of the two other teams.</p> <p>Derek replies:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	"I want to give it a chance even though attending trainings and conferences outside of my field of expertise, is not something I would spontaneously do."	Rather Appropriate
Response 2:	"I am somewhat skeptical about this type of studies. I find it hard to understand that innovation increases by creating more generic profiles instead of real experts."	Inappropriate
Response 3:	"This is interesting. I suggest that if someone has attended an inspiring session, that they briefly shares some insights at the next team meeting of their own team."	Appropriate
Response 4:	"I hope you don't take this the wrong way, but I think we should invest the limited budget for training and development primarily in the personal development of each staff member in his or her own field of expertise."	Neutral

Competency	NETWORKING	
<p>Case:</p> <p>Evelyn is a materials engineer at a large fire protection product company, and represents her company on a tradeshow with her colleague Mira, a product marketing intern. Evelyn has brought Mira to the tradeshow to give her a sense of the competition in the market and to meet potential clients that may be interested in doing business with the company in the future.</p> <p>Mira has been tasked with providing a showcase of their new product line at the trade show. She received specific targets to establish 10 concrete leads with new clients. After the show, Mira asks Evelyn how they should best engage with the crowd in order to approach potential clients.</p> <p>Evelyn responds:</p> <p>Instruction:</p> <p>Please rate the appropriateness of each of the following responses:</p> <p>Response 1:</p> <p>Response 2:</p> <p>Response 3:</p> <p>Response 4:</p>	<p>Evelyn is a materials engineer at a large fire protection product company, and represents her company on a tradeshow with her colleague Mira, a product marketing intern. Evelyn has brought Mira to the tradeshow to give her a sense of the competition in the market and to meet potential clients that may be interested in doing business with the company in the future.</p> <p>Mira has been tasked with providing a showcase of their new product line at the trade show. She received specific targets to establish 10 concrete leads with new clients. After the show, Mira asks Evelyn how they should best engage with the crowd in order to approach potential clients.</p> <p>Evelyn responds:</p>	
	<p>“We can mingle with our competitors so that we can take part of their conversations. This way, we can find out what they are currently working on.</p>	Inappropriate
	<p>“We can walk around in front of our booth and see if someone approaches us. It is important that we are available to anyone who has questions.”</p>	Neutral
	<p>“I saw several people taking notes during the presentation so I have neatly arranged all the product information on our booth so that interested parties can easily find the required information.”</p>	<p>Rather</p> <p>Inappropriate</p>
	<p>“I noted that a participant in the crowd had a comment about the novelty of one of our products. Let’s approach her and see whether she would like to have an in-depth discussion about it”</p>	<p>Rather</p> <p>Appropriate</p>

Competency	SOLUTION ORIENTED	
Case:	<p>Simon works at Ring, a company that produces smart phone screens. He is responsible for the contact and the relationship with Ring's biggest clients. This week, Ring will work on a giant delivery of 350000 screens for a major phone manufacturer. Every day, 50000 screens will be produced. That is the company's maximum capacity. On a daily basis, these screens will be shipped to three of the client's phone factories: 10000 to factory 1, 15000 to factory 2 and 25000 to factory 3.</p> <p>It's a Monday morning and the production of the screens started up a couple of hours ago. Simon receives a phone call from the operations engineer. He says: <i>"One of the machines experienced a serious technical failure. As a result, the production will decrease to 35000 screens per day through Thursday because the machine cannot be repaired earlier. The spare part we ordered will only be delivered on Thursday. I really cannot speed up this process. What are we going to do now?"</i></p> <p>Simon replies:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	"I suggest that you reach out to all vendors of this kind of machines to check if you can find the necessary spare part earlier."	Rather Appropriate
Response 2:	"I would just deliver everything we can produce and try to catch up from Thursday onwards."	Inappropriate
Response 3:	"We'll have to contact the client and explain the situation. We'll have to ask what he prefers, given the limitations we are experiencing."	Rather Appropriate
Response 4:	"I will contact the client, explain the situation and offer them a financial compensation. I'll ask our colleagues from the administration to find out if our insurance covers this compensation."	Neutral

Competency	NEGOTIATION	
Case:	<p>Sarah is field project specialist in “Care 4U” a large pharmaceutical company. Care 4U recently developed a new product: innovative packaging of Alzheimer medication that helps patients to dose and time their medication intake. Trial studies have shown promising results in the areas of patient empowerment and reduction of time allocation for nurses.</p> <p>On top of pharmacies, Care 4U now wants to enter the nursing home market. Today, Sarah has a meeting with Mike, director of a big nursing home. They have a meeting to discuss the opportunity to buy the medicine in the new packaging for the Alzheimer patients in his nursing home.</p> <p>Mike shares his opinion about the new product:</p> <p><i>“I understand that a lot of people are enthusiastic about this packaging solution for Alzheimer medication. But for us, it's useless. The patients in our home don't need to take their medication by themselves: our nurses are in charge of this. As such, it does not make sense to pay extra for a packaging we don't really need. Furthermore, we have already made a lot of progress in the negotiations with another supplier.”</i></p> <p>Sarah responds:</p>	
Instruction:	Please rate the appropriateness of each of the following responses:	
Response 1:	<p>“Let’s consider another approach: Would you for example be interested in the medication without the innovative packaging? I’m sure we can offer you a cheaper price with the classic packaging.”</p>	Rather Appropriate
Response 2:	<p>“I understand. Too bad we cannot be of any assistance. But thank you so much for your input. We will take it into account and I will come back to you later.”</p>	Inappropriate

Response 3:	“Maybe you don’t have to buy from another supplier. I can offer you a 30% discount. That’s really the lowest we can go.”	Rather Inappropriate
Response 4:	“I understand your point of view. It might be interesting to know, however, that trial studies in nursing homes demonstrated a reduced workload for nurses. I can offer you a free package to try it out. “	Rather Appropriate

Competency	FOCUS ON RESULTS	
Case:	<p>Jared is responsible for the operations of a large brewery. The brewery has a contract with a festival organizer to deliver several hundred barrels of beer for an open air festival that will take place this weekend.</p> <p>The beer has been specially brewed for the occasion. To mitigate the risk of drunkenness amongst festival visitors, the festival organizer has requested that the ‘festival beer’ contains a lower volume of alcohol than usual. The barrels need to be delivered by tomorrow morning. From that moment on, it will be much more difficult to deliver the barrels because the fences around the festival area will be put in place.</p> <p>Tony, one of the Jared’s colleagues who is running the installation comes to Jared and says: <i>“We’ve had a few setbacks with the installation, we screwed up the replacement of a filter. As a consequence, we’re running three hours behind schedule. I can ask some of the guys to do some overtime but you know that overtime is paid at 200% so that will weigh on the profitability of this contract. Or I can ask them to load the trucks with barrels of regular beer from our stock. In that case, no one will have to do any overtime.”</i></p> <p>Jared replies:</p>	
	<p>Instruction: Please rate the appropriateness of each of the following responses:</p>	
	<p>Response 1: “Delivering regular beer instead of ‘festival beer’ is not an option. We’ll just have to bear the additional costs for the overtime. It’s important to live up to our commitments. Otherwise, the reputational damage may be way larger in the long run”</p>	Appropriate
	<p>Response 2: “Everybody can go home tonight as planned. We will deliver the barrels tomorrow around midday. We’ll find a way to circumvent the fences.”</p>	<p>Rather Inappropriate</p>

Response 3:	<p>“I’ll ask the other managers if we can pull staff from the brewery over here to give us a hand with the installation. The next regular batch will suffer but at least we can deliver on time to this client.”</p>	Appropriate
Response 4:	<p>“I’ll call the festival organizer to explain the situation and ask if they’re ok with a delivery of regular beer now or if they prefer to have the ‘festival beer’ delivered tomorrow.”</p>	<p>Rather Appropriate</p>

APPENDIX B: EVALUATION OF THE SJT

8.1 ITEM STEM EVALUATION FOR PRODUCT LEADERSHIP

TABLE 8.1 ITEM STEM EVALUATION FOR PRODUCT LEADERSHIP FROM EXPERT PANEL
WITH ACADEMICS

Participants						Skill match	Role match
Innovation							
Innovation	Networking	Creativity	Planning & organising	Creativity		1	3
Negotiation	Innovation	Team spirit	Perseverance			1	2
	Vision		Initiative			0	3
Creativity							
Solution oriented	Solution orientated	Solution orientated	Positive critical attitude	Innovation		0	1
Negotiation	Work organisation	Focus on results	Innovation	Work organisation		0	1
Persuasiveness	Focus on results	Vision	Perseverance			0	3
Vision							
Focus on results	Conceptualisa tion	Innovation	Vision	Vision	Positive critical attitude	2	3
Solution orientation	Solution Orientation	Conceptualisa tion	Positive critical attitude	Conceptualisa tion	Vision	1	1
	Helicopter quality					0	0
Persuasiveness							

Focus on results	Clear communication	Persuasiveness	Innovation	Persuasiveness	Persuasiveness	3	4
Solution orientation	Negotiation	Networking	Negotiation	Clear communication	Negotiation	0	0
	Persuasiveness					0	1
Initiative							
Helicopter view	Team player	Helicopter view	Initiative	Positive critical attitude		1	1
Innovation	Initiative	Planning & Organising	Networking	Helicopter quality		1	2
Networking	Capacity for empathy	Persuasiveness		Innovation		0	2
Client focus							
Planning & Organising	Innovation	Team spirit	Solution oriented	Planning & Organising		0	1
Networking	Capacity for empathy	Positive critical attitude	Client focus	Vision		1	1
Positive critical attitude	Result oriented	Capacity for empathy		Team spirit		0	0

TABLE 8.2. ITEM STEM EVALUATION FOR PRODUCT LEADERSHIP FROM EXPERT PANEL
WITH INDUSTRY

Item	Siemens	ENGIE
Innovation	<ul style="list-style-type: none"> • Good case. • But we had to explain our line of reasoning here... 	

Creativity	<ul style="list-style-type: none"> • Participants do not see the link with creativity. • Creativity stems from different solutions. Maybe include the thinking process to come to the solutions? • R2: Flip a coin: soften this... • Our approach: ask feedback from an outside party is the 'creativity element' (R1 & R4) > they don't see this... 	
Vision	<ul style="list-style-type: none"> • This item hints at positive critical attitude. • A look at the future: OK 	<ul style="list-style-type: none"> • Case is rather clear. However the different response categories might need some more work. • R4: easy critique • R1: Instead of 'it is a pity', open up opportunities to something else.... Turn something negative around instead of just complaining about an outdated technology. •
Persuasiveness	<ul style="list-style-type: none"> • Good case, very clear. 	<ul style="list-style-type: none"> • The case is very clear... However, the participants have issues with the responses. • R1: take out the personal element ('you will be gaining my expertise'). It doesn't work that way. • You need to convince an investor that You really belief in the product, its qualities, market potential,... Build this more into the responses... • It is patented: So what?! (not solid argument). • R4 is not neutral but rather inappropriate ('I am only interested in' points at ivory tower, avoid this...) --> change into mostly interested?
Perseverance	<ul style="list-style-type: none"> • Case is very clear. • more clearly indicate that this study is needed for the development process. • Maybe add some more complaining to R2 (otherwise it's more appropriate) 	<ul style="list-style-type: none"> • Case is clear. Maybe express the necessity of reviewing the remaining 150 reports (e.g., results inconclusive) • Convince the manager that it is worth the effort (to spend time on this)
Initiative	<ul style="list-style-type: none"> • Case is clear. Initiative is apparent. • R1: also inviting colleagues might not be very appropriate... • R3: Appropriate instead of inappropriate 	<ul style="list-style-type: none"> • The case is now pretty 'lightweight'. Maybe phrase the case a bit harder (go the extra mile). • R1: leave out 'definitely' to make it more rather appropriate

Client focus	<ul style="list-style-type: none"> • Case is ok. Clear. 	<ul style="list-style-type: none"> • Case is ok. Clear. • Maybe initiate update instead of imitate
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8.2 ITEM STEM EVALUATION FOR OPERATIONAL EXCELLENCE

TABLE 8.3. ITEM STEM EVALUATION FOR OPERATIONAL EXCELLENCE FROM EXPERT
PANEL WITH ACADEMICS

Participant response						Skill match	Role match
Solution oriented							
Helicopter quality	Solution oriented	Planning & organising	Planning & organising	Leadership		1	4
Planning & organising	Planning & organising	Focus on results	Clear communication	Persuasiveness		0	2
Clear communication	Team spirit	Team spirit	Initiative	Clear communication		0	0
Positive critical attitude							
Focus on results	Focus on results	Initiative	Capacity for empathy	Initiative		0	1
Positive critical attitude	Positive critical attitude	Positive critical attitude	Positive critical attitude	Positive critical attitude		5	5
Negotiation	Client focus		Team spirit			0	1
Planning & organising							

Solution oriented	Solution oriented	Conceptualisation	Solution oriented	Negotiation	Solution oriented	1	3
Focus on results	Creativity	Planning & Organising	Focus on results	Solution oriented	Focus on results	1	1
	Planning & organising						
Planning & Organising 2							
Planning & Organising	Team spirit	Focus on results	Planning & organising	Solution oriented	Positive critical attitude	0	3
Work organisation		Solution orientated	Work organisation			0	0
Team player							
Negotiation	Capacity for empathy	Capacity for empathy		Negotiation	Team spirit	1	1
Clear communication	Team spirit	Networking			Networking	1	1
Helicopter view							
Clear communication	Solution orientation	Clear communication	Planning & organisation	Focus on results	Conceptualisation	0	2
	Vision	Focus on results	Positive critical attitude	Clear communication	Clear communication	0	1
						0	0
Initiative							
Positive critical attitude	Solution oriented	Positive critical attitude	Clear communication	Positive critical attitude		0	4

Clear communication	Planning & organising	Work organisation	Negotiation	Team spirit		0	3
Work organisation	Clear communication	Vision		Stress tolerance		0	2

TABLE 8.4. ITEM STEM EVALUATION FOR OPERATIONAL EXCELLENCE FROM EXPERT
PANEL WITH INDUSTRY

Item	Siemens	ENGIE	ESB
Positive critical attitude	<ul style="list-style-type: none"> Fully agree with the case. The cases matches Operational excellence very well. 	<ul style="list-style-type: none"> As this was the first item to review, there was some discussion on how it actually works. There is also an initiative element in this case (Robert asks Sarah), this confused them. It is not clear what is expected: Being critical could be considered a positive thing (e.g., R3). Maybe change appropriateness R3 and R4 (suggestion). 	<p>Red light. case is not aligned to the role or to definition of competence.</p> <p>The case is more about communication to superiors.</p>
Solution oriented	<ul style="list-style-type: none"> The case does not match Solution oriented (the case in itself is not bad - it is clear for students). There is a leadership/management aspect that clouds good judgement The case might need a problem at the end, to react solution-oriented This case is less clear 	<ul style="list-style-type: none"> The team aspect confuses the ENGIE participants (e.g., do the team members know each other?; Is there a prior trajectory?; people with common objective?) 2 weeks' time, is that enough to build a bridge? There is no time for brainstorming etc. Engineer said : 2 weeks is possible to build a bridge Construction and design of the bridge are both used in the case: confused them, so make a choice. Also: if it's the design, it's ok to 	<p>Red light. Case is really about leadership rather than solution orientation. Also none of responses are great examples of how to solve problem.</p>

	<p>than the previous one.</p> <ul style="list-style-type: none"> • The first response could be appropriate for team spirit/trust in team 	<p>brainstorm, otherwise not really.</p> <ul style="list-style-type: none"> • Suggestion: Use this item for planning and organising? 	
Planning and organising (1)	<ul style="list-style-type: none"> • The Siemens panel likes this case better for Planning & organising. It is more clear than the second item. • There is a hint of solution orientation here as well... 	<ul style="list-style-type: none"> • The case is ok but more links with solution orientation. • The case is ok, but not convinced by the responses • Suggestion: Maybe use this item for solution orientation? 	Red light. Case is more about solution orientation
Planning and organising (2)		<ul style="list-style-type: none"> • The case appeals more to planning and organising but everything seems more or less done... What still needs to be planned? • In the current responses, there is not much planning involved... • This could also be done by a non-engineer. Make it bit more engineering minded? • They suggested a case similar to the one with the bridge for planning & organisation 	Orange light case and responses need more focus on plan and organisation aspect. Expand on how Shelia will organise the moving company.
Team player	<ul style="list-style-type: none"> • Definitely a realistic case: good case but a narrow interpretation of team player • Suggestion: take the 'friendship' aspect a bit away and make it more among colleagues • The engineer in the room indicates that maybe the answers are a 	<ul style="list-style-type: none"> • The ENGIE team also indicates that softening the friendship aspect is a good idea • Change level of appropriateness of R2 and R3? • There is some discussion on the appropriateness of R4: thinking about the cultural aspect is a good thing. Maybe now it too inappropriate? You might need to explain the inappropriateness to the 	Orange. Case as it stands is more about communication. Refocus on Felicia and Carla as the people having the dispute and how they resolve it together.

