Research Paper

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DON'T JUST THINK, PONDER: METACOGNITIVE SKILLS AMONG ENGINEERING STUDENTS WITH AND WITHOUT WORK PLACEMENTS

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ABSTRACT

In today's world engineers need to be equipped with a range of different skills and experiences to succeed. There needs to be a combination of strong levels of meta-cognition and self-awareness. Nineteen final year mechanical engineering students who completed an industry placement and 20 students who did not took a metacognitive Self-Reflection and Insight Scale (SRIS) survey to test their levels of self-reflection and self-awareness. The two groups' results found higher metacognitive skills in the work placement group in all three areas tested: self-reflection, need for self-reflection (self-awareness) and insight. The study suggests that these metacognitive levels could be increased from taking a work placement year Recommendations are offered on how universities can improve the course curriculum to benefit work placement students and non-work placement students.

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INTRODUCTION

1.1 Background

In today's competitive job market, companies are increasingly seeking graduates who possess a blend of technical expertise and strong interpersonal skills (WEF 2020). While proficiency in technical knowledge remains essential for engineering roles, employers place a significant emphasis on attributes such as self-awareness, analytical abilities, critical thinking, and work experience. Self-awareness refers to the ability to recognize and understand your own thoughts, feelings, and behaviours. The ability to understand your strengths and weakness as well as knowing your limitations (Eurich, 2018). A key factor to improving self-awareness is through self-reflection, which, with practice, can lead to a deeper understanding of yourself and identifying your strengths and weaknesses (Grant et al. 2002). Many top CEOs exhibit exceptional self-awareness marked by fully comprehending their distinctive work styles and adeptly delegating tasks to employees who excel in areas where they may be less proficient (Resick et al. 2022). Therefore, there is a pattern of success with self-awareness that stems from self-reflection.

Extensive research conducted on the psychology of metacognitive function and self-awareness and their relevance in personal and professional development is well established (Dawson 2008). However, there is a notable absence of research on how self-awareness can enhance employability, despite several studies on graduate employment strategies (Morgan & O'Gordon 2011; Kinash et al. 2016; Su 2014). Similarly, there is a lack of literature focusing on how students' self-awareness evolves with industry experience. Addressing these gaps could provide valuable to the career development of students. This could lead to improvements in students' employability and career prospects as they secure employment more rapidly after graduation.

1.2 Metacognitive Function and Relevance to Employment

Moore and Parker (2013) carried out an analysis using pre-existing data on the importance of teaching critical thinking and problem solving in education. They summarized the importance for practical applications in the real world arguing that these cognitive skills and metacognition are closely related and are vital for students when navigating complex challenges. These challenges could occur in both academic and employment scenarios.

Critical thinking and problem solving are key skills looked for by employers (QS 2021; WEF 2020). These are often assessed through interview questions that demonstrate skills in strategic thinking and planning, for example using the STAR response format (Situation-Task-Action-Result). They demonstrate critical thinking by responding quickly to address questions and showcase time management by adhering to specified response times.

Critical thinking is a transferable skill and can be applied to various situations and fields making it an asset in employment. It allows a person to approach a problem with a structured and analytical solution. Graduates with strong critical thinking and problem-solving abilities are better equipped to handle workplace challenges and can contribute more effectively to their own organisations (Moore & Parker 2013). Therefore, developing metacognitive skills should not be overlooked as a pre-requisite to developing these highly sought skills like critical thinking.

1.3 Research Aim and Objectives

This study will investigate whether there is a difference in metacognitive skills and self-awareness between mechanical engineering students that have undertaken a work placement year and those who have not. A metacognitive survey designed and validated by Grant et al. 2002 will be used to assess three metacognitive areas: self-reflection, need for self-reflection (self-awareness) and insight that can be taken from self-reflection. From this report a summary of recommendations will be put forward to aid in developing the employability of mechanical engineering students in the programme. The objectives were:

1. To carry out a survey on final year mechanical engineering students that have completed an industry work placement year and those that have not.
2. To carry out a comparative analysis of the data between the two groups comparing work placement and non-work placement students.
3. To conclude recommendations for the engineering department for further curriculum development

2 METHODOLOGY

2.1 Survey

This study was carried out by using the Self Reflection and Insight Scale (SRIS) questionnaire that was designed by Grant et al. (2002). The questions were designed to identify three aspects of metacognition: engagement in self- reflection, need for self-reflection and insight. The targeted inclusion criteria for this study focused on final year students enrolled in Mechanical Engineering and Design Engineering undergraduate courses at the author's university.

