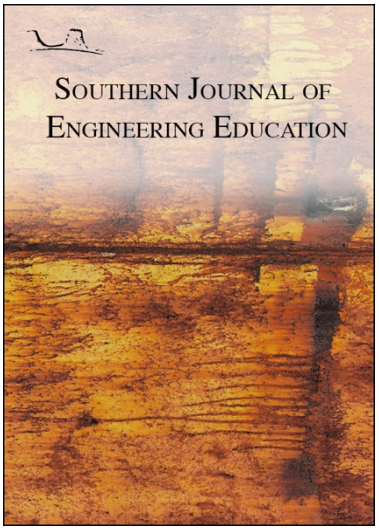

SOUTHERN JOURNAL OF ENGINEERING EDUCATION

Publication details, including instructions for authors and other information can be found at https://journals.uct.ac.za/index.php/sjee

Engineering capstone projects: student motivation in selection and impact of allocation procedures

Talia S. da Silva Burke [a]
Karin Wolff [b]

[a] *Department of Civil Engineering, Engineering Faculty, Stellenbosch University, Stellenbosch, South Africa*
[b] *Dean's Division, Engineering Faculty, Stellenbosch University, Stellenbosch, South Africa*

To reference this article: da Silva Burke, T. S. & Wolff, K. (2026). Engineering capstone projects: student motivation in selection and impact of allocation procedures, *Southern Journal of Engineering Education, 4*, 82–107. DOI: 10.15641/sjee.v4i1.1891

Southern Journal of Engineering Education, 2026
Vol 4, 82–107

Engineering capstone projects: student motivation in selection and impact of allocation procedures

Talia S. da Silva Burke*[a]
Karin Wolff[b]

[a] *Department of Civil Engineering, Engineering Faculty, Stellenbosch University, Stellenbosch, South Africa*
[b] *Dean's Division, Engineering Faculty, Stellenbosch University, Stellenbosch, South Africa*

The engineering capstone project is a crucial bridge between academia and practice, enabling students to demonstrate graduate-level competencies, with the project topic central to students' experiences. In the South African context, these projects are typically conducted individually and driven by academic research interests. This study explored students' motivation in topic selections using a qualitative survey of current final-year students together with a review of the impact of alternate allocation systems through a quantitative analysis of five years of historical project selections. Findings show that students' choices are primarily driven by affective factors such as personal interest, confidence, excitement, and engagement. Prior academic performance showed only a weak correlation with capstone performance, raising caution with regard to the validity of its use as a key criterion for allocation. Student satisfaction was deemed highest when they received one of their top-choice topics, while staff satisfaction was linked to balanced student ability across supervisors. Comparisons of allocation methods suggest that systematic approaches based on academic performance result in lower satisfaction for both students and staff compared to optimisation procedures. The study recommends offering a diverse range of topics incorporating meaningful connections for students and prioritising interest-based allocation over academic metrics.

Keywords: capstone projects; cognitive-affective-systemic motivations; student motivation; capstone allocation

Introduction

Capstone projects are a significant culminative learning experience where students are given the opportunity to apply knowledge, skills and proficiencies gained in their course to substantial real-world projects, similar to what would be encountered in practice (Brackin et al., 2011; Steiner et al., 2015). The inclusion of a capstone project is a specific requirement from accreditation bodies such as the Accreditation Board for Engineering and Technology (Stresau & Steiner, 2020) and is used to demonstrate professional competence in specified

graduate outcomes (Rasul et al., 2016). Capstone projects are considered the 'best reflection of how well the current university curricula match industrial needs' (Liu, 2023, p. 1) and are often used as a proxy for the quality of the programme as a whole (Jawitz et al., 2002). Ultimately, the capstone project provides a 'bridging' experience between academia and practice (Parker, 2017) and allows students to demonstrate that they are prepared for professional practice (Steiner et al., 2015).

Capstone projects can take multiple forms: they can be design or research-based, related to industry-sponsored projects or academic research interests, and can be completed either individually or in teams (Ward, 2013; Jawitz et al., 2002; Brackin et al., 2011). Capstone projects are often considered from the educator's perspective, i.e., considering what learning objectives and competencies should be addressed with a focus on the values and skills that students should gain as part of the process. Many engineering capstone projects are designed with labour market needs in mind, such as the Conceive-Design-Implement-Operate (CDIO) approach (CDIO, n.d.), which mimics what engineers might do in industry. Such approaches seek to develop technical and professional competencies, but are not always feasible in different engineering disciplines, nor in resource-constrained contexts.