	<p>bit too soft: You can express more clearly/harsher that peer to peer you need to address yourself (R2)</p>	<p>end user.</p> <ul style="list-style-type: none"> • Some think R1 is more inappropriate than R4 	
Helicopter quality	<ul style="list-style-type: none"> • Try to shorten the case. • The link between the case and the helicopter view is not completely clear. • The case is more about coherent reporting than a display of helicopter view. It might be a bit too farfetched. 	<ul style="list-style-type: none"> • Case does not entirely match with operational definition (e.g. take important decisions) • this is more about efficient reporting, not about helicopter view • Comment senior engineer: You would need some intel on the financial impact of each minor element that is observed (to prioritize). • Comment senior engineer: common mistake of engineers is that they only focus on 1 aspect. Maybe tweak your item this way 	Green Light - case and responses are appropriate
Initiative (1)	<ul style="list-style-type: none"> • Very clear case / basic 'initiative) • Representative for a junior engineer (realistic) • The case is very basic but it fits the competence better than (2) • Rephrase R4 	<ul style="list-style-type: none"> • This is pure initiative but some more work on the responses is needed: now it is just about expressing intentions > no actions. • Good case. Basic but good. 	Orange light. Appropriate responses should include more actual initiative (for example offering to read up on the project)
Initiative (2)	<ul style="list-style-type: none"> • Case clearly fits with operational excellence but more complicated. • This goes further than initiative... 	<ul style="list-style-type: none"> • The case is more complicated than the previous one. • Positive about this case it that the response include more actions (rather than intentions). • Maybe if we simplify this case it might also work. 	Red light. Case is too major to highlight initiative such a decision would be made at board level.

Work organisation	<ul style="list-style-type: none"> • The case might be a bit too far of the competence it is supposed to measure. • Make it a bit less journalist and more engineer. • More explicitly bring in the organisation element (e.g., colleague who got sick and you need to rearrange your schedule). • Now it is very extreme (Noble Prize winner) > make it more a daily realistic situation. Now it is more about grasping an opportunity that suddenly arises and less about the work organisation... 	<ul style="list-style-type: none"> • Similar comment: it is predominantly on choosing/setting priorities... • Same difficulty/challenge as planning item... • Not too many comments on this item 	Orange Light: Case is appropriate but might be better if there was more scope to display organisation (eg have another project or person involved)
Stress resistance	<ul style="list-style-type: none"> • No comments. Realistic case. You could easily see the stress aspect here... 	<ul style="list-style-type: none"> • Not completely convinced on the stress resistance element (coming from the head of a nuclear plant this makes sense) • Are we targeting the right 'stress': permanent stress or peak stress • Now, the response categories are too obvious (socially desirable answer) • All these answers might happen in the first five minutes... • A panicking CEO maybe replace to something else? For example, being called up at night for an emergency in a plant (this is pretty common for IT engineers to be 'on duty'...) This gives it a more realistic twist... 	Red Light. Neither case nor solutions measures the competency. Stress resistance is more related to health and wellbeing. Also students won't empathise with the senior manager involved they won't appreciate the stress level involved.

8.3 ITEM STEM EVALUATION FOR CUSTOMER INTIMACY

TABLE 8.5. ITEM STEM EVALUATION FOR CUSTOMER INTIMACY FROM EXPERT PANEL
WITH ACADEMICS

Participants						Skill match	Role match
Client focus							
Client focus	Team player	Positive critical attitude	Negotiation	Client focus		2	2
Focus on results	Client focus	Focus on results	Client focus	Networking		2	5
Negotiation		Capacity for empathy	Capacity for empathy			0	3
Capacity for empathy							
Clear communication	Positive critical attitude	Perseverance	Negotiation	Planning & organising		0	2
Negotiation	Perseverance	Stress tolerance	Client focus	Client focus		0	3
Stress tolerance	Solution oriented	Client focus	Positive critical attitude	Negotiation		0	3
Clear communication							
Persuasiveness	Conceptualisation	Networking	Persuasiveness	Clear communication	Networking	1	3
Negotiation	Solution Orientation	Negotiation	Negotiation	Persuasiveness		0	4
	Vision					0	0
Creativity							

Helicopter quality	Positive critical attitude	Vision	Capacity for empathy	Creativity	Positive critical attitude	1	2
Positive critical attitude	Team spirit	Team spirit	Team spirit	Innovation		0	0
	Capacity for empathy		Work organisation			0	1
Networking							
Persuasiveness	Stress tolerance	Perseverance	Clear communication	Clear communication	Client focus	0	3
Communication		Clear communication		Persuasiveness	Networking	1	3
						0	0
Solution orientation							
Client focus	Solution oriented	Helicopter quality	Stress tolerance	Negotiation		1	3
Negotiation	Initiative	Initiative	Client focus	Solution oriented		1	3
Solution oriented		Stress tolerance	Clear communication	Work organisation		1	3
Negotiation							
Innovation	Negotiation	Positive critical attitude	Creativity	Creativity		1	3
Negotiation	Solution oriented	Innovation	Persuasiveness	Persuasiveness		1	2
Solution oriented	Capacity for empathy	Initiative	Client focus	Focus on results		0	4
Focus on results							
Negotiation	Creativity	Solution orientated	Clear communication	Stress tolerance		0	4

Client focus	Solution oriented	Initiative	Client focus	Perseverance		0	3
Work organisation		Negotiation	Initiative	Creativity		0	2

TABLE 8.6. ITEM STEM EVALUATION FOR CUSTOMER INTIMACY FROM EXPERT PANEL
WITH INDUSTRY

Item	Siemens	ESB
Client focus	<ul style="list-style-type: none"> •Excellent case. • Case: maybe leave out "explicitly" asked me to put you on the project ... 	Happy with the case and think that it fits the competence and the role. Not as happy with the rating of the responses. Response 1 not inappropriate and response 4 more appropriate.
Capacity for empathy	<p>Realistic case. Happens in real life.</p> <ul style="list-style-type: none"> • However, price element lacks somehow in the responses. For example, with R2, also a price element comes into play... There almost is no customer that signs a blank cheque... 	Not happy with case. This is more of a contractual issue. Empathy would be more to do with people. Feel that super yacht suggests rich client and not necessarily requiring empathy.
Clear communication	<ul style="list-style-type: none"> • Good case. Communication pops up nicely. • R2 might be a bit too pushy. Maybe rephrase: 'Would it be okay if I call you next week around 11' 	Orange light. Communication is not so clear in the case. The four responses all beat around the bush. A lot of the responses are conveying information that should have been in the meeting. The responses should be about moving the problem forward.
Creativity	<ul style="list-style-type: none"> • Creativity does not really show in this item... This needs more elaboration • R1: neutral or rather inappropriate. • R3: response from participants: another meeting? Something new again? 	Red Light. Case doesn't highlight creativity nor do the responses.
Networking	<ul style="list-style-type: none"> • Clear networking • R2 maybe not as neutral... (Rather negative). 	Red light the case is too one way (sales pitch) the responses are better but are constrained by the case. This is more communication skills than networking

Solution orientation	<ul style="list-style-type: none"> • Case is good! 	Green light. Cases and responses work.
Negotiation	<ul style="list-style-type: none"> • Clear • R1 and R4: appropriate 	Orange light negotiation is appearing in the answers but not in the case. Concern that end user isn't appropriate for the product.
Focus on results	<ul style="list-style-type: none"> • Case is good and will appeal to students • R1 is not really realistic as it completely ignores the cost aspects (companies will rarely say 'we'll just bare the additional costs') --> rather appropriate • R2: very inappropriate, problem is postponed • R3: maybe extend this a bit. • R4: "... delivered by tomorrow MORNING" like in the case --> to avoid confusion about timing 	Green light. Case is interesting and responses are appropriate. Did note that there are commercial and safety aspects to this case as well.

TABLE 8.7 EXPERT SCORING OF PRODUCT LEADERSHIP ITEMS

Solution orientation			
Resp.	Scoring key	Experts	Reason
R1	Rather Appropriate	Neutral	
R2	Inappropriate	Rather inappropriate	Least appropriate, wouldn't be possible to catch up on work
R3	Rather Appropriate	Rather appropriate	Best response
R4	Neutral	Neutral	This is disaster management
Persuasiveness			
Resp.	Scoring key	Experts	Reason
R1	Rather appropriate	Rather appropriate	Answers the question
R2	Appropriate	Rather appropriate	Better, value selling. But a fluffy answer
R3	Rather inappropriate	Rather inappropriate	
R4	Neutral	Rather inappropriate	Investor wants a return, so he's investing in the person as well

Perseverance			
Resp.	Scoring key	Experts	Reason
R1	Rather inappropriate	Rather inappropriate	Don't stop working!
R2	Rather appropriate	Rather appropriate	Sharing the workload is good
R3	Neutral	Neutral	
R4	Inappropriate	Inappropriate	Don't stop working!
Initiative			
Resp.	Scoring key	Experts	Reason
R1	Rather inappropriate	Rather inappropriate	It's not what you look for
R2	Appropriate	Appropriate	It's not what you want either, not the best delivery, but! You are at a senior meeting so take responsibility
R3	Neutral	Neutral	
R4	Inappropriate	Inappropriate	If you can do something do it with help of your team
Innovation			
Resp.	Scoring key	Experts	Reason
R1	Appropriate	Rather appropriate	More innovative, some opportunities
R2	Neutral	Neutral	
R3	Inappropriate	Rather inappropriate	
R4	Appropriate	Neutral	Working within office hours, not overemphasising
Client focus			
Resp.	Scoring key	Experts	Reason
R1	Inappropriate	Rather inappropriate	Very short sighted, should inform client, leads to poor satisfaction. Some say it is appropriate, eager to learn, but on a critical project it may become an issue
R2	Rather appropriate	Neutral	
R3	Appropriate	Appropriate	He gave the info & was transparent, honest attitude, empathy for consultant
R4	Neutral	Neutral	
Creativity			

Resp.	Scoring key	Experts	Reason
R1	Appropriate	Rather appropriate	Positively rewarding ideas, more appropriate for brainstorming
R2	Neutral	Neutral	like saying "that's not what I had in mind, lets park it "but softens it a bit
R3	Inappropriate	Inappropriate	Inappropriate
R4	Rather appropriate	Rather appropriate	Best solution

TABLE 8.8 EXPERT SCORING OF OPERATIONAL EXCELLENCE ITEMS

Positive critical attitude			
Resp.	Scoring key	Experts	Reason
R1	Rather appropriate	Rather appropriate	A wee bit less harsh but depends who bought the sensors
R2	Appropriate	Neutral	Opens up a conversation about the sensors
R3	Inappropriate	Rather inappropriate	A bit inappropriate
R4	Rather inappropriate	Neutral	Wasted opportunity to tell her
Positive critical attitude			
Resp.	Scoring key	Experts	Reason
R1	Rather appropriate	Neutral	"Is there a reason you bought these" - Sassy
R2	Appropriate	Neutral	Combo of 2 & 4 would be best
R3	Inappropriate	Rather inappropriate	
R4	Rather inappropriate	Neutral	
Solution orientation			
Resp.	Scoring key	Experts	Reason
R1	Rather Inappropriate	Inappropriate	
R2	Appropriate	Rather appropriate	Thought through the problem
R3	Rather Inappropriate	Rather inappropriate	Not thinking about rental, lease
R4	Neutral	Rather appropriate	This is affective communication
Helicopter quality			
Resp.	Scoring key	Experts	Reason
R1	Appropriate	Rather appropriate	
R2	Rather Appropriate	Rather appropriate	Stating rather than asking
R3	Inappropriate	Inappropriate	Legal route not desirable
R4	Rather Inappropriate	Inappropriate	

Planning & organising			
Resp.	Scoring key	Experts	Reason
R1	Inappropriate	Rather inappropriate	Just figuring out, not planning
R2	Neutral	Rather appropriate	Only looking at one part of the process
R3	Rather inappropriate	Rather inappropriate	
R4	Appropriate	Appropriate	Clear plan of what is needed
Team player			
Resp.	Scoring key	Experts	Reason
R1	Rather Inappropriate	Rather inappropriate	Shouldn't be discussing with Liz or the TL.
R2	Rather Appropriate	Neutral	This is the text book answer
R3	Appropriate	Rather inappropriate	A better response would be to pass it up to management without "naming names"
R4	Inappropriate	Neutral	
Initiative			
Resp.	Scoring key	Experts	Reason
R1	Rather inappropriate	Rather inappropriate	It's not what you look for
R2	Appropriate	Appropriate	It's not what you want either, not the best delivery, but! You are at a senior meeting so take responsibility
R3	Neutral	Neutral	
R4	Inappropriate	Inappropriate	If you can do something do it with help of your team
Stress resistance			
Resp.	Scoring key	Experts	Reason
R1	Rather inappropriate	Rather inappropriate	
R2	Appropriate	Rather appropriate	
R3	Rather appropriate	Appropriate	
R4	Inappropriate	Rather inappropriate	
Work organisation			
Resp.	Scoring key	Experts	Reason
R1	Appropriate	Neutral	More focussed on collaboration to make something happen. When the boss calls - it is important. More innovative
R2	Rather appropriate	Neutral	Skip a night's sleep! (Big debate)
R3	Rather inappropriate	Rather inappropriate	

R4	Inappropriate	Neutral	Turning down but showing appreciation. Not looking for alternatives
Work organisation			
Resp.	Scoring key	Experts	Reason
R1	Appropriate	Rather appropriate	Confer with colleagues and agree to do it and get back to him
R2	Rather appropriate	Neutral	Some wont, some will, don't know how much work it is, depends on level of motivation
R3	Rather inappropriate	Neutral	I will ask someone else, but the manager came to you!
R4	Inappropriate	Rather inappropriate	