The survey contained 22 questions in total with the first question differentiating students with and without placement year experience and the second question applicable to the placement students on their job title during their placement. The third question asked for consent. The last 20 questions were the SRIS survey questions, which employed a grading scale ranging from 1-6, where 1 indicated strong disagreement and 6 indicated strong agreement with the statement.

Before proceeding with the survey, the participating students were asked to read the Participant Information Sheet and ask to give consent. Responses were anonymously collected. The Participants were made aware that they had the right to not participate at any point during the survey up until they press submit. The study was approved by Aston University's Engineering and Physical Sciences Ethics Committee.

2.2 Data Collection and Statistical Testing

The survey was distributed electronically via Microsoft Forms and data collected were anonymised. Mann Whitney U test was performed on each question to assess if there was any difference between the scores. The results were also displayed onto bar graphs comparing work placement student's vs non work placement students.

3 Results and Discussion

3.1 Survey Outcomes

A total of 40 students participated in the Self Reflection and Insight Scale (SRIS) survey, where 20 students had taken a placement year and 20 students had not. One of the results from the placement side was disregarded as they had completed the survey in 11 seconds. The duration of this submission contrasted with the average time taken to complete the survey, which was 4:25 minutes and therefore was unlikely to have been a true reflection of the participant's experience. After this submission was excluded from the data, there were 19 students who had taken a work placement year and 20 students who had not.

4 work Placement Students Vs Non- Work Placement Students

The work placement participants were working in a wide range of roles including manufacturing and packaging, quality testing, mechanical engineering, and financial services.

During the data collection phase of this study, qualitative insights were gathered through conversations held while surveys were distributed, and participants were briefed. It became apparent that several non-work placement students did not take a work placement year by choice, and some didn't go as they didn't get offered a placement when they applied. Several students did not apply for placements a sighted reasons due to not wanting a placement, the desire to graduate earlier or wanting to pursue a Master's degree after graduation. However, all students who applied but were unable to secure placements stated that they stopped applying around December time unlike the successful placement students who continued to apply and often received offers around March. This raises the question of why the non-placement students had prematurely stopped applying. Is there an underlying perseverance trait from the placement students that meant they didn't lose confidence too soon? Perhaps these students didn't have enough knowledge, expectation, and guidance as to the typical time frame required for getting a placement and how many applications were needed. Noting that students start applying during year 2 starting from September, the start of the UK academic calendar, with the expectation that they begin placements the following summer in year 3.

4.1 Metacognition Skill: Engagement in Self Reflection

Questions 1 to 6 of the SRIS survey evaluates "engagement in self-reflection", showing no significant difference in this aspect of metacognition between the placement versus non-placement group except in one question. The statement: "I often think about the way of feel about things," shows significant difference with the work placement group agreeing more strongly (figure 1). It is important to note that the work placement group rated higher levels of engagement in self-reflection for all other statements, even if they were not significant between the groups.

The questions respond to engaging in thinking about thoughts (Q1), spending time self-reflecting (Q2), examining their feelings (Q3), thinking about cause of behaviour (Q4), examining other thoughts (Q5), and examining their feelings (Q6). What would be interesting is to schedule interviews with some students and evaluate how they

spent their time evaluating or if they thought emotional reflection was beneficial or not. It is noted that the non-placement students were less engaged with emotional reflection (Q3 and Q6), a sense of how one feels. Perhaps non-placement students are less aware of the benefits of emotional reflection.