What is seldom considered is the students' perspective of motivation, interest and potential engagement. The project that a student works on is the 'heart of the capstone experience' (Brackin et al., 2011, p. 1164), and Parker (2017) suggests that 'students invest themselves emotionally' (p. 41) in these projects. As such, cognisance must be given to the nature of the projects and the factors that allow for the specification of projects that cater to student values and objectives (Whalley et al., 2017). Cheville (2010) noted that the attributes of successful design projects are that they are viewed as worthwhile, have relevance to the engineering discipline, involve the use of modern and emerging technology, and are generally appealing to students. 'Projects have intrinsic appeal when they include innovative technology, allow a wide range of creative solutions, and/or are related to current cultural issues' (Brackin et al., 2011, p. 1165). Students have been shown to perform well on capstone projects when the projects are perceived as authentic and when the product is cared about and has utility (Christensen & Rundus, 2003).

There is limited literature that directly explores what students consider as important in the selection of capstone project topics and that recognises them as subjective agents who have an influence on the project outcomes. No literature discussing alternate allocation strategies and

the impact this has on student project selection or experience was identified. Hart & Polk (2017) surveyed 83 mechanical, biomedical, and electrical engineering students, asking them to rate the importance of 14 predetermined factors in their selection of topic preferences for an individual project. They found that the three most important factors were: obtaining engineering experience in a particular field or technical area, gaining exposure to a company for employment opportunities, and working on an industry-sponsored project. Desire to work on a 'faculty-sponsored project' (p. 1423), i.e., an academic research project, was ranked as least important. Ward (2013) noted that 'active industry involvement' (p. 215) is a key element of capstone projects in mechanical engineering at the world's top-ranked engineering universities. A similar preference for industry over internal (faculty) projects was noted by Latorre & Meier (2023).

Whalley et al. (2017) explored the value that computer science students undertaking a capstone project placed on five core areas, namely difficulty, experience gained (framed in relation to employability skills), social value (positive social benefit), fun, and topic familiarity. Students were asked to give each value a score resulting in a total score of 100 for all five values. The results from 28 students out of a cohort of 111 showed that difficulty and experience gained were the most important factors, with topic familiarity being the lowest. In semi-structured interviews with 19 students aimed at identifying the affective response of computer science students during the capstone project, Parker (2017) identified the 'importance of project impact' (p. 40) noted by students in discussions relating to project selection as a key driver for engagement and motivation.

This research study explores the aspects that influence student selection of topics for individual research-based capstone projects in a Global South context at a research-intensive institution. The intention of the study is to assist academic staff in providing projects that engage the students, whilst meeting the relevant academic requirements, and ensuring that the capstone project is an effective bridge between academic and professional practice. The research question is: *What drivers motivate student interest in the selection of final-year projects?* This prompts a secondary research question: *How can project allocation strategies impact the overall number of students working on projects of primary interest?* Understanding what students value when interested in various projects will assist in creating allocation strategies that maximise the number of students working on projects that are meaningful to them and where they believe they have impact.

Theoretical framework

Education is a process which, according to the philosophy of Pestalozzi, considers a holistic approach and nurtures intellectual, emotional, and practical development in the whole person following the 'Head, Heart and Hand' principle (Brühlmeier, 2010), also commonly reflected in the 'Know-Be-Do' model in leadership development. This integrated approach aims to develop well-rounded individuals who can think critically, act ethically, and contribute meaningfully to society through both thought and action. Pedagogies, curriculum, and student support should be provided in a manner which reflects these principles. Educational learning objectives were classified by Bloom (1956) into three domains: *cognitive* (thinking, mental skills, knowledge), *affective* (feeling, emotional skills, attitudes), and *psychomotor* (doing, physical skills). Together, these domains guide educators in designing balanced and comprehensive learning experiences. Tait (2000) defined three functions of student support which can be considered as aligning with each of these domains: cognitive support related to the provision of standard course materials and learning resources; affective support to provide an environment that enhances self-esteem; and systemic support related to the provision of student-friendly administrative and information processes. This combined holistic model of education, learning and student support is represented in Figure 1.