TABLE 8.9 EXPERT SCORING OF CUSTOMER INTIMACY ITEMS

Clear communication			
Resp.	Scoring key	Experts	Reason
R1	Rather inappropriate	Rather appropriate	Don't like "is it okay for you", but its ok.
R2	Rather appropriate	Rather inappropriate	This is like taking the work away from her
R3	Neutral	Rather appropriate	Good because you're collaborating
R4	Rather appropriate	Rather inappropriate	The worst, taking all the work away from her
Clear communication			
Resp.	Scoring key	Experts	Reason
R1	Rather inappropriate	Rather appropriate	Good, planning and organising
R2	Rather appropriate	Rather inappropriate	A bit distant and harsh
R3	Neutral	Neutral	She offers to collab, more positive
R4	Rather appropriate	Neutral	Inappropriate, rude, no chance to organise next meeting
Creativity			
Resp.	Scoring key	Experts	Reason
R1	Rather Appropriate	Rather Appropriate	The best but not a great response
R2	Inappropriate	Rather inappropriate	Not giving a solution
R3	Appropriate	Appropriate	3,4 equally good, best would be mixture of 3 & 4
R4	Neutral	Neutral	This is fine, its' constructive criticism
Creativity			

Resp.	Scoring key	Experts	Reason
R1	Rather appropriate	Neutral	
R2	Inappropriate	Rather inappropriate	Not willing to listen to new ideas, wont have their own perspective widened
R3	Appropriate	Rather appropriate	Showing interest, creativity, outside the box thinking
R4	Neutral	Neutral	Don't show openness but just an opinion so softens it a bit
Client focus			
Resp.	Scoring key	Experts	Reason
R1	Inappropriate	Rather inappropriate	Very short sighted, should inform client, leads to poor satisfaction. Some say it is appropriate, eager to learn, but on a critical project it may become an issue
R2	Rather appropriate	Neutral	
R3	Appropriate	Appropriate	He gave the info & was transparent, honest attitude, empathy for consultant
R4	Neutral	Neutral	
Capacity for empathy			
Resp.	Scoring key	Experts	Reason
R1	Rather inappropriate	Rather inappropriate	Never say its' impossible, not leaving the clients many options
R2	Appropriate	Appropriate	Demonstrates empathy, gives client ability to decide, clear communication
R3	Neutral	Rather inappropriate	Never say its' impossible
R4	Rather appropriate	Neutral	Shows some elements of empathy, message to client is delivered in a soft way
Capacity for empathy			
Resp.	Scoring key	Experts	Reason
R1	Rather inappropriate	Rather inappropriate	By far the worst
R2	Appropriate	Rather appropriate	By far the best, finds a solution
R3	Neutral	Rather inappropriate	More inappropriate "we can do everything, you have to choose/prioritise"
R4	Rather appropriate	Rather appropriate	Doesn't ask feedback for a decision, what is possible to get back into the deadline
Networking			

Resp.	Scoring key	Experts	Reason
R1	Inappropriate	Neutral	Neutral, it doesn't add much but also doesn't take away
R2	Neutral	Neutral	You need to signal to people that you are open and available
R3	Rather inappropriate	Rather appropriate	Neutral but more proactive
R4	Rather appropriate	Appropriate	
Networking			
Resp.	Scoring key	Experts	Reason
R1	Inappropriate	Inappropriate	Very passive, need to engage the client if you want something out of it
R2	Neutral	Rather inappropriate	
R3	Rather inappropriate	Neutral	Very neutral
R4	Rather appropriate	Rather appropriate	
Focus on results			
Resp.	Scoring key	Experts	Reason
R1	Appropriate	Neutral	Telling the customer after the fact
R2	Rather inappropriate	Rather inappropriate	What if?
R3	Appropriate	Rather appropriate	Better, making it happen. Noble, but not realistic
R4	Rather appropriate	Neutral	Not ideal but a good result
Negotiation			
Resp.	Scoring key	Experts	Reason
R1	Rather appropriate	Rather appropriate	
R2	Inappropriate	Neutral	Closes the communication, short term discussion is over. Maybe after discussion with superior they can come back with a better deal. Giving up, but in a very gentle way
R3	Rather inappropriate	Rather inappropriate	Very strong emphasis on price, could ruin your credibility
R4	Rather appropriate	Appropriate	Lots of additional information in this response
Solution orientation			
Resp.	Scoring key	Experts	Reason
R1	Rather Appropriate	Neutral	
R2	Inappropriate	Rather inappropriate	Least appropriate, wouldn't be possible to catch up on work
R3	Rather Appropriate	Rather appropriate	Best response

R4	Neutral	Neutral	This is disaster management
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APPENDIX C: CODING OF TRANSCRIPTS

9.1 CODING FOR GROUP 1A

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
Innovation	Respondent 1. he's just like, "it's pointless I wouldn't put too much work into it"	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 2. So 1 or 2? Ah, but he does say it sounds interesting, he's being a gentleman, he's being a gentleman	Checks with others to decide on a score	Monitoring	Checking progress
	Respondent 2. And he does suggest that they should explore it for a short time	Evaluates the quality of the response	Evaluation	Quality/success
Innovation	Respondent 1. We're all in agreement?	Checks for agreement on level of appropriateness of response	Monitoring	Checking progress
Creativity	Respondent 2. I'd say [response] four is the best one	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 3. Yeah, I think so, 3 is kinda just saying like, you're choosing for people			
	Respondent 2. Three is like "shut up" . . .			
	Respondent 1. Yeah it's like shut up, no one would like what you're saying			
	Respondent 3 I think 3 is a 1, like it's a kick in the balls. 3 should be a one			
	Respondents: ooooooh			
	Respondent 1: I said it was a 4			
	Respondent 1. She's completely mugged Justin off here.			
Creativity	Respondent 1. But we're all in agreement 4 is good	Checks for agreement on level of appropriateness of response	Monitoring	Checking progress
	Respondent 2. Yeah			

	Respondent 3. Oh yeah definitely yeah.			
Creativity	Respondent 2. Is this not just about being sound to the person, not putting them down, is that no kinda the whole point of this?	Checks understanding of the purpose of the activity	Monitoring	Checks understanding
Creativity	Respondent 1. I think it's more about, if we were in her position what would we say?	Checks understanding of the purpose of the activity	Monitoring	Checks understanding
Vision	Respondent 4. This would be pretty hard for someone who didn't know English very well "thoroughly thought through"	Recognises difficulty in the phrasing of a response	Knowledge of task	Task difficulty
Vision	Respondent 1. [Response 2] She has a point though like. For the amount of money it's going to take to implement that, they have to invest the money to put it in, it'll cost money to fix it	Respondent identifies a lack specific detail in the response	Monitoring	Known/unknown info
	Respondent 2. I think it's very presumptuous of her to assume that it will break down. She's basically saying it's going to break down all the time			
	Respondent 3. How could she know that, she hasn't seen a plan or anything.			
Vision	Respondent 1. I said [response] 3 was neutral	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 2. Yeah I said 3 was 3 [neutral]			
	Respondent 4. Yeah she's trying to sound professional but you gain nothing from her.			
Vision	Respondent 1. I think [response] 4 is a 4	Evaluates the reasonableness of an item response	Evaluation	Quality/success
	Respondent 4. I think it's a 3 though, in the sense that she's saying . .			
	Respondent 1. No but she has an idea and stuff . . .			
	Respondent 4. But not really providing a solution.			
	Respondent 5. No, but she is actually coming up with a solution, she's giving another			

	direction to go, in my opinion a better direction.			
	Respondent 2. I don't think so			
	Respondent 4. I think 4 is the best, because reducing waste . .			
	Respondent 1. She's pushing the idea and whatever way they react to it, then she can put in her ideas.			
	Respondent 4. She needs to put that on the table straight up			
Vision	Respondent 5. The whole idea of working in a team is that you put out your ideas and then everyone else tries to build on that	Identifies process for effective teamwork	Knowledge of persons	Knowledge of others
Persuasiveness	Respondent 1. [Response] 2 is kind of desperate though	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 5. Have you ever seen dragons den though? If they think something is good, that's how they speak – its' passion really.			
	Respondent 1. It's also pure waffle.			
	Respondent 1. [Response 3] ohhhh! That's hitting deep, he's saying you're heartless.			
	Respondent 2. [Response 4] ah no that is terrible			
	Respondent 1. He wants someone else to take control			
	Respondent 4. He's missing an opportunity to make a name for himself and work on bigger things.			
	Respondent 1. I'm saying [response] 2 is 2, he just sounds desperate – I like 3 because he shuts him down.			
	Respondent 4. Very stark move.			
	Respondent 1. You could say it's mean but I think it's a valid point.			
Persuasiveness	Respondent 4. [Response] 1 is not good, he's trying to sell it on novelty. Novelty is crap		Evaluation	Reasonableness

	Respondent 2. Nah I like [response] 1	Evaluates the reasonableness of an item response		
	Respondent 4. [Response] 1 is not good, he's trying to sell it on novelty. Novelty is crap			
	Respondent 4. Him just selling it on novelty . . that's not . .			
	Respondent 3. I think that's just reinforcing his point, his point . .			
	Respondent 4. Yeah but if he doesn't have anything else to say about it . .			
Perseverance	Respondent 5. [Response 4] if she can do 150 she can do the rest	Evaluates the difficulty of the task as conclude the task is no too difficult to complete	Knowledge of task	Task difficulty
	Respondent 1. Yeah, I agree with you on that one.			
	Respondent 5. and because they are medical record, it will be necessary to read them all before she can start the design.			
	Respondent 1. She's basically giving up			
	Respondent 2. Yeah, that's a bad look			
Perseverance	Respondent 2. I gave {response} 1 a 4, she like, believes in what she's done already no? She thinks she has it sorted so she just wants to start working on it.	Checks their interpretation of the response	Monitoring	Checks understanding
Perseverance	Respondent 4. No because eh, she starts off with 250 because she thinks that's enough – she's letting the tiredness affect her too much.	Clarifies the content of the case	Monitoring	Corrects others
Perseverance	Respondent 1. She didn't realise the initial work that was in it	Identifies an underestimation of the task difficulty and strategy	Monitoring	Error detection
	Respondent 4. She's losing sight of the actual goal			
	Respondent 3. She shouldn't be going at it by herself			
Initiative	Respondent 3. I think we should revisit the first one [response]	Comments on the reasonableness of their chosen rating	Evaluation	Reasonableness

Client focus	Respondent 3. [Response] 1 is not good because he's completely ignoring the fact that the update looks shit. He's no problem solving.	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
Client focus	Respondent 1. [Response] Four is alright, but he should just make it easy to understand without needing a manual. – who reads a manual? I think that's inappropriate – expecting them to read a manual for an update, if it was a new system, fair enough.	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 3. He says he wants it to be intuitive and having a manual isn't the most intuitive option.			

9.2 CODING FOR GROUP 2A

Item	Activity/dialogue	Summary of activity	Primary code	Subcode
Client Focus	Respondent 3. How do you rate it, just a tick?	Students check how to select/rate responses	Monitoring	Checks understanding
	Respondent 2. Yeah I think so			
	Respondent 1. Or is it 1,2,3. . .			
	Respondent 3. I think it's 1,2,3,4			
Client Focus	Respondent 2. Oh, yeah "rate these responses from 1-5"	Respondents 2 & 4 correct the others on how to approach the items	Monitoring	Corrects others
	Respondent 3. But there's only 4 of them			
	Respondent 4. Yeah but it's 5 for each one			
	Respondent 3. Oh, yeah yeah yeah			
Client Focus	Respondent 2. Oh, yeah "rate these responses from 1-5"	Respondent 2 & 4 have adjusted the answering strategy moving forward	Control	Changes strategy
	Respondent 3. But there's only 4 of them			
	Respondent 4. Yeah but it's 5 for each one			
	Respondent 3. Oh, yeah yeah yeah			
Client Focus	Respondent 2. I think both of the other ones [responses 1 & 4] are kind of a 2 to be honest,	Respondent evaluates the effectiveness of	Evaluation	Reasonableness

	he's kind of forcing himself on it, even though he's not the best at it	response 1 and 4		
Capacity for empathy	Respondent 2 Alright, so what are we saying	Checks that respondents are ready to provide their ratings	Monitoring	Checks progress
Clear communication	Respondent 3. Not very much information, he doesn't actually give her what happened, he just says, oh yeah it was grand.	Highlights missing information for rating the response	Monitoring	Known/unknown info
Clear communication	Respondent 1. **Reads response 4. Formal, polite and quick	Comments on the quality of approach highlighted in the response	Evaluation	Quality/success
Clear communication	Respondent 2. It's a lot more casual as well, I would prefer it was a bit more formal	Comments on the quality of approach highlighted by another respondent	Evaluation	Reasonableness
	Respondent 1. Isn't this after office hours though? So you wouldn't need to be formal			
Clear communication	Respondent 3. I think he's talking shit, he didn't actually give her any information about what actually happened.	Respondent evaluates the effectiveness of the response	Evaluation	Reasonableness
Creativity	Respondent 1. The first [response] one isn't that like . . "yeah I'm not about that but this is interesting"	Respondent evaluates the effectiveness of the response	Evaluation	Reasonableness
Creativity	Respondent 2. How come we're not giving any 5's?	Compares scoring pattern with previous cases	Knowledge of task	Across tasks
Networking	Respondent 1. So, what's the best way to engage with the crowd **Reads response 1 & 2.	Respondent identifies a goal	Planning	Collects info

		and collects the necessary information		
Networking	Respondent 1. So, what's the best way to engage with the crowd **Reads response 1 & 2.	Respondent comments to themselves before reading the response allowed	Monitoring	Self-commentates
Networking	Respondent 1. **Reads response 4	Respondent evaluates the effectiveness of the response	Evaluation	Reasonableness
	Respondent 2. She's saying she wants to go up to someone who had a question but that's not engaging the full crowd – going up to one person			
Negotiation	Respondent 1. **Reads response 1. Yeah that's professional, making money, that's appropriate. She's not taking no for an answer and she's being polite about it.	Respondent evaluates the effectiveness of the response	Evaluation	Reasonableness
Negotiation	Respondent 1. Using science, less workload on the nurse, free 2 week trial, it's a gamble for the company because they're losing 2 weeks worth of product . .	Respondent summarises pertinent information from the response	Planning	Collects info
Focus on results	Respondent 1. Right, the first thing I noticed about that the client is not getting what he wants in either case – so drinks going to be late, its' a lose-lose for the client. Because the client doesn't want the full beer because the contractor is going to have to do overtime	Respondent identifies that neither strategy is a reasonable solution	Evaluation	Reasonableness
Focus on results	Respondent 2. So we're just looking for a solution that satisfies both parties – so the first one isn't, he's just saying he wants to pay the extra money	Respondent explains the approach to rating the responses	Knowledge of strategy	Explains approach
Focus on results	Respondent 1. That's pretty professional though, they have a job to do, they have to be ready to face problems that may come if you don't do. . .	Respondent evaluates the	Evaluation	Reasonableness

		effectiveness of the response		
Focus on results	Respondent 4 It depends on what the loss is on that batch compared to the time	Highlights time constraints as an unknown	Monitoring	Known/unknown info