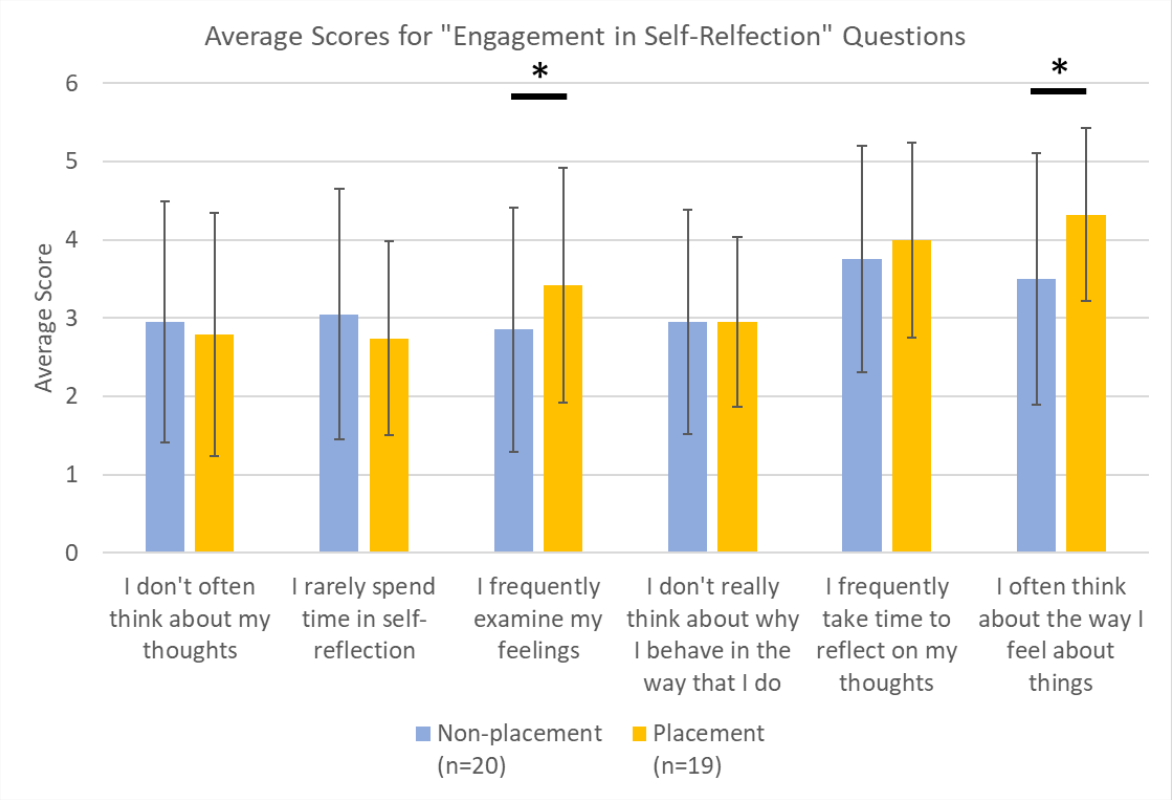

*Figure 1: Average Scores (+/- SD) for the "Engagement in Self-Reflection" questions showing no significant difference between placement versus non-placement students. * Significant difference, p<0.05.*

4.2 Metacognition Skill: Need for Self-Reflection

Questions 7-12 of the SRIS survey evaluates the "need for self-reflection" as shown in figure 2 with a notable increase in average scores among the placement students except for Q7 statement "I am not really interested in analysing my behaviour", where a lower response indicates an interest in analysing behaviour – a metacognitive trait. Therefore, on average, work placement students demonstrated a higher need for self-reflection compared to their non-placement peers. All the questions in this section of the survey showed significant differences in results with placement students performing better in every question, except Q7 where it was not statistically different.

The remaining questions respond to engaging in evaluating the things done by the student (Q8), examining thoughts (Q9), understanding feelings (Q10), the need to understand how their mind works (Q11) and understand how thoughts arise (Q12). Placement students often receive feedback and get challenged with their university knowledge at work, this common practice can push students to analyse themselves more often to improve. It is safe to say that the placement students think it is important to evaluate the things they do as they scored remarkably higher than non-

placement students (Q8). It is possible that after partaking in self-evaluation at work and understanding how quickly they developed from this the placement students recognise the benefits of self-reflection.