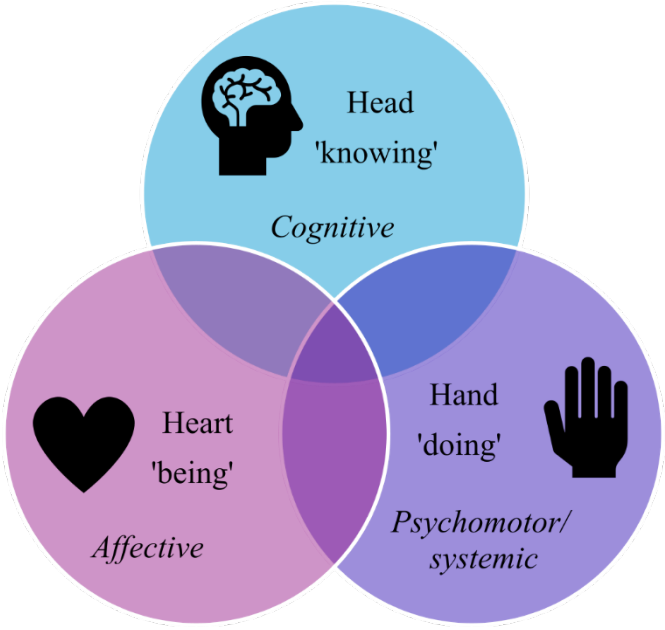

Figure 1: *Holistic model of education, learning and student support*

These complementary theoretical frameworks have been used to frame this investigation into understanding what drives student interest in capstone projects when they are required to

make a selection of preferred topics. The cognitive-affective-systemic (CAS) model has been used in research investigating student spatial thinking (Schreve & Wolff, 2023), postgraduate learning communities (Lewis et al., 2021) and scaffolded virtual reality strategies (Kruger et al., 2021). In this paper, the CAS domains have been used as a lens to consider the drivers of student preferences and articulate the relationship between the three core aspects of the student learning experience in context.

Context

Globally, engineering education has seen continued pressure to meet the needs of our dynamically evolving society, industry, and profession. Increasing challenges in recruitment, retention and employment in STEM (Science, Technology, Engineering and Mathematics) related fields (Sithole et al., 2017) have seen dedicated strategies to develop engineering staff, engage schools in STEM activities, and collaborate across academic-industry boundaries. These strategies have long informed curriculum design and pedagogical innovation in engineering. The research in this paper is located at a research-intensive institution in South Africa. The engineering faculty is similarly engaged in ongoing programme renewal initiatives, as are most engineering faculties and schools in South Africa, particularly in light of the release of updated International Engineering Alliance (2021) graduate competency profiles and the subsequent review of national engineering standards. As such, the faculty has a dedicated developmental engineering education focus and has been proactive in addressing the first-year transition challenges and key knowledge-building approaches beyond the first year. Many of these initiatives, however, have been focused on what the educators see as necessary. Although student focus groups are included in the design and implementation of the current strategies, their voice is absent in the context of their final-year design projects. The single case-study-based research in this paper offers the opportunity to bring the student voice into the space of 'engineering curriculum renewal' in context (Wolff et al., 2025).

In this paper, the focus is on the capstone project of the Civil Engineering department, which is proactively addressing programme improvements using the overarching CAS domains. A more recent focus has been on student vacation work portfolios designed to support holistic theory-practice bridging (Way et al., 2024) and evaluative judgement research to improve student problem-solving capabilities (MacRobert, 2025). Examining the final-year capstone project builds on the departmental research on the holistic student experience of the curriculum and opportunities to improve this. The project is conducted individually in the

second semester of the final year (fourth year) of the course. The module comprises 30 credits (300 notional hours) and forms a major component of the assessment of competencies in multiple Graduate Attributes as defined by the Engineering Council of South Africa (ECSA) accreditation requirements (ECSA, 2023). Students are provided with a list and short description of available project topics towards the end of the first semester. The topics are predominantly influenced by the research interests of the academic staff, with no specific industry sponsorship. This is common in either resource-constrained contexts or those institutions which are specifically focused on research. A range of topics across the seven subdisciplines represented in the department are provided, depending on the number of staff in each field, i.e., geotechnical, informatics, management, pavements, structures, transport and water. In the past five years the cohort size has ranged from 43 to 77 (average 62), with the number of available supervisors ranging from 19 to 23.

An event is held to present information about each of the research groups in the department, and students are encouraged to talk to the staff about the projects at this event (or to schedule a meeting). Students have one week to consider the available topics and are then required to submit a list of their top ten topics in order of preference but are restricted to selecting only two topics from a single supervisor. This aims to encourage a wider distribution of selections across all supervisors, especially for newer or less sought-after staff.