9.3 CODING FOR GROUP 4A

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
Positive critical attitude	Respondent 1: I don't get why it's 1-5 if there are 4 answers	Respondent seeks to clarify response strategy	Monitoring	Checks strategy
Positive critical attitude	Respondent 2: Are you done? I'm done as well, what did you put down?	Respondent checks with others to see if they are finished assigning scores	Evaluation	Checks progress
Positive critical attitude	Respondent 1: It depends how it's said	Respondents point out unknown about how the response should be interpreted	Monitoring	Known/unknown info
	Respondent 3: Yeah it depends, I think I read it in a snarky way			
	Respondent 1: Yeah I read it in a nice way, like "may I ask you why did you choose this"			
Positive critical attitude	Respondent 2: He shouldn't be like "I think you should", it's better for him to say his opinion and if there are cheaper ones [sensors] out there not to say it.	Respondent corrects the strategy of the actor	Knowledge of strategy	Evaluates effectiveness
Solution Orientation	Respondent 2: "ill make them pay" It's just like, rude	Respondent evaluates the reasonableness of the response	Evaluation	Reasonableness
	Respondent 1: You don't go in with guns blazing, you have to ease into that sort of stuff			

	Respondent 2: It's a bit childish to say I'll make them pay – it's not professional			
Solution Orientation	Respondent 2: Response 2 I gave a 5 – I was so in between these two (response 2 & 4)	Respondent evaluates the reasonableness of the response	Evaluation	Reasonableness
	Respondent 3: [Response] 2 is giving a solution			
	Respondent 2: Yeah, it'd make them more likely to actually help, and response 3 . .			
	Respondent 4: That's just, gets them nowhere			
	Respondent 2: And 4 is really good I think because they're taking control			
Team Player	Respondent 1: For this [item] I gave 2 fives and 2 threes – I think it all depends on how it's said	Identifies response pattern depends on the individual	Monitoring	Known/unknown info
Team Player	Respondent 3: It depends on what kind of person it is – how she'll respond to that	Identifies response pattern depends on the individual	Monitoring	Known/unknown info
Team Player	Respondent 1: That's were I kinda . . three I was on the fence about, [response] 2 I gave it a three, its' kind of not one or the other because it would depend on friendships and relationships	Identifies response pattern depends on interpersonal relations	Monitoring	Known/unknown info
Team Player	Respondent 2: What responses did you guys give? Oh you have response 3 a 5!	Respondent questions another respondents choice of rating	Monitoring	Error detection
Team Player	Respondent 2: Yeah its' giving her a chance, I gave that a 5, it's just being fair and being honest with her.	Respondent explains why they rated the response a certain way	Knowledge of strategy	Explains approach
Helicopter view	Respondent 2: What did everyone get for the first one?	Respondent 2 checks the responses of	Evaluation	Checks progress

		others in the group		
Helicopter view	Respondent 2: Why did you all say 4?	Respondent 2 checks the responses of others in the group	Evaluation	Checks progress
Helicopter view	Respondent 1: I thought it was a good way to lead into it, to tell the team to be back	Respondent explains why they rated the response a certain way	Knowledge of strategy	Explains approach
Helicopter view	Respondent 2: When it comes to safety I think you need to be as straight forward as possible – pillars are going to fall	Evaluates the effectiveness of an item response	Knowledge of strategy	Evaluates effectiveness
Helicopter view	Respondent 1: If you were just to start a conversation with that, I don't think it will go well – burning bridges	Respondents evaluate the effectiveness of a response	Evaluation	Reasonableness
	Respondent 4: But they kind off messed up			
	Respondent 1: Yeah but you still need to work with them to get it fixed			
	Respondent 2: If you said can you please fix this and then they said no, then . .			
	Respondent 1: I don't think you should just jump straight in with lawyers.			
	Respondent 2: Response 4 I thought was ok . .			
	Respondent 3: I thought It was a 2			
	Respondent 2: I gave it a 3, they didn't say what was wrong with the pillars, they didn't give any details or anything			
	Respondent 1: I don't know, I also thought that, she says I'm not concerned with time, they can take their time with this. . .			
Initiative	Respondent 4: Yeah because I think to be an engineer you have to be an enthusiast – to get better in yourself you have to be enthusiastic	Respondent explains why they rated a response a particular way	Monitoring	Explains approach

Initiative	Respondent 1: Oh I know but he could have phrased it differently	Respondent points out that a response is not optimal due to the phrasing	Monitoring	Error detection
Work organisation	Respondent 3: I think the first one is a 5	Respondents highlights the quality of the response	Evaluation	Quality/success
	Respondent 2: Yeah, it's very mature of him to understand that it's an important opportunity.			
	Respondent 1: He's acknowledging the fact that the work has to be done but also acknowledging that this is a once in a lifetime opportunity			
Work organisation	Respondent 3: [Response 4] He's being honest, you can't neglect everything else just for . .	Respondents refers to the procedure used by others to perform a task	Knowledge of person	Knowledge of others
	Respondent 2: I think it's just him being selfless, other people are out so I'm being left to – it's my responsibility			
	Respondent 1: I gave it a 3 because, like it has to be done, they're just putting it off to do something else, like its' just going to pile up			
	Respondent 4: I gave it a 4 because your putting yourself out there, I think its' really important for you to actually progress			
Stress resistance	Respondent 2: I just think, as an engineer she should probably find a way to fix it instead of saying it's not my problem . . . wait . . . that's the wrong one, never mind	Respondent realises they made an error in their evaluation of a response	Monitoring	Self-corrects
Stress resistance	Respondent 1: I gave the next one [response 2] a 4, I think it's because, I think an online message that the website is down, I don't think that's the most efficient way	Respondent comments on the ineffectiveness of the strategy	Evaluation	Reasonableness
Stress resistance	Respondent 2: I thought [response] 3 was good but if its' still the priority of the	Respondent comments on the	Evaluation	Reasonableness

	migration that's not going to just end tomorrow	reasonableness of the response		
Stress resistance	Respondent 2: [to respondent 3] why did you give [response 1] a 1?	Respondent comments on the correctness of another respondents score	Evaluation	Correctness/accuracy
Stress resistance	I've just completely lost you, you guys are still going and I'd be like . .	Respondent remarks that they fell behind on that item	Evaluation	Progress
Planning & Organising	Respondent 2: [response] 2 I gave it a 5 but then I read response 4 and thought she should just ask each team leader, instead of asking . .	Respondents highlights the quality of the response	Evaluation	Quality/success
	Respondent 1: At a time where it doesn't disrupt their work, that part I would have given higher but putting off labelling them . . there's a better way to get it done			

9.4 CODING FOR GROUP 5A

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
Client focus	Respondent 1. I really like the third response	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 2. I think it's the most diplomatic			
	Respondent 1. Because its' the client at the end of the day that makes the decision			

Client focus	Respondent 3. I like his drive for it, if we say 1 for [response] 4, and then 4 for 3	Plans the response pattern	Planning	Make a plan
Client focus	Respondent 2. They've worked up a good relationship with their client and it's definitely not something you just outright ignore.	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
Client focus	Respondent 3. Em, what is your opinion Jamie? I haven't heard your voice in a while	Asks for a respondents views on the rating for a response	Planning	Collects info
Client focus	Respondent 3. What did you guys think of the second one? We haven't spoken about the second one	Asks for a respondents views on the rating for a response	Planning	Collects info
Client focus	Respondent 1. I get what you mean, but at the same time, that's not him actually trying to do it	Respondents evaluate the quality of a response	Evaluation	Success/quality
	Respondent 2. Like he's differing the problem to someone else			
	Respondent 5. Yeah like he's saying "I give up", he's saying I can't do this. That's definitely a 1			
Client focus	Respondent 4. In the third one [response] I feel as though he's giving the client the option, to show both of their work, instead of not even giving Sarah a chance	Respondent identifies appropriate behaviour	Knowledge of person	Others
Capacity for empathy	Respondent 2. I think one is probably the worst because he's just saying theirs straight up nothing we can do, very blunt	Respondent evaluates the effectiveness of the response	Knowledge of strategy	Evaluates effectiveness
Capacity for empathy	Respondent 2. I think [response] 4 is not very appropriate because you're not really considering your own team	Respondent identifies	Knowledge of person	Others

		appropriate behaviour		
Clear communication	Respondent 3. You didn't like [response] 1?	Respondent checks the answering strategy of another respondent	Monitoring	Checks strategy
Clear communication	Respondent 5. Yeah because he's just saying "oh it's me" we connected on a personal level	Respondent clarifies their choice of rating	Monitoring	Comments on understanding
Clear communication	Respondent 1. He say's "I think she is" is he not sure?	Respondnet checks their own understanding	Monitoring	Checks understanding
Clear communication	Respondent 2. Like, if I was getting that email "you can always call me" I'd be like, hmmm . .	Respondents comment on reasonableness of a response	Evaluation	Reasonableness
	Respondent 3. . . like, why don't you want to tell me now			
Clear communication	Respondent 2. Nadder, would you like to read the next one?	Respondent assigns reading task	Planning	Assigns task
Creativity	Respondent 2. I think 4, because he's not lying, he's just going to be straight up and honest	Respondents comment on reasonableness of a response	Evaluation	Reasonableness
	Respondent 5. Oh I know but some people might take it as an offence			
Creativity	Respondent 3. Yeah 3 sounds the nicest	Respondents comment on reasonableness of a response	Evaluation	Reasonableness
	Respondent 1. Yeah and in the first one he's like "yeah we can give it a chance"			
	Respondent 5. Yeah but that one is like, "yeah, and I don't really have anything else to say"			
Networking	Respondent 1. You can't just approach people and be like "I saw you doing that . . "	Respondents comment on reasonableness of a response	Evaluation	Reasonableness
	Respondent 3. you think so?			

	Respondent 4. It depends on whether or not they . . .			
	Respondent 3. Yeah but they're making a comment			
Networking	Respondent 2. Yeah but I would find it a bit creepy if someone came up to me after a presentation and was like	Identifies missing context in the item to formulate a rating	Monitoring	Known/unknown info
	Respondent 5. It depends on your own views, if you don't want to approach people taking notes then . . .			
Solution oriented	Respondent 5. I don't like [response] 4	Point to the poor quality of the response	Evaluation	Quality/success
	Respondent 3. Personally, I think it's a bit of a, a bit of a cop out			
	Respondent 2. Also, he's offering the client compensation <i>and then</i> finds out if the insurance will cover it? That's just bad management			
Solution oriented	Respondent 1. Yeah and the second one really bad "let's just do everything"	Respondents have a discussion about the quality of the response	Evaluation	Quality/success
	Respondent 5. Nah, 1 is kind of rushing things, but like. .			
	Respondent 3. I didn't think it was two bad personally			
Solution oriented	Respondent 2. If you combine 1 and 3, happy days, I think 3 for me anyways, the best one	Tries to formulate an optimal solution based on 2 responses	Knowledge of task	Across tasks
Solution oriented	Respondent 3. That's what I think, it's not necessary the worst, delays are . . they do happen	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 1. Yeah but you wouldn't just let the person know about it			
	Respondent 2. At least with [response] 3, at least he would have known			

	Respondent 1. It's what would happen, but it's not really that appropriate though			
Negotiation	Respondent 1. Why don't we all read this one at the same time? Ha ha	Suggests a change in strategy	Planning	Makes a plan
Negotiation	Respondent 1. I think [response] 2 is giving up on people	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 3. I agree with that, I think, I mean, it's safe, you know?			
	Respondent 5. It's too neutral			
Negotiation	Respondent 5. Number 4 is reasonable I guess, you could change it but you don't really say oh "you don't need it"	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 2. Yeah it's just common knowledge though			
	Respondent 5. Yeah but you can't really know until you test it			
	Respondent 4. Yeah I think 4 is probably the best			
Negotiation	Respondent 4. I also think, a 5 for [response] 4	Respondent questions the reasoning in the item response	Evaluation	Correctness/accuracy
	Respondent 2. Would you test it for 2 weeks though?			
Negotiation	Respondent 3. I think, less. Maybe a week and see how it goes for them	Respondent changes their approach to rating	Control	Changes strategy
Focus on results	Respondent 4. Well the thing is, if you don't have any other options [response] 4 seems reasonable	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 2. I like how [response] 4 asks that you explain it to the organiser			
	Respondent 4. If there was a form of compensation, I don't know that in response 4 there was a form of compensation			

	Respondent 3. Yeah but if the client says, you know, we want some festival beer you can't just bring over regular beer			
	Respondent 4. Yeah but if they want it, then sure thing but they'll have to have some form of compensation			
	Respondent 1. But I feel like that if they can't deliver well next thing they will think is "well these people can't deal with us" you won't want to work with them again			
Focus on results	Respondent 5. I think [response] 2 is the worst, like they should be allowed to go home	Evaluates the reasonableness of an item response	Evaluation	Reasonableness
	Respondent 3. Yeah I thought that was very inappropriate, personally			

9.5 CODING FOR GROUP 1B

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
Positive critical attitude	Respondent 3: Right, is everyone ready?	Respondent checks group are ready to evaluate the item	Monitoring	Checks progress
Positive critical attitude	Respondent 1: Same response 2, but I think we need to mark them all 1-5 . . . or do we just pick a good one?	Respondent checks how to approach the rating of responses	Monitoring	Checks strategy
Positive critical attitude	Respondent 3: Wait, 1-5, 1-4, so is 1 highest and 4 lowest? . .	Respondent checks how to approach the	Monitoring	Checks strategy

		rating of responses		
	Respondent 4: I think 5 is highest			
	Respondent 1: It's just a scale of 1-5			
Positive critical attitude	Respondent 1: Ehhhh, and then number 2 would be our 5?	Respondent checks understanding of rating system	Monitoring	Checks understanding
Positive critical attitude	Respondent 3: No there's only 4	Respondent corrects another respondents understanding	Monitoring	Corrects others
	Respondent 1: Yeah but it's just a scale			
	Respondent 3: Oh yeah sorry			
Positive critical attitude	Respondent 1: I'd say [response] 1 and 4, give that a 3	Respondents deliberate over the reasonableness of a response	Evaluating	Reasonableness
	Respondent 4: I'd give [response 4] it a 2, because he's not saying that they're bad sensors			
	Respondent 3: That's a good point, I'd say give that one a 2 and not a 3			
Solution orientation	Respondent 1: Alright, everyone read it?		Monitoring	Checks progress
Solution orientation	Respondent 3: I'd say [response] 2 is 5 again like,			
	Respondent 4: Yeah			
	Respondent 1: Yeah because the rest of them were all . . . they're not very professional		Evaluating	Quality/success
	Respondent 3: it's kinda like, ahhh it's somebody else's problem			
Team player	Respondent 2: I think 3 is . . but, would you not want to go to the team leader straight away?		Monitoring	Checks understanding