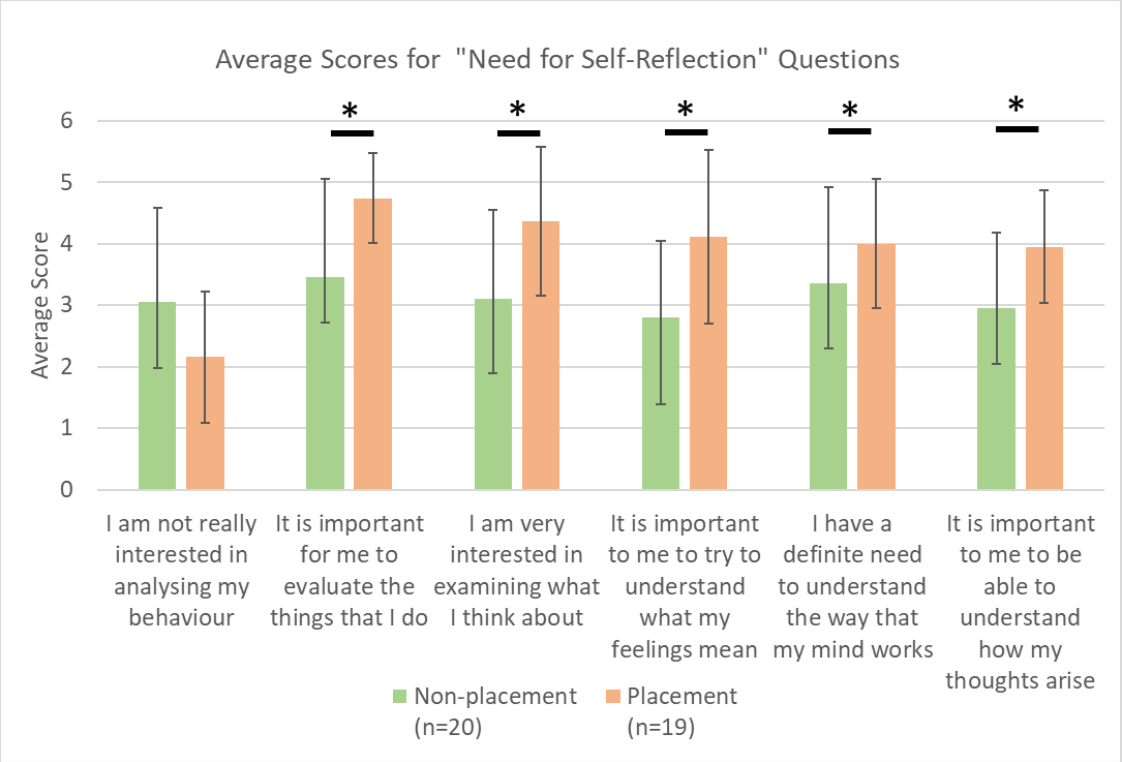

*Figure 2: Average scores (+/- SD) for the "Need for Self-Reflection" questions showing significantly higher responses in students that completed a placement versus students that had not. * Significant difference, $p<0.05$.*

A key question for the placement students, is whether the skills of self-reflection and self-awareness is what led them to secure the job in the first place or whether these traits were developed through the work placement. It is very possible that the students that secured a placement were naturally predisposed with higher metacognitive levels to perform better in securing these placements either through experience, a better understanding of the interview process or even personality types. Examining this and whether the university experience does build these skills would be interesting to look at.

4.3 Metacognition Skill: Insight

Questions 13-20 of the SRIS survey evaluates "insight" as shown in figure 3 with varied responses showing no clear distinction between the two groups. The work placement group have a slightly better insight into their thoughts and emotions compared to the non-placement group, however only Q14 and Q20 were significantly different. The score for Q16 "I'm often aware that I'm having a feeling, but I often don't quite know what it is" was almost identical between the groups. This question relates to emotional regulation, with neither group showing any differences.