The allocation system awards all unique first choice selections first, i.e., if only one student has selected a certain topic number, then that student is guaranteed *that* topic. Students have no formal way of knowing the selections of others, so their impression of how popular a topic is will be based on their discussions with peers. Where multiple students have selected a particular topic as their first choice, the topic is awarded to the student with the highest prior academic performance. The average mark of all third-year modules is used to determine this performance mark, which is essentially a meritocratic approach. For any students who are in the process of completing third-year modules at the time of the allocation, these modules are given a mark of 0 in the calculation of the average. Students without a topic after these first two steps are listed in academic rank order, and the allocation proceeds from the top of the list, assigning the highest available preference remaining. Any students without an allocated topic after the completion of this process are required to participate in the second round of allocations, together with any invalid or missing initial selections. Students are provided with the results of the project allocations at the end of the first semester.

Methodology

Within the broader faculty-wide engineering education research space, a number of sub-projects are interlinked and follow a pluralist methodology, including quantitative and qualitative strategies. As a new appointment to the institution, the first author was given the portfolio of coordinating the capstone project in the Civil Engineering department. This, together with an existing relationship with the faculty engineering education research (EER) team, provided an opportunity to engage in an alignment and practice-sharing review of the management and assessment procedures of capstone projects across the various engineering departments in the faculty, which forms the background for this particular study. This included collaborative discussions with the capstone project coordinators and with the faculty EER team, and formal feedback to staff via faculty workshops entailing data covering approximately 550 final-year students and approximately 150 staff. An empirical review of the effect of disciplinary differences on management and assessment procedures is planned for future research.

From this broad faculty-wide context, an opportunity was available to focus more closely and explore the student perspective using the project data from a single department, with particular focus on students as subjective agents. The empirical review noted that the student voice was largely missing from consideration in the management and assessment of capstone projects, with little understanding of what was important to students when they were selecting their project topics. It was also noted that the topic allocation procedures varied widely across the departments, something which even the staff were surprised about in the presentation of the review at the faculty workshops. A qualitative survey of the cohort of 74 students currently undertaking the project in the department was undertaken to gain insight into the values and influences driving project selection as well as to determine if the allocation strategy employed was influencing this. As the project topic is very important to students, it is worthwhile to consider how various allocation systems might result in more students getting higher preference topics. The qualitative results were thus substantiated with a quantitative analysis of alternate allocation strategies using the topic selection data of 296 students over five years, with the aim of determining various metrics of performance from the student and staff perspective.

An electronic survey was sent to the final year civil engineering students registered for the research project in 2025. 74 students were registered for the module; 63 students submitted

their project choices (2 students did not indicate their topic preferences and 9 students had proposed their own topic to a supervisor of choice prior to the general pool selection and thus did not participate in the selection and allocation process). The survey was sent to all students who submitted their project choices (n = 63) after the project selections were received, but before the allocations were completed, to ensure that the process was fresh in their minds. The analysis was conducted by the dedicated research team on the sub-project who collaboratively reviewed and verified the results. While only 12 students completed the survey, the collaborating researchers believed their responses worthy of examination as they offered rich and nuanced insights for this exploratory work.

The survey comprised three sections:

1. An open-ended question that asked students to reflect on the factors that influenced their top three choices. The aim of this was to generate data that could provide insight without restricting students along pre-defined factors.

2. A rating of 11 influencing factors on a five-point Likert scale ranging from 1 (not important at all) to 5 (very important). Again, students were asked to consider only the factors that influenced their top three choices. The influence factors and CAS model mapping of each of these is shown in Table 1; where a factor relates to multiple CAS elements, these are listed in order of significance. These factors were determined from considerations of what was expected to be important to students in the selection process from prior experience and from the literature review. The motivation for selecting a particular CAS dimension is given for each factor.

3. A yes/no question aimed to determine the impact of the allocation procedure, paired with an opportunity to provide further motivation for the answer given.

Table 1: *Influence factors and mapping to Cognitive-Affective-Systemic (CAS) domain of self and learning*