Team player	Respondent 1: I think [response] 3 is close to [response] 4 though		Evaluating	Reasonableness
	Respondent 2: Because its' pretty good to give a heads up as well, just to see if she . .			
Team player	Respondent 1: Yeah, definitely, everyone agree?		Monitoring	Checks progress
Team player	Respondent 2: Like as a response it's not that bad, but as an action to take	Respondent identifies missing context in item case	Monitoring	Known/unknown info
	Respondent 2: They're out for dinner, so it's not going to be . . well is it casual or formal, the dinner?			
Helicopter view	Respondent 1: I'd say [Response] 1 is a bit laid back though		Evaluating	Quality/success
	Respondent 2: 2's pretty good though like			
	Respondent 1: If you're a project manager you're not going to be like "oh, whenever"			
Helicopter view	Respondent 2: I'd give [response] 3 a 1 I'd think, I'd give [response] 4 a 2 because it's pretty bad		Evaluating	Reasonableness
	Respondent 3: It's just the fact that in the first 2 she's a big jumbled up by . .			
	Respondent 2: It doesn't have any merits behind it			
	Respondent 1: It's not that it's bad, she says I don't care about how long that it takes			
	Respondent 3: Yeah, safety should come first I guess			
	Respondent 2: She also needs to take the whole thing into account			

Helicopter view	Respondent 1: Like compared to [response] 2 . . you could give it a 3 or a 2			
Initiative	Respondent 3: What are we gonna rate this one?		Monitoring	Checks answer
Initiative	Respondent 1: Have you all read this?		Monitoring	Checks progress
Initiative	Respondent 2: And then he's saying I'll do anything you's ask me to, which isn't very . . there's no initiative there		Evaluating	Success/quality
Initiative	Respondent 1: I think [response] 2 is pretty screwed on though		Evaluating	Success/quality
	Respondent 2: Yeah but, it would be easier for the company instead of coaching him up to the same level as the rest of them, to just use the rest of them, I doubt that one person would make that much of a contribution			
	Respondent 4: But they do need to train him in eventually, for the long run			
Initiative	Respondent 1: [Response] 3 is like, "I'll do it" but like he's not really qualified to do much at the time		Evaluating	Effectiveness
	Respondent 2: [Response] 1 is, he's admitting that it might be too much			
	Respondent 3: That's a good response though, like why would he take on something, why would he take on the responsibility if he's not			
Initiative	Respondent 1: And then [response] 4 is just saying that he doesn't really care, so I think [response] 4 should be a 1		Evaluating	Effectiveness
Initiative	Respondent 2: Like if you mix the other three together, it would be a good answer, but the rest of them on their own it's like he's leaving out bits here and there		Knowledge of task	Across tasks

Initiative	Respondent 1: But in terms of a company, like if they need to solve this problem fast, they're not going to take the time to train him up		Evaluating	Effectiveness
	Respondent 2: Yeah but he was taken in informally, so he should be saying I'd like to help but I don't have any of the coaching but if you'd like to coach me I'd be able to help, whereas [response] 3 is, I'll do it anyway			
Initiative	Respondent 1: What are we thinking for [response] 3?		Monitoring	Checks answer
Work organisation	Respondent 1: They're all a bit kind of odd		Evaluating	Quality/success
	Respondent 3: Yeah, they're all a bit censored			
	Respondent 2: Yeah but just the responses are all a bit like, unrealistic you know?			
Work organisation	Respondent 1: Like if your bosses asks asking you to do something and you say you're pretty swamped here, I'll see what I can do		Evaluating	Effectiveness
	Respondent 3: I mean your boss should know that like			
	Respondent 1: Yeah like if your boss is asking you to do something . . I mean, unless they're sound.			
Work organisation	Respondent 2: So what are we thinking? I think [response] 1 is a 3 at most			
Work organisation	Respondent 2: What do you's think?		Evaluating	Progress
Work organisation	Respondent 1: [Response 1] I would have said it was a 2		Monitoring	Checks understanding
	Respondent 2: How come?			

Work organisation	Respondent 4: I mean if she's telling the truth and not just trying to make him feel bad . . and she wants to do it		Monitoring	Comments on understanding
Work organisation	Respondent 4: I think response 4 is a 5,		Evaluating	Effectiveness
	Respondent 1: Eh, yeah I think . . .			
	Respondent 2: Yeah she said they might be back and they could catch up			
	Respondent 3: Do you think it's a good response though considering like . . . not rushed but just found out about it			
	Respondent 2: It was short notice			
Work organisation	Respondent 1: I feel like 3 would be a bit of a, a kind of a more professional response because if you have too much stuff going on and you're not able to make it or prepare for it		Evaluating	Effectiveness
	Respondent 3: Just be honest			
	Respondent 2: Yeah I agree with that			
Work organisation	Respondent 5: I would rate [response] 2 high though, because he knows that people are out sick, so he knows he has to step up a bit and has to do some overtime if he cares		Evaluating	Effectiveness
	Respondent 3: It's unrealistic, no one's going to do overtime			
	Respondent 1: . . you get more money			
	Respondent 3: Yeah but it's very rare someone would say ill do some overtime, I'm going to make it work			
Work organisation	Respondent 1: Yeah I think we were getting our numbers mixed up		Monitoring	Checks strategy
Work organisation	Respondent 1: I think [response] 4 is pretty unrealistic, I think it's a 2, anyone else?		Monitoring	Checks answer
Work organisation	Respondent 1: I'd say maybe a 3, what do you guys think?		Monitoring	Checks answer

Work organisation	Respondent 4: But like isn't she losing the work that she's supposed to do		Evaluating	Quality
	Respondent 1: It's an alright response considering like its just, you don't notice it			
Work organisation	Respondent 2: It depends on how important her work is, like if there's a back log, they need to get rid of that as soon as possible		Monitoring	Known/unknown info
Work organisation	Respondent 1: Yeah, I'd say maybe in between a 3 . . what do you's think?		Monitoring	Checks answer
Stress resistance	Respondent 3: I'd say response 4 is definitely a 5		Evaluating	Quality
	Respondent 1: A 5?!			
	Respondent 3: Yeah, like the marketing, they know they should tell him that like			
	Respondent 1: Yeah but . . yeah, I guess. I wouldn't have given it a 5 though			
	Respondent 5: The ending of it, it's kind of like . . .			
Stress resistance	Respondent 1: Yeah, I guess. I don't think [response] 3 is feasible		Evaluating	Reasonableness
	Respondent 2: No			
	Respondent 3: No, "see you tomorrow" it's 5 to 6 so I'm going home, that's like a 1 or a 2			
	Respondent 2: I'd say it's a 1			
Stress resistance	Respondent 2: It's kind of your job to deal with it. [Response] 2 he says like okay I'll get my message and we'll try get it under control while as this one [response] 1 he's saying "oh, well that's a shame, in future we'll have to do something for it"		Evaluating	Reasonableness
	Respondent 4: I feel like that's a 2			

Stress resistance	Respondent 2: Yeah I think [response] 2 would be our strongest out of all of them. What are you thinking?		Monitoring	Checks answer
Stress resistance	Respondent 2: So . . . 2? What do we think? 1 and 2 I think would be in the same rough area of not being too good		Monitoring	Checks answer
Planning & organising	Respondent 3: I'd say 4 for number 1 though		Monitoring	Checks answer
	Respondent 2: 4 for number 1?!			
Planning & organising	Respondent 3: Sorry did you say 1 & 2 are the same?		Monitoring	Checks understanding
	Respondent 2: I think [response] 1 and 3 are not the best responses		Planning	Repeats strategy
	Respondent 3: Oh, yeah I thought you meant . .		Monitoring	Self-corrects
Planning & organising	Respondent 5: 1 is good though, in the beginning "from today"		Evaluating	Reasonableness
	Respondent 2: Yeah but if prototypes are circulating different in plant divisions and they want to know about them starting now won't fix any of the ones that have been lost			
	Respondent 3: I'd give it a 2			
Planning & organising	Respondent 3: Id say response 4 is pretty decent, I'd give that a 4		Evaluating	Reasonableness
	Respondent 1: Yeah, it's kind of putting it off too, it's not a great response but it's pretty . . I'd say it's a 3			

9.6 CODING FOR GROUP 2B

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
	Respondent 1: Alright, are we ready to go with case 1, innovation? Do we want to read it allowed or?	Respondent decides on a strategy for approaching the activity	Planning	Make a plan
	Respondent 4: What if we took turns?			
	Respond 3: We're rating them 1-5	Respondent clarifies the strategy	Planning	Repeats strategy
Innovation	Respondent 4: I think either [response] 1 or 4, [response] 2 and 3 mean at some point you have the possibility to stick with the old system and you're sure that it works great, but everyone knows the old system is shit.	Respondents evaluate the effectiveness of the response	Evaluation	Reasonableness
	Respondent 6: So, I mean my vote is . . . should we rate them all out of 5. They're asking for a score from 1 to 5, so we can put a score from 1 -5			
	Respondent 1: So, do we all just rate them and see who which one gets the highest			
	Respondent 2: Wait can you pick the same number for the each one?			
Innovation	***Respondent 1 lists response patterns of the group	Respondent summarises progress thusfar	Monitoring	Checks progress
	Respondent 1: Ok, seems like pretty much everyone agrees that number 4 is the most appropriate response			
Creativity	Respondent 6: I switched off for that whole thing	Respondent comments on state of consciousness	Monitoring	Mental clarity

Creativity	Respondent 5: They want to do seminars as webinars or something is it? . . . How much storage does your phone have?	Respondent checks that they understand the item stem	Monitoring	Checks understanding
	Respondent 1: Let's see oh yeah, it's still recording, we're 10 minutes in	Respondents check how long they have been engaged in the activity and evaluate how long it will take to complete	Monitoring	Checks progress
	Respondent 5: And how long is it supposed to be?			
	Respondent 6: We're on the second fucking one!			
Creativity	Respondent 1: The second response sounds interesting but it would focus on applications with direct relevance to their field, but they would perhaps use it as a fall back option, I think that's a fairly reasonable response . . . number 4 is saying they would need to focus on content that is better tailored to the construction domain however as an ending, as a closure, 2 and 4 might work.	Respondent identifies the optimal answering strategy	Evaluation	Reasonableness
Creativity	Respondent 1: Number 1, thanks for bringing this up, blah blah blah contemporary applications of the technology may spark us to incorporate some ideas into our designs . . . fairly relevant but	Respondent comments on reasonableness of the response	Evaluation	Reasonableness
	Respondent 4: Depending on how you know the people in the team, [response] 3 should be . . . 3 depends but if these guys are really into designing stuff, this is the best one, but if they just want pure . . .			

	Respondent 1: If they just want to see how the technology can be used, number 3's pretty good			
	Respondent 4: If they just want cold hard concrete, then number 3 is the worst one			
Creativity	Respondent 5: I gave it a 4, what do you think of that?	Respondent checks their strategy with others	Monitoring	Checks answer
Creativity	Respondent 1: So [response] 4 has got the highest score, does anyone want to make a case for one of the others?	Respondent asks for external input in selecting an appropriate response	Monitoring	Checks answer
*	Respondent 1: Right who's reading?	Respondent highlights the need for a reader	Planning	Repeats strategy
	***Respondent 4 reads			
Vision	Respondent 4: Okay, response 1 is obviously gonna be way too expensive	Respondent identifies cost as a limiting factor in the reasonable of a response	Evaluation	Reasonableness
	Respondent 5: It's a solar powered bin			
	Respondent 4: Yeah, do you know how much a solar panel costs?			
	Respondent 5: Yeah but how does it work?			
	Respondent 4: Yeah but you see if the bag is pretty large, you can reduce it by crushing it, just crush the waste			
Vision	Respondent 1: Okay, look can we get to the responses, I think response 3 is the least relevant one, because the aim is not to increase convenience for citizens the aim is to reduce costs for local	Respondent steers conversation back to identifying responses	Evaluation	Reasonableness

	government or whoever, that seems to be what these people are doing			
	Respondent 2: And overall reduce waste			
	Respondent 1: And reduce waste, however they're not reducing waste their just increasing the efficiency in processing it. . . well it is reducing waste by not having as many cars driving around			
	Respondent 3: I mean, how many jobs would be lost?			
Vision	Respondent 1: Right, settle on scores . . . so far the fourth one . . because its between [response] 4 and 1 it seems. Although number 2, the fact that the new system is more complex, there could be more things to go wrong with it. I thought that was quite relevant as well. Because if the system breaks down a lot you're not actually decreasing anything since you're still going to have as many people working on the same system so its not going to be any cheaper.	Respondent prompts others to evaluate the quality of the various responses	Evaluation	Success/quality
Vision	**Respondent 2: Isn't this the type of stuff we're supposed to be doing in engineering and society	Respondent makes a link between item and course material	Monitoring	Comments on understanding
Persuasiveness	Respondent 4: Okay, 4 is the worst	Respondent comments on the reasonableness of a response	Evaluation	Reasonableness
	Respondent 1: The thing is, the actual question "what makes this product truly unique" and the guy did not answer it			

	Respondent 5: He answered in [response] 1			
	Respondent 1: In 1, but he doesn't say what makes it unique but he doesn't say what makes it unique			
Persuasiveness	Respondent 1: Yeah? So do we all just wanna drop in our responses and then . . .	Respondent reiterates the approach taken in previous items	Planning	Repeats strategy
Persuasiveness	Respondent 3: "The main reason you should invest in the product is that it will help save people's lives". You're in business to make money. . . It sounds cruel, but it's a business so that's 1.	Respondent evaluates the reasonableness of the response based on monetary gains	Evaluation	Reasonableness
Perseverance	Respondent 4: [Response] 1 and 4 are definitely not the ones . . you can just read them off . . if you're assigned something then either you share it with someone by ways of management but you still do it in the end, you get it done	Respondent evaluates the efficacy of the responses	Evaluation	Reasonableness
Perseverance	Respondent 1: I think 3 seems better because 250 reports is an awful lot for 1 person, so if she's already done more than half of it . .	Respondents deliberate over time frame for reading reports to inform their chosen scoring pattern	Evaluation	Reasonableness
	Respondent 3: Yeah but she's got 2 months			
	Respondent 5: Two months, 150 reports . . .			
	Respondent 1: She's done 150 in 2 weeks, so she needs 250 in . . . 1 month. She's got 100 left to do in 2 weeks			
	Respondent 5: Well she shouldn't have left it till the last minute			

	Respondent 3: (sarcasm) Yeah, I hate people like that			
	Respondent 5: Wait, how long did she have to do it? 2 months?			
	Respondent 1: She's got 1 month			
	Respondent 4: That makes 4 a day, 4 reports a day that's fine			
	Respondent 3: Depends how big the reports are going to be. You know if you have to go and interview people, if you've gotta go ask questions, get down to the hard stuff			
Initiative	Respondent 1: I mean if she hasn't started her research it seems like . . . a great way to kick start it by going to this talk, because you're meeting experts	Respondent evaluates the reasonableness of the response	Evaluation	Reasonableness
	Respondent 2: Well it's good to have a broad range of opinions on a subject, so I'd giving that one [response 1] a 4 because nothing's perfect			
Initiative	Respondent 4: Response 3 is not that great because, she doesn't really know what she's talking about now she is just finding an expert and getting straight up into the hard-core stuff.	Respondent evaluates the reasonableness of the response	Evaluation	Reasonableness
	Respondent 1: Yep, feels like we're leaning towards response 1 so . . . inviting more colleagues for a broader range of perspectives and what not.			
Client focus	Respondent 2: I think everyone give their opinion and then we'll converse, let's not be swayed by public opinions	Respondent evaluates the reasonableness of the response	Evaluation	Reasonableness