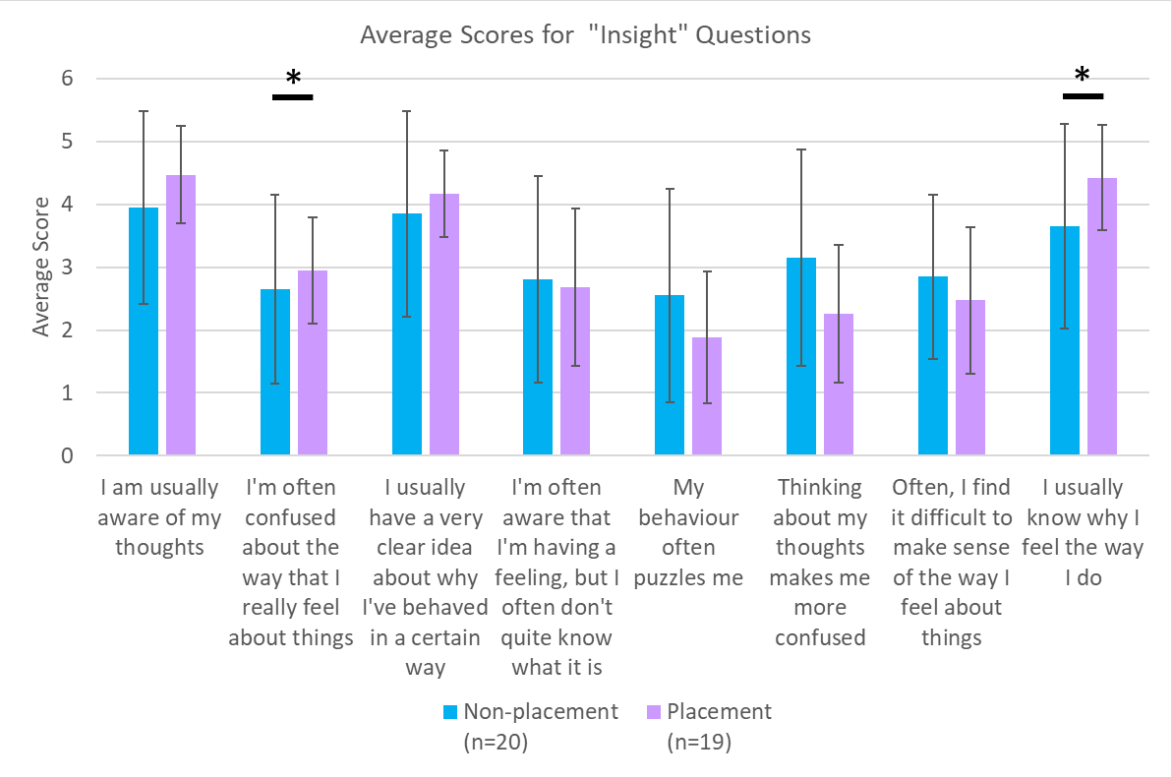

*Figure 3: Average (+/- SD) scores for the "Insight" questions with only the last question showing significant difference in average responses. * Significant difference, p<0.05.*

Emotional regulation is the ability to effectively manage and modulate one's emotions in response to internal and external stimuli (Sanchis et al. 2020). It is interesting that both groups of students scored similarly in this "Insight" section of the survey, showing no clear difference between groups. Exploring the link between work placement experience and developing emotional regulation would be interesting and offer a new understanding into the impact of developing professional skills in the workplace. However, this area is beyond this study and would need to be explored further.

Question 20 "I usually know why I feel the way I do" and question 18 "Thinking about my thoughts makes me more confused" the placement students performed better. Although both groups are usually aware of what feelings they are having (Q19) the placement students are better at understanding why they feel those feelings (Q20, significant). The non-placement students are not as good at making sense of their thoughts and get more confused the more they think about them. These two results argue that a placement year may have some benefits for emotional regulation and the constant behaviour analysis in a workplace supports this finding. It seems logical that an environment where you are being challenged and taught by others on new tasks would be a training ground for emotional regulation and improving communication skills.

The exposure to real-life work experiences gained through a work placement might have contributed to the better metacognitive scores among the work placement group. On the other hand, students who secure placements may have specific personality traits or characteristics that make them pre-disposed to have higher metacognitive skills. However, a longitudinal study is needed to explore this further,

particularly exploring metacognitive development at university in comparison to a work placement.

The need for developing lifelong learning and learning strategies has not been missed in engineering curriculums, however, more awareness of how to develop underlying metacognitive skills is needed to provide effective recommendations for programme development. Engineering industries are calling for these non-technical skills, with a recent World Economic Forum reporting “active learning and learning strategies” as a top three skill needed in the advanced manufacturing industry (WEF 2020).

There are several limitations in this study. Firstly, the group sizes for this study were small (n=20 and n=19) and should be expanded in future studies. Secondly, a longitudinal study is needed to also allow a comparison of metacognitive development in the initial years at university while students engage in academic studies and metacognitive development before and after a work placement. Thirdly, a look at other engineering disciplines would also be advantageous, allowing a cross-sectional look across disciplines, which would provide better oversight across the engineering profession. Finally, employer views would be interesting to analyse to see any correlations between students and employer perceptions. However, despite these limitations, the study provides valuable preliminary insights into this field that would benefit engineering educators.

5 SUMMARY

The aim for this project was to determine if mechanical engineering students at a UK university demonstrated different metacognitive skills between students that had completed a work placement compared to students that had not. The study aimed to assess the two groups metacognitive levels through a validated survey assessing three areas of metacognition: their engagement in self-reflection, the need for self-reflection and insight. The results revealed a heavy slant towards work placement students engaging in more in self-reflection and showed a greater awareness of the need for it. Placement students performed better overall with several significant findings, most notably in the awareness of the need for self-reflection. Placement students generally spent more time reflecting on thoughts, feelings, and behaviours in their roles. The results also indicated that placement students drew more insight from their reflection. In a workplace where colleagues challenge and guide interns through new tasks the results suggests that such an environment is highly conducive to developing self-reflection and self-awareness.

While placement students performed better in this study further research needs to be done to understand cause and effect. This will help drive research-informed curriculum development and pedagogical reform towards training highly skilled and employable engineering graduates.

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