No.	Influence factor	CAS	Motivation
1	Desire to work with a particular supervisor.	**A**	Driven by a good perception of the supervisor, reports from previous students of good support and/or high marks when working with a specific supervisor.
2	Desire to work within a specific field of specialisation.	**C**	Driven by a specific type of knowledge or application.
3	Clarity of information available about the project.	**S**	Clear visualisation of the scope of the project and what the research will entail.
4	Desire to work on a laboratory project.	**S**	Usually related to clear methodologies, practical applications, hands-on learning, 'doing'.
5	Desire to work on a project with fieldwork investigation.	**S**	Usually related to clear methodologies, practical applications, hands-on learning, 'doing'.
6	Desire to work on a desktop project (no laboratory or fieldwork components).	**C-S**	Underpinned by a strong cognitive focus and desire to work in a more theoretical realm with a secondary component of clear systemic expectations of skills (e.g. programming, numerical)
7	Ability to envision the required methodology to complete the project.	**S-C-A**	Focus on *methodology* related to skills and proficiencies (S), which allows for a grasp of the related concepts (C) and thus instil confidence / comfort for the student for the topic (A).
8	Ability to envision the intended outcome of the project.	**C-S-A**	Focus on *outcome* related to grasp of the related concepts (C), which gives the basis for the required skills and proficiencies (S), which thus instil confidence / comfort for the student for the topic (A).
9	Topic was personally relevant or important to me.	**A**	Related to the emotions, feeling and attitude of the student.
10	Topics were related to subjects that I have enjoyed.	**A-C**	The 'enjoyment' relates to the affective experience and learning, which has a secondary component of a specific type of knowledge from an academic learning environment.
11	Topics were related to projects that I have enjoyed during vacation work.	**A-S**	The 'enjoyment' relates to the affective experience and learning, which has a secondary component of a specific skill or application area from a practical environment.

The paper proceeds as follows: the qualitative survey results first are unpacked with thematic coding of the open-ended question to identify key themes (Braun & Clarke, 2006; Cohen et al., 2011). The second aspect of the survey is then presented, i.e., a review of the ratings of the various influence factors and mapping of the results to the CAS domains, which is followed by a brief review of the insight gained in the final question of the survey related to the influence of the allocation systems on project selection. This leads into the quantitative analysis of the allocation systems where the details of the different systems used are

summarised, followed by an analysis of the performance of these systems from the student perspective (primarily based on the assumption that greater student satisfaction is related to being allocated topics higher up in their selection list); and from the staff perspective (exploring the relationship between prior academic performance and final project mark, as well as the distribution of students of varying academic performance to each staff member that results from each allocation system). Finally, the discussion brings together the findings and observations from the research.

Discussion of survey results (qualitative review)

Open-ended question

The open-ended question was presented as follows: 'Consider the topics that you selected as your top three preferred topics. Describe in as much detail as possible why you chose these topics. What factors were important to you when making your selection?'

The primary theme that emerged from the responses was **personal interest** in a topic, with a strong affective notion often expressed with words such as 'passion', 'fun', 'excited' and a sense of liking the topic and/or supervisor. This included genuine interest in the topic or field, prior interest in a specific research area due to personal experience and alignment with personal strengths or favourite modules.

> [The topics] were things that I had personally been interested/invested in since before topic selection [S1].
>
> Interest (how excited they make me feel) [S6].
>
> My main reason for this preference is my genuine passion for pavement engineering [S8].
>
> Most of my topics are transport-related because I really do like it [S9].

The second key theme was related to the systemic **practical and logistical project specifications**, expressed as the positive desire to work on laboratory topics, or the negative desire to specifically avoid either laboratory or fieldwork topics. Those that were positively seeking laboratory topics expressed an interest in practical application of theory and the desire to gain a new skill set.

> I wanted to make sure I learn more than just the literature behind the topics but also gain lab skills in the process [S1].

> I enjoy getting my hands dirty and learning through doing [S8].

> I would like to do lab work … so that I can be able to understand fully and interpret test results we receive from lab [in work context] [S12].

The third theme related to the relevance of the topic to **employment**, either in relation to prior vacation work experience (influencing familiarity and confidence with certain topics), career opportunities / employability (relevance to future career plans, desire to gain experience valued by future employers) or alignment with current job responsibilities.

> The chance to build on my previous vacation work experience in a meaningful way [S8].

> Future employer influence (try gain specific experience, e.g., structures) [S7].

> I am wanting to work in that industry in the future so I feel the topic would help me prepare for that [S5].

The **supervisor** linked to the topic was noted as an influencing factor in the selection; this was related to a positive rapport with the supervisor or strong affective sense of 'enjoyment' and perceived quality of supervision.

> My first choice was … because she is a very good lecturer, she is a good leader as well [S9].

> Supervisor (it would be nice to have a supervisor you enjoy) [S6].

> I … get on well with the lecturer and find his topics interesting and challenging – which is what I was looking for [S5].

Prior academic performance was noted as the final theme indicated by multiple respondents, with students specifically mentioning choosing