9.7 CODING FOR GROUP 3B

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
Innovation	Respondent 1: What makes something appropriate or inappropriate?	Respondent checks understanding	Monitoring	Checks understanding
Innovation	Respondent 3: We don't know the system they have is better	Respondent questions their understanding of the case	Monitoring	Checks understanding
	Respondent 2: Well you don't know until you try so it's a stupid answer			
	Respondent 4: Fair point, if there was info on was there a before a data breach? Because if there wasn't then why change?			
Innovation	Respondent 4: We <i>should</i> stick to what we have?	Respondents evaluate the reasonableness of the response	Evaluation	Reasonableness
	Respondent 1: They should definitely look into it			
	Respondent 4: Yeah, yeah. I like 4, it's like that but more cautious			
Innovation	Respondent 3: I think 4 is good	Respondents evaluate the reasonableness of the response	Evaluation	Reasonableness
	Respondent 4: Yeah, so why do <i>you</i> like 4?			
	Respondent 3: As a famous man once said you miss 100% of the chances you don't take			
	Respondent 4: Exactly, and also number 4 seems to be putting a lot of thought into it, not just being like let's totally do			

	that and being like let's explore it, and then decide			
Innovation	Okay, is everyone satisfied? . . . Okay, so second one	Respondent checks everyone is satisfied with the responses before moving on	Monitoring	Checks progress
Creativity	Respondent 1: What are we thinking boys?	Respondent checks that everyone has read and evaluated the item	Evaluation	Checks progress
Creativity	Respondent 4: [Response] 1 is pretty good, I quite enjoy 1	Respondents evaluate the reasonableness of the response	Evaluation	
	Respondent 1: But I don't think it's a 5, it's very much jumping at the chance			
	Respondent 4: Yeah, like we should totally do this			
Creativity	Respondent 3: I think [response] 3 makes sense though	Respondent explains why they evaluated response 3 as a good response	Metacognitive Knowledge	Explains approach
	Respondent 2: Yeah but 3 is bad			
	Respondent 3: No, because whats . . it's like at any of our seminars, if something is really boring, if it's something that's nothing to do with it really, its' like an art piece, that doesn't really have anything to do with . .			
Vision	Respondent 4: These one's have pretty good answers, I'm quite enjoying the answers	Respondent comments on quality of the item responses and check emotional state	Evaluation	Success/quality

Vision	Respondent 2: I have them read, but what does the second part of the first one mean?	Respondent seeks clarity on the meaning of the response	Monitoring	Checks understanding
Vision	Respondent 3: It would just get congested	Respondents comment on the effectiveness of the solution presented in the case	Evaluation	Success/quality
	Respondent 4: Yeah and you'd have to clean the pipeline as well, it doesn't seem very effective			
	Respondent 3: And you'd have to set all that up			
	Respondent 4: And there'd only be one collection point in the whole city			
Vision	Respondent 1: I think [response] 4 is actually the most sustainable, you're actually looking to what you can do about the waste, not just trying to hide it	Respondents evaluate the reasonableness of response 4	Evaluation	Reasonableness
	Respondent 3: I'd give that a 5			
Persuasiveness	Respondent 4: Is there any particular one you like? Anyone?	Respondent seeks clarity from others in the group	Control	Asks for help
Persuasiveness	Respondent 3: for this one? [Persuasiveness]	Respondent checks their understanding	Monitoring	Checks understanding
Persuasiveness	Respondent 2: The second one is awful	Respondent seeks clarity on why the response was considered poor	Monitoring	Checks answer
	Respondent 3: Why is the second awful?			
Persuasiveness	Respondent 1: Yeah, and the last one, it seems if you doesn't want to commercialise it, it seems like he doesn't have trust in his own research	Respondents evaluate response 4	Evaluation	Reasonableness

	Respondent 3: Why would someone put money in just to do research and not have an end thing to like . .			
Persuasiveness	Respondent 2: That is stupid but like, [response] 2 and 1 he doesn't even answer the question, what makes it unique, he's just done his research and he has clinical results and he's trying to scale up but he doesn't say why it's different	Respondents evaluate response 2	Evaluation	Reasonableness
Persuasiveness	Respondent 4: Yeah, I like [response] 4 because it's more interested in being beneficial to people than selling for like, loads of money, like it could be really helpful for patients who don't have access to some of the other bio-wear that they need	Respondents evaluate response 4	Evaluation	Reasonableness
Perseverance	Respondent 4: I do not like 1 or 4, strongly do not vibe	Respondents evaluate responses 1 and 4 simultaneously	Evaluation	Reasonableness
	Respondent 1: No, I don't think the boss will either			
	Respondent 4: No, could you imagine going to your boss and saying "hey, you know those things that are totally vital to my project, what if I just skip it?"			
	Respondent 2: [response] 4 is awful			
	Respondent 4: It's like hey I know we haven't tested on animals but let's go to humans, straight to human trials . . . not that we should test on animals			
Perseverance	Respondent 1: I think [response] 2 and 3 are the only really good ones	Respondents evaluate responses 2 and 3 simultaneously	Evaluation	Reasonableness

	Respondent 3: I mean, she's only asking . .			
	Respondent 4: Yeah, but even if the does say boss you can start it now, those 100 could give totally different results to the first 150, you kind off need to include all of the data to get a fair look at it			
	Respondent 1: For solid research you need more than that			
	Respondent 4: Yeah, you need as much data as you can pull out, if you aren't into collecting data then why are you researching in the first place? Sharing the burden is fair enough, can I have someone to help me			
Initiative	Respondent 4: Is this the last one?	Respondent checks task progress	Monitoring	Checks progress
Initiative	Respondents 2: I thought 2 was pretty good	Respondents evaluate responses 2	Evaluation	Reasonableness
	Respondent 3: Two is alright			
	Respondent 1: I think it's not a bad idea but I think he should still go			
	Respondent 2,4: Yeah			
	Respondent 1: I don't think he should say it's a better idea if he invites this person			
	Respondent 4: And what if he goes and he doesn't actually like what it is and they've already invited him you know?			
	Respondent 1: I don't think the last one's very . .	Respondents evaluate responses 4	Evaluation	Reasonableness
	Respondent 4: No its' very negative, never pass up an opportunity for knowledge			

Initiative	Respondent 1: Kyle, any thoughts? Head empty	Respondent checks on mental clarity of other respondent	Monitoring	Checks understanding
Client focus	Respondent 1: Okay last one	Respondent remarks that the task is almost complete	Monitoring	Checks progress
	Respondent 4: The last one [response] isn't my vibe because let's just give them the instructions	Respondents evaluate responses 4		
Client focus	Respondent 1: Yeah, I guess its not making you . . . but it's not a bad idea		Evaluation	Reasonableness
	Respondent 4: Yeah but if someone's not bothered to update they probably aren't bothered to read the manual either			
	Respondent 3: Well, no, it's your job. It's not like if you buy a new microwave, it's a new operating system			
	Respondent 1: I think it's a bit of both, I think the actual company should put effort into pushing an update and then give a manual			
Client focus	Respondent 1: I think they should do response 2 and 4 combines, then that would be good	Respondents try to devise the optimal solution from the responses	Knowledge of task	Across tasks
	Respondent 4: Yes, I would enjoy that			
Client focus	Respondent 4: Now, I think that's it, Kyle any thoughts?	Respondent checks on mental clarity of other respondent	Monitoring	Checks understanding
Client focus	Respondent 1: Are we done?	Respondent 1 checks if the task is complete	Monitoring	Checks progress

9.8 CODING FOR GROUP 4B

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
Positive critical attitude	Respondent 1: Right, what did you say for number 1 then?	Respondent checks their answers with other respondents	Monitoring	Checks answer
Solution orientation	Respondent 3: What did you say for response 1?	Respondent checks their answers with other respondents	Monitoring	Checks answer
Solution orientation	Respondent 1: Response 1 I gave it a 1 because I just thought that you can't be that . . it just seems a bit aggressive like you can't be suing everyone because of my mistakes if it's under control	Respondents discuss reasonableness of response 1	Evaluation	Reasonableness
	Respondent 3: Yeah she needs to take responsibility instead of blaming someone else			
Solution orientation	Respondent 1: Yeah . . blame someone else, so what did you give the number 5 to?	Respondent checks their answers with other respondents	Monitoring	Checks answer
Solution orientation	Respondent 2: I gave the 5 to response 4 because it's up to them to get the moving truck and do something about it	Respondents discuss reasonableness of response 4	Evaluation	Reasonableness
	Respondent 4: I gave number 2 a 5 as well			
Solution orientation	Respondent 1: I thought response 2 and 4 were the best, but I'd say that 2 is a little bit more aggressive	Respondent compares reasonableness of responses 2 and 4	Knowledge of task	Across tasks

Team player	Respondent 3: It's hard to pick an appropriate one out of these	Respondents comment on task difficulty	Knowledge of task	Task difficulty
	Respondent 1: Yeah because they all seem kind of reasonable			
Team player	Respondent 1: I thought that 1 and 2 were sort of stand-offish like she wasn't going to do anything about it. . . response . . oh yeah response 1 and 4 I thought were bad, 2 and 3 I thought they were more like attacking the problem, then again there is no easy way out, it depends on Liz as well, if she is . . or if she is just being uber professional. It all depends on the person's personality as well, the 3 people.	Respondent compares reasonableness of responses 1 and 2	Knowledge of task	Across tasks
Helicopter view	Respondent 1: What did you think?	Respondent asks for respondents accounts	Monitoring	Checks progress
Helicopter view	Respondent 4: I think response number 2, I gave it a 5. Are Thomas and Keisha working for the same company?	Respondents discuss reasonableness of response 2	Evaluation	Reasonableness
	Respondent 1: Yeah, well, no actually I don't think they are. They could be on separate teams in the same company			
	Respondent 2: Well we don't actually know			
Helicopter view	Respondent 3: I don't like response 4 because she doesn't not interested in the cost or time constraints	Respondents discuss reasonableness of response 4	Evaluation	Reasonableness
	Respondent 1: Yeah, well I thought that was a good answer because your main concern is safety, if your main concern is cost and time constraints it could be a danger to others. Response 3 was em,			

	again quite aggressive, there's no need for that kind of stuff, there's no need to be so . .			
Helicopter view	Respondent 1: Yeah that's why I put in response 2 as my number 5, because she says "we can't continue the floors of the hospital until they are replaced" she makes it clear the whole construction of this building needs to be my main focus, so I thought that was the most appropriate one	Respondent comments on their own response pattern	Monitoring	Checks understanding
Initiative	Respondent 1: Right so, I thought response 1 and response 4 were quite similar, the way he was again quite standoffish, he was avoiding any kind of responsibility, obviously he doesn't have much but . . so I gave them both 1's because if he's a junior engineer . . yeah he's a junior and they're all senior workers so this was a chance to show off how good of a worker he is but he just shifted any responsibility away from himself. So response 3 and response 4 I gave both of them 4's because he wasn't taking . . he wasn't saying that he was overly able but he was willing to take on some responsibility or even if he was that he was going to need a bit of help so response 2 and response 3 are the best ones there.	Respondents discuss reasonableness of all responses simultaneously	Evaluation	Reasonableness
Work organisation	Respondent 1: I think response 2 is a little bit better because em, like in response 1 he was just saying his colleagues would take care of the work, I just thought that was a bit unfair on his colleagues so eh, saying they'll do some	Respondents discuss reasonableness of all responses simultaneously	Evaluation	Reasonableness

	overtime, and then response 3 and 4, well response 3 I thought it was a great opportunity and he'd be a fool to pass it up and also like it would prove, like the manager obviously trusts it so he should take advantage of that trust and then response 4 I thought it wasn't great because he's assuming it'll all be done and not assuming responsibility			
Stress resistance	Respondent 2: I thought the first response and the last response were pretty bad, he's just being a dickhead and eh he kinda left out the part explaining what was going on so I gave that a 2 to a 1 because he didn't give an explanation. And eh for number 2 I'd give that a 4 again he said he was going to make contact about the high number of visitors	Respondents discuss reasonableness of all responses simultaneously	Evaluation	Reasonableness
Stress resistance	Respondent 1: I thought response 1 and response 4 were bad, response 1 theres a bit of . . he cant exactly like. . if he's going to get in trouble for em ditching his job because that's high priority, well he could get in trouble for that so I can see where he's coming from but response 3 I thought was okay as well	Respondents discuss reasonableness of all responses simultaneously	Evaluation	Reasonableness
Planning & organising	Respondent 1: I found it kind of hard to judge response 1, because I don't know the dynamic of the company and how it's working if all prototypes are recorded and documented . . . is it just sentimental? Just to be able to look back at old prototypes? I gave response 4 a 5 because I thought it was the most believable and then em, response 2, response 1 and response 3 is hard to	Respondents discuss reasonableness of all responses simultaneously	Evaluation	Reasonableness

	judge because I don't know how the company works.			
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9.9 CODING FOR GROUP 5B

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
	Respondent 1: Will I read?	Respondent makes a plan by suggesting to read the item out loud for the group	Planning	Makes a plan
	Respondent 2: So is this . . . is this based off what we would say or what would be an appropriate response	Respondent checks that they understand the answering strategy	Monitoring	Checks understanding
	Respondent 1: Yeah, so did he say like 5, so you give 1 if it's bad, 5 if its good?	Respondent checks that they understand the answering strategy	Monitoring	Checks understanding
	Respondent 3: I think we just rank them		Monitoring	Comments on understanding
	Respondent 1: I think that he said you can give them all 5 if they're all good responses		Monitoring	Comments on understanding
Client focus	Respondent 1: Yeah, so 'I suggest that you extend my contract' . . . I will work extra hard	Respondents evaluate the reasonableness of response 3	Evaluation	Reasonableness
	Respondent 3: I think the third one he gives the choice to the client like, and all the information like, you know			
	Respondent 1: Yeah and allow him to make an informed decision			

	Respondent 3: Exactly			
Client focus	Respondent 1: Did you say put 5?	Respondent checks that they understand the answering strategy	Monitoring	Checks understanding
	Respondent 3: 5			
Client focus	Respondent 3: Because for the first one you could argue that that's what the client wants but then you could say the second response you could say that's what's best for the client . . so the client might not know about . . this person is better suited for . .	Respondents evaluate the reasonableness of response 1	Evaluation	Reasonableness
Client focus	Respondent 1: Yeah exactly, so now that's like a 3, it's okay . . both of them a 3 . . yeah? Okay	Respondent checks that they understand the answering strategy	Monitoring	Checks understanding
Capacity for empathy	Respondent 2: The first one's very straight to the point, like facilitating . . . like they're being open with the fact that like, they don't have the . .	Respondents evaluate the reasonableness of response 1	Evaluation	Reasonableness
	Respondent 1: That it's not realistically gonna fit in			
	Respondent 2: Yeah			
Clear communication	Respondent 1: Em . . . well the first one was weird . . . weird isn't it? But like, I dunno they're all kind of saying the same thing	Respondents evaluate the reasonableness of response 1	Evaluation	Reasonableness
	Respondent 3: Yeah, like, that's something you would do in relation to working . . like this lady's telling them how she's going to tell them			
	Respondent 1: Yeah, but 3 is good because like she says she's interested I'll send you the report and ask some questions, so I guess that one's the 5	Respondents evaluate the reasonableness of response 3	Evaluation	Reasonableness

Clear communication	Respondent 1: Okay, so would [response] 1 get like a 2? And then what would 2 get?	Respondent summarises response pattern and last score	Monitoring	Checks progress
Creativity	Respondent 3: [Response] 2 is a bit like, insubordinate. It's like yeah, I doubt your reasoning at all	Respondents evaluate the reasonableness of response 2	Evaluation	Reasonableness
	Respondent 1: It's like a 1			
	Respondent 3: I think maybe a 2, I think 1 would be like "you're an idiot!"			
Creativity	Respondent 1: And, the next one's not too bad, it's an alternative but its not like "oh that's' shite"	Respondents evaluate the reasonableness of response 3	Evaluation	Reasonableness
	Respondent 3: It's more like 'we should look into this more'			
	Respondent 3: Yeah! Like a 3 or 4 then			
Creativity	Respondent 1: Like, the other one is considerate at least, [response] 4 is considerate	Respondents evaluate the reasonableness of response 3	Evaluation	Reasonableness
	Respondent 3: Yeah, it brings up a new idea while not being . . so much as			
	Respondent 1: Yeah, it's not like negative			
Networking	Respondent 1: The one at the bottom [response 4] sound like a nightmare. Like if someone came up to you and was like 'I saw you'	Respondents evaluate the reasonableness of response 3	Evaluation	Reasonableness
	Respondent 2: That one and the one about arranging the product information			

	Respondent 3: Yes, if you wanna read about it, there it is			
Networking	Respondent 1: Okay so what are we thinking? Well the first one is kind of a bit of like, a spy, or I don't really know what the aim is? So I think that one is like a 2 or? and then 2 is probably the best	Respondent checks progress	Monitoring	Checks progress
Networking	Respondent 3: I honestly think that one's a 2 as well [response 1]	Respondents evaluate the reasonableness of response 1	Evaluation	Reasonableness
	Respondent 1: Okay, A 2 or a 3?			
	Respondent 2: I think a 3, it's not as bad as the last one			
	Respondent 1: Like, I mean it's kind of helpful like it could serve a purpose			
	Respondent 2: Yeah true			
Networking	Respondent 1: And then the bottom one	Respondents evaluate the reasonableness of response 3	Evaluation	Reasonableness
	Respondent 2: There's nothing really bad about the third one,			
	Respondent 1: The third one?			
	Respondent 2: Is it not just saying like, leave information so if people want to find certain information			
	Respondent 1: Yeah it's not very engaging, but I guess that's up to them			
Networking	Respondent 1: I think the bottom one is a little bit far fetched	Respondents evaluate the reasonableness of response 4	Evaluation	Reasonableness

	Respondent 2: 1 or a 2?			
	Respondent 3: I'd say 1			
	Respondent 1: I don't know, it's pretty . . like you feel bad for the woman, or the, kit doesn't say, the participant like all she was doing was showing interest now she's going to get harassed			
Solution orientation	Respondent 3: [Response] 2 is not great, like not telling the client	Respondents evaluate the reasonableness of response 2	Evaluation	Reasonableness
	Respondent 1: Yeah because then if they can't catch up . .			
	Respondent 1: Okay, is this the last one? Oh, never mind	Respondent checks progress	Monitoring	Checks progress
Negotiation	Respondent 2: I would say, [response] 4 and 1 are both very good	Respondents evaluate the reasonableness of response 4 and 1	Evaluation	Reasonableness
	Respondent 3: Yeah			
	Respondent 1: Yeah, where as the 30% like . . nice of her			
	Respondent 2: They're just immediately losing 30% of their profit			
	Respondent 1: Yeah exactly, like it doesn't change their need for it			
Negotiation	Respondent 2: [Response] 2 is nearly too passive, she just hits a problem and says, 'uh, bye'	Respondents evaluate the reasonableness of response 2	Evaluation	Reasonableness
	Respondent 3: Yeah			

	Respondent 1: Yeah, she didn't even try			
Negotiation	Respondent 2: Wait, I think 2 is better than 3 actually	Respondent realises they wish to change their response pattern	Control	Change strategy
	Respondent 1: I think 2 is better than 3 as well actually			
	Respondent 2: It's kind of more considerate to the client. . . maybe flip them around			
	Respondent 1: Is this the last one?	Comments on progress	Monitoring	Checks progress
Focus on results	Respondent 1: I think the fourst . . . the fourth even, I don't really know actually	Respondents evaluate the reasonableness of response 2	Evaluation	Reasonableness
	Respondent 3: It doesn't solve . . .			
	Respondent 1: I can't really see how their reputation would be ruined by their festival beer			
	Respondent 2: One of the things that I'm thinking is that they've clearly asked that they want less alcohol			
	Respondent 1: Yeah so it does kind of have to be, because that's what they want. So [response] 4 is probably the best, because you're giving them another option you know?			
Focus on results	Respondent 3: Like any response where they consult the client on what's best . .	Respondent identifies a schema for answering the item	Knowledge of strategy	Evaluates effectiveness
Focus on results	Respondent 3: Like the first one, I think in the first one they have good	Respondents evaluate the	Evaluation	Reasonableness

	intentions but they aren't weighing up the fact that if they are paying them overtime it's going to increase the cost on the client side. So like 3,4?	reasonableness of response 1		
Focus on results	Respondent 1: Like, [response] 2 is probably what's going to happen but it's not very organised or planned it's just 'oh we'll find a way'	Respondents evaluate the reasonableness of response 2	Evaluation	Reasonableness
	Respondent 1: Well it depends, does it open at midday tomorrow?			
	Respondent 3: Yeah, I think that's going to be a late one			
	Respondent 2: The way it's praised is like 'what ever'			
	Respondent 1: Which probably doesn't work when it's big barrels. Okay			

9.10 CODING FOR GROUP 6B

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
	***Respondent 4: reads response 1	Respondent re-reads response	Planning	Collects info
Solution orientation	Respondent 4: So response 1 we give what? 2? Everyone happy with a 2?	Respondent checks their answer with others	Monitoring	Checks answer
Solution orientation	Respondent 4: Ehhh, [response] 3? Neutral? Kind of neutral?	Respondent checks their answer with others	Monitoring	Checks answer

Solution orientation	Respondent 4: And the last one? I'd be saying a 1 because . . .	Respondent compares different responses	Knowledge of task	Across tasks
	Respondent 1: I would have said the first one was worse			
Solution orientation	Respondent 2: I mean it's within their rights but it's also a bit of a . . . it's not very professional	Respondents evaluate response 4	Evaluation	Reasonableness
Team player	Respondent 2: I think response 3 is the perfect one, I'm gonna give it a 5, because it's keeping it anonymous as well	Respondents evaluate response 3	Evaluation	Reasonableness
	Respondent 4: That's bang on, yeah			
Team player	Respondent 1: In the first one she just passes it on to someone else rather than doing anything about it in a way . . . it's more like, I don't want to be involved in this	Respondents evaluate response 1	Evaluation	Reasonableness
	Respondent 4: Fair, a 2?			
	Respondent 1: Yeah or a 3 maybe, or maybe 2			
Team player	Respondent 4: Response 2 she's kind of getting past it all by saying she talks a lot, so its . . .	Respondents evaluate response 2	Evaluation	Reasonableness
	Respondent 3: It's probably better than mentioning it to her rather than just hoping that someone else will sort it out			
	Respondent 4: Yeah, far. 3?			
	Respondent 1,2,3: Yeah			
Team player	Respondent 4: Ehh and the last one then, she hasn't really addressed the problem at all, I'd say it's fairly poor, 2?	Respondents evaluate response 2	Evaluation	Reasonableness
	Respondent 1,2,3: Yeah			
	Respondent 4: Alright Mikey, you're up	Respondent signals to another respondent to read the next item	Planning	Assigns task
Helicopter view	Respondent 2: Both of those 2 yeah, I think four is . . . it's not making them worry and feel that they've done super wrong but it	Respondents evaluate response 4	Evaluation	Reasonableness

	needs to be fixed and needs to be replaced, more respectfully			
	Respondent 4: So what are we saying for 4 so, 5?			
	Respondent 2: 5			
Helicopter view	Respondent 4: Yeah?	Respondent checks the score of 5 for response 4	Monitoring	Checks answer
Helicopter view	Respondent 4: And then the third one, I don't think it was the right way to go about it	Respondent checks the score of 5 for response 3	Monitoring	Checks answer
	Respondent 1: It's very threatening as well			
Initiative	Respondent 4: I don't think any of them are really bad	Respondents evaluate response	Evaluation	Reasonableness
	Respondent 1: I think he should try and take part in it, maybe coaching from a senior team member is a better way to go about it			
	Respondent 5: Yeah that's what I was going to fill in for my favourite			
	Respondent 4: Yeah fair enough			
	Respondent 1: It's probably the strongest response because it's saying that he's happy to do work as well but he knows he's not going to be the best person there.			
	Respondent 4: Yeah. So what we'll go for a 5 for it?			
	Respondent 1,2: Yeah			
Initiative	Respondent 4: Response 1 emmm	Respondents evaluate response	Evaluation	Reasonableness
	Respondent 1: I think he's kind of backing out of it			
	Respondent 4: I don't think it's bad though			
	Respondent 1: It's kind of neutral			
	Respondent 4: 3?			
	Respondent 1: Yeah			
Work organisation	Respondent 4: Ehh, I don't think any in particular are bad but response 4 does kind of like abandons all other duties just to say 'right lets go full on'	Respondents evaluate all responses simultaneously	Evaluation	Reasonableness

	Respondent 3: I think the first response, talking about how he's gonna confer with his colleagues as well, like that's just saying that, i'm not just going to offer it out everyone			
	Respondent 4: Yeah, I also think [response] 2 is quite good because he's saying he'll do the overtime			
	Respondent 3: Yeah he wants, he says he's look for that			
	Respondent 4: I'd say [response] 1 and 2 are probably . . . 4's?			
	Respondent 4: [Response] 3 then, it's no particularly good, but it's not particularly bad, I'd say it's fairly neutral . . . 3?			
	Respondent 1: 3 yeah			
	Respondent 4: And then [response] 4 one, it's not really putting too much focus onto it, so			
	Respondent 1: No he's kind of backing out of it a bit			
Stress resistance	Respondent 3: I think the second one is probably the best response out of all them. Because they're trying to resolve without causing . . . while still looking out for the public and not trying to put the blame on anyone else	Respondents evaluate all response 2	Evaluation	Reasonableness
	Respondent 4: Yeah, I would say 4?			
	Respondent 1,2: yeah			
Stress resistance	Respondent 2: I think [response] 3 is similarly . . . it's like, it's really inconvenient but it's really a problem do you know what I mean?	Respondents evaluate all response 3	Evaluation	Reasonableness
	Respondent 1: Yeah, I feel like it's a real inconvenience to have to reschedule the competition			
	Respondent 4: 4?			
	Respondent 1: Yeah			
Stress resistance	Respondent 4: First one? I don't think it's pretty great but it's also not particularly bad	Respondents evaluate all response 3	Evaluation	Reasonableness
	Respondent 2: He sort of just passes it off			
	Respondent 4: 3?			
	Respondent 2: 2			
	Respondent 4: 2, yeah			

Planning and organising	Respondent 4: What do we think?	Respondent checks that group have read and evaluated the items	Monitoring	Checks progress
Planning and organising	Respondent 3: I think the first one kind of just passes it off, saying I don't want to retrace anything but we'll do it from now on	Respondents evaluate all response 1	Evaluation	Reasonableness
	Respondent 4: 2?			
	Respondent 3: I was going to say it was a bit more neutral, I was going to say a 3			
	Respondent 4: A 3? Okay yeah			
Planning and organising	Respondent 3: Ehhhh, that one's kind quite [response 2] like, trying to retrace them all trying to do the job	Respondents evaluate all response 2	Evaluation	Reasonableness
	Respondent 4: 4?			
	Respondent 3: Yeah			

9.11 CODING FOR GROUP 1C

Item	Activity/dialogue	Summary of activity	Primary code	Sub-code
Creativity	Respondent 1: So we all say basically that we would give a 5 to the first answer, because that's a good way to have new ideas and eh... he doesn't shock the person that proposed the idea	Respondents evaluate the reasonableness of response 1	Evaluating	Reasonableness
	Respondent 1: [Response 2] I gave it a 3			
	Respondent 2: I gave it a 3 as well			
	Respondent 3: I gave it a 3			
	Respondent 4: I gave it a 2			
	Respondent 5: 3			
	Respondent 6: I gave it a 3 as well			

Creativity	Respondent 4: I don't like. . . you know its . . . the seminar is for the developments in the technology as a whole and well the seminar is about construction I think it's important to . . to see where the technology is going not just in your sector but in other sectors where this technology is being used. I just think . . . and even just saying like we'll find something else but we'll use it as a backup option I just feel like that's kind of almost . . . rude.	Respondents evaluate the reasonableness of response 2	Evaluating	Reasonableness
	Respondent 1: I don't think it's in a bad way, but it could be better said			
	Respondent 1: [Response 3] I gave it a 1			
	Respondent 3: I gave it a 2			
	Respondent 5: 2			
	Respondent 6: I gave it a 2			
	Respondent 4: I also gave it a 1			
	Respondent 7: 2			
Creativity	Respondent 1: So I gave it a 1 because I think like eh . . who is she to judge like what's going to reflect badly on people's perception of the seminar you know, it's a way of dividing, you know it's a pre-meeting so no idea is dumb	Respondents evaluate the reasonableness of response 3	Evaluating	Reasonableness
	Respondent 3: I do agree			
	Respondent 1: Everybody should hear and know and do the research on it before saying its' a dumb idea you know		Evaluating	Reasonableness
	Respondent 3: Quite a negative perspective on it as well			
	Respondent 1: Yeah, just saying yeah we want to keep focussed on just that			
	Respondent 6: And she's also an inspirational speaker so that'll keep it interesting as well			

	Respondent 8: It wouldn't encourage someone else to give their idea because she shut it down as well like so abruptly			
Creativity	Respondent 1: [Response 4] I gave it a 5,	Respondents evaluate the reasonableness of response 4	Evaluating	Reasonableness
	Respondent 6: I gave it a 4			
	Respondent 8: I gave it a 4			
	Respondent 5: I gave it a 4 as well			
	Respondent 7: 4 yeah			
	Respondent 5: 4			
	Respondent 1: Well I think you know it's as much eh . . well it's not exactly in the field they want to focus on but at least you know like an inspiring closing session is something to open perspective you know			
	Respondent 8: Yeah she acknowledged it had potential			
	Respondent 1: Because it's not exactly in the field but I think that's how you finish for example a presentation like it's good to have an opening for example that's what people do in other fields and we can inspire to do this kind of stuff. Especially artists you know they're . . . they go like really in depth in the techniques so yeah			
Helicopter view	Respondent 1: I think it's just missing maybe a . . like I think the estimate of time and cost it is important but after you know they explain why they are . . why they wait for the answer, that they wait for them to be back on site because they cannot continue the floor, but that's all from me		Evaluating	Reasonableness
	Respondent 1: 1			
	Respondent 7: I gave it a 1			
	Respondent 8: 2			

	Respondent 1: I think that's a good way to put a hold on your, how do you say your . . . on the building, to put a hold on the construction work on the building, like when you start being menacing with lawyers and stuff			
	Respondent 3: It's not very professional at all			
	Respondent 4: I think just from like, like a relations point of view like the last thing you want to do is start making threats when something seemingly was a mistake and makes you come across incredibly unreasonable			
	Respondent 1: Especially for the first contact you know			
Helicopter view	Respondent 1: [Response 4] I gave it a 1 as well . . . could be 2 maybe		Evaluating	Reasonableness
	Respondent 3: Yeah I said 2			
	Respondent 2: I said 2			
	Respondent 8: I said 2			
	Respondent 1: I think as an engineer you know cost and time is always like one of the main concerns that you need especially for construction work and a hospital as well because you need to meet the delays and stuff			
	Respondent 3: Would the hospital be open when they're working on it? Just because it might fall down because of one of the pillars or whatever			
	Respondent 1: I Haha, yeah that would halt the construction!			
Stress resistance	Respondent 1: I think if the website is down it's the main priority, the migration can wait a little bit and have everything up and ready for the clients and you cannot just say ah I have better stuff to do		Evaluating	Reasonableness

	Respondent 8: He never gave a solution either			
	Respondent 5: Yeah, there's a problem that needs to be solved and you need to solve it			
Stress resistance	Respondent 1: So what did you give for response 2? I gave a 5		Monitoring	Checks progress
Stress resistance	Respondent 1: Alright, anybody can tell me why?		Monitoring	Checks answer
Stress resistance	Respondent 6: Well it's offering a solution so . .		Evaluating	Reasonableness
	Respondent 8: He does everything that was needed really			
	Respondent 1: Yeah I think it deals with the urgency first you know, he's trying to help at least			
	Respondent 3: He's not just like "ah yeah we'll deal with that another time"			
	Respondent 2: He's trying to do both like			
Stress resistance	Respondent 1: Ehhh and so response 3? I gave a 3		Monitoring	Checks answer
Stress resistance	Respondent 7: I gave it a 3		Evaluating	Reasonableness
	Respondent 5: I gave it a 2			
	Respondent 3: I gave it a 2			
	Respondent 6: I gave it a 2			
	Respondent 2: I gave it a 2 yeah			
	Respondent 1: Yeah I was thinking between a 2 and a 3 to be honest because I don't think you can suspend a competition like this for the public you know it would be very very bad publicity. To saw "ah guys sorry the website is down, it's suspended".			
Stress resistance	Respondent 1: Anybody else anything to say on that?		Monitoring	Checks progress
Stress resistance	Respondent 1: Alright response 4, I gave a 1		Evaluating	Reasonableness
	Respondent 2: I gave it a 1			

	Respondent 4: I gave it a 1 as well yeah			
	Respondent 3: He's blaming everyone else like			
	Respondent 1: Yeah exactly, like voiding responsibility. That's his job to make sure everything goes smooth. Even if it's someone's fault you cannot say			
	Respondent 4: At the end of the day, the website is still down so like . .			
	Respondent 1: So is everybody . . in consensus on most of the cases			
	Respondent 3: Yeah			
Vision	Respondent 1: So for response 1 I gave a 5 because we can go like . . people can go like even more, you know. We don't talk about visibility there but, what can be done		Evaluating	Reasonableness
	Respondent 5: I said 3, it's like, it's good but it doesn't help the idea that they're putting forward you know			
	Respondent 2: Yeah I agree I gave it a 4 or a 3			
	Respondent 3: Yeah I put a 3 in there as well			
	Respondent 8: It doesn't really say what they're going to do with the waste afterwards you know			
Vision	Respondent 1: I think they talk about recycling though no?		Monitoring	Checks understanding
Vision	Respondent 1: Yeah and I mean, and he's not [re-reads response] I mean he's not talking about the implementation with the actual system at the moment he's just talking about what can be done		Control	Verbally repeats
Vision	Respondent 1: So what did you do for response 2?		Monitoring	Checks answer

Vision	Respondent 1: Yeah I gave it a 2 as well, I like the way like he talks about what can go wrong with it because that's what he was asked you know the opinion about this project but at the same time it's very negative you know so		Evaluating	Reasonableness
	Respondent 6: I think there's a better solution towards it			
	Respondent 1: Yeah			
Vision	Respondent 1: What about response 3? I gave a 2		Monitoring	Checks answer
Vision	Respondent 1: Ah because I eh, you know like in that case the main thing is not about convenience, is it done or not and in what way is that sustainable, or not. I mean it's good that it's convenient but it's not the main reason that you do this. If it was just convenient people would just throw it by the window you know? It's convenient but it's not useful		Evaluating	Reasonableness
	Respondent 1: Do you see what I mean			
	Respondent 5: Yeah, it's the only like. . it's the only positive one but still it's . . it doesn't help at all, it just says "ah yeah, I wonder how it will go", not really great			
Vision	Respondent 1: Eh response 4 I gave a 4		Evaluating	Reasonableness
	Respondent 3: I gave it a 3			
	Respondent 5: I gave it a 4			
	Respondent 8: I gave it a 3			
	Respondent 1: Yeah because I think its' good because they see it's like a . . . it's like it's done but they still feel like there's improvement . . . in a waste reduction project it's important			
	Respondent 1: So should we go towards the next one or?		Monitoring	Checks progress

Solution orientation	Respondent 1: Alright guys, are you finished?			
Solution orientation	Respondent 1: Anybody hasn't finished?			
Solution orientation	Respondent 1: Alright cool, so for response 1, eh, I said 1		Evaluating	Reasonableness
	Respondent 8: I said 1 as well			
	Respondent 1: Yeah because why be confrontational, you wont help your problem you know			
	Respondent 2: I gave it a 2			
	Respondent 5: I gave it a 2 as well			
	Respondent 7: I gave it a 2 yeah			
	Respondent 1: You're not even giving them a call to ask them to find a solution, you're just like oh yeah "make them pay" . . . I mean that's some point			
Solution orientation	Respondent 1: Any eh, any argument for why?		Monitoring	Checks answer
Solution orientation	Respondent 4: I, I'd, I was gonna give it a 5 but it's still their responsibility to find a solution because they're at fault so . .		Evaluating	Reasonableness
	Respondent 5: That and I doubt a company will ask another company for help you know, with their job			
	Respondent 1: Yeah the other moving company is a bit weird, that's true, I'll move to a 4 yeah			
	Respondent 1: But I mean like it's your job as well to like, work together to find a solution and because your j . . your goal is to have it done, that's just like "oh yeah, that's their problem, let them . . " and then sit on your ass while waiting for them to find a solution you know, it's better to assist them			

	Respondent 4: It's not necessarily all their responsibility to find a solution but I'm still saying it's . . . it's . . . in the end they screwed up, you can help them fix it but in the end they're the ones who have to fix it and from			
	Respondent 1: Yeah they will fix it because they're willing to try but I mean if they say no we don't want to rent a truck there you can say that would be confrontational and say "that's your problem" in the contract it's written that you have to resolve the problem in one day, like, now that's your problem. I mean that's the first contact, to try to solve the problem, if they give bad will, bad will is it? Yeah if they give bad will then . . .			
Solution orientation	Respondent 1: So what did you give for response 3? I gave a 3		Monitoring	Checks answer
Solution orientation	Respondent 5: I gave it a 2		Evaluating	Reasonableness
	Respondent 4: I gave it a 1			
	Respondent 7: A 1			
	Respondent 1: I gave it a 3 because in this he's trying to find a solution, but not really			
	Respondent 4: I don't know, I'd give it a 1 because like, it's our contact with the property owner, if we're not out, we're legally liable, like, it has to be done, like it's non-negotiable, like we have to be out of there			
	Respondent 1: After you could give a call to the guy and ask if it's okay you know? Some people would say it's fine			
	Respondent 4: I know, but I'm just saying from the way it's written I don't think he'd give up the property			

	Respondent 5: I think it could be a last resort but I don't think you should be going to that instantly you know			
	Respondent 1: Yeah but you can ask if it's okay you know "hey man, is that a problem, if we move is that okay"			
	Respondent 1: The other one is really better you know, to just say you rent a truck and that's it . . but . . I'll give a 2 I guess			
Solution orientation	Respondent 1: So what did you do for response 4? I gave a 2		Monitoring	Checks answer
Solution orientation	Respondent 7: A 1		Evaluating	Reasonableness
	Respondent 2: I gave a 2			
	Respondent 8: I gave it a 2			
	Respondent 1: Why did you give it a 1?			
	Respondent 5: Well, you're not saying anything, you're just calling them to say solve it, you're not exactly giving them solutions or helping them in any way			
	Respondent 1: Yeah, definitely yeah			
	Respondent 5: It's pushing everything on to them			
	Respondent 6: I think what it's trying to say is do the move over like a day and half with the 2 trucks instead of a day with 3 trucks			
	Respondent 1: Ehhh yeah, they could, but I mean that's ehhh, you just let your frustration get out in response 4 you know, that doesn't help any way,			
	Respondent 1: Alright, do you want to do Client focus now?		Evaluating	Progress
Client focus	Respondent 1: Have you guys finished?			
Client focus	Respondent 1: Anybody still working on it? No?		Monitoring	Progress

Client focus	Respondent 1: Yeah I think the only thing where it's not a 5 is the guy is not very honest with the client, you know he could offer the client to be . . to have a service for cheaper you know. But at the same time you know it's better to satisfy the client then just to		Evaluating	Reasonableness
	Respondent 4: Yeah, I'd kinda say like you know, if that's what the client wants then that's what the client wants. The customer is always right and if they're happy with it then you know I think . . so yeah I'd give it a 5, but I see where you're coming from yeah			
	Respondent 1: Sorry I had the other classroom open and it was making some noise I didn't hear everything you said, could you repeat some of it?			
	Respondent 4: Well I was just saying that's what the client wants and the customer is always right but I see where you're coming from yeah			
	Respondent 1: Yeah you know if I was at this place I would say lets do it because it brings more money and eh and the client is satisfied and it's better to have the client relationship but at the same time it's kind of dishonest the guy realised it can be bad publicity for the company or even for you not giving the option			
Client focus	Respondent 1: Do you want to go ahead to response 2, I gave it a 3		Evaluating	Progress
Client focus	Respondent 5: Yeah I gave it a 3 as well		Evaluating	Reasonableness
	Respondent 8: I gave it a 3			
	Respondent 4: I gave it a 3			
	Respondent 1: Yeah because if the client says something then you know go ahead, it's			

	better for the company, better for you, why not?			
	Respondent 5: It's good as well but, it's probably not great to say someone in the company is better than you as well			
	Respondent 1: Yeah, but at the same time it's good to recognise that you don't have all the skills necessary for everything. Even though you know he knows a little bit about this thing you know he knows the ins and outs of the IT system I guess but			
Client focus	Respondent 1: So for the third one I gave a 5		Evaluating	Reasonableness
	Respondent 5: I gave it a 5			
	Respondent 8: I gave it a 5			
	Respondent 4: I gave it a 5			
	Respondent 1: It's always good to practice I guess, being as transparent as possible. That's how you keep the trust of your client and that's how you build a relationship and you're covered, if anything ever happens you're covered because you gave the option they cannot			
Client focus	Respondent 1: What about for response 4?		Monitoring	Checks answer
Client focus	Respondent 1: Can you tell me why you gave it a 4 maybe?		Monitoring	Checks answer
Client focus	Respondent 5: Em, it's good and you're giving the employer confidence that you'll keep up with your work		Evaluating	Reasonableness
	Respondent 7: Yeah and it sort of shows you have initiative for the product or whatever, shows you'll work hard			
	Respondent 1: Yeah but the thing is it means you cost more to the client, like, it's the picture of honestly I guess			
	Respondent 1: Do you want to go on to the next one?		Evaluating	Progress
Networking	Respondent 1: Alright guys are you finished?		Monitoring	Progress

Networking	Respondent 1: Anybody still working on it?		Monitoring	Progress
Networking	Respondent 1: Anybody want to, explain his choice or? No, should i?		Monitoring	Checks answer
Networking	Respondent 4: Well, I think you should be representing your own products and it's just a little bit shady		Evaluating	Reasonableness
	Respondent 1: Ha ha ha, yeah			
	Respondent 4: Yeah it's just like, if someone comes up to me and says "why don't you just come over here" I don't think, I don't think it's a very			
	Respondent 1: Yeah there are better products, I think it's good to be aware of what your competitor is doing you know like it's one of the most important aspects of you know, how is your product fighting with the others			
	Respondent 4: Yeah, I suppose yeah			
	Respondent 8: Yeah you can do it, but not take part in their conversations, you should be confident enough in your own product			
	Respondent 1: Yeah exactly and if you get caught up you know they would . . its bad publicity you know, "ah what are you doing here", "ah just snooping around, sorry"			
Networking	Respondent 1: Can you tell us why you gave a 3 or?		Monitoring	Checks answer
Networking	Respondent 5: Em, it's good that you're available for questions but you're not really actively engaging with the people there, you're just waiting for them to come to you		Evaluating	Reasonableness
Networking	Respondent 1: Why did you give a 5?		Monitoring	Checks answer

Networking	Respondent 4: Well, I think this is a professional conference with professional people like, they know what they want and so all they need to know is will the product meet their requirements and I think having it all clearly laid out is a really good idea		Monitoring	Comments on understanding
Networking	Respondent 1: Yeah, it's good to have it laid around but your goal is to interact with them because like, direct contact is always better than . . you know that's why we call it elevator pitch because you know like even if you do a pitch in an elevator it will be more effective than just the pamphlets		Monitoring	Comments on understanding
	Respondent 4: I suppose that's fair		Monitoring	Self corrects
Networking	Respondent 1: And you have to do like 10 concrete leads, so how can you count them as leads if you just say all the information is there		Monitoring	Comments on understanding
	Respondent 4: Actually yeah, I, I skipped over that part in fairness yeah, that's actually quite fair			
Networking	Respondent 1: Do you want to go ahead to response 4, I gave a 5		Evaluating	Progress
Networking	Respondent 4: I gave it a 3, I just think that's incredibly intimidating, like if someone came up and said "hey I saw you taking notes" I'd just treat that . . like if someone did that to me I would be immediately put out		Evaluating	Reasonableness
	Respondent 8: It just seems like they're desperate, they're stuck to the one person that asked a question and they're just sticking to the one thing they asked the question about			

	Respondent 1: Ah, I don't think so because you know if they have something to say that means they're interested you know and if you go ahead and say "hello, how are you, I see you were taking notes, if you have a comment" or whatever you know like			
	Respondent 5: Yeah like "do you want to hear about the product"			
	Respondent 1: Yeah "is there something you didn't understand" or like, I mean that's how you sell stuff, you have to go ahead and just like			
	Respondent 7: You have to see if they're interested			
	Respondent 1: Yeah exactly and after if they had a comment, like it doesn't have to be a negative comment or like "it's nice it looks nice" or if you have a question it's nice to go ahead and answer it			
	Respondent 4: Yeah that's fair			
	Respondent 7: Like if you only get 1 concrete client so . .			
	Respondent 1: True, true but if you talk to someone, maybe like if you answer to it people are going to come back and you can do it many times, like the 10 leads are meant to be throughout the day, like if you do 5 presentations a day for example, like unless it's like a proper, big ass conference or something. Like if you give a quick presentation at your booth you know like and you go and see 2 people every time you do a presentation it's goofy because you'll ask 10.			

	<p>Respondent 1: It's better to go ahead and talk to someone that has something to say rather than some random person it mean they'll talk about it. Anyone have anything to say on that? Sorry I talked a lot haha.</p>		Monitoring	Self-commentates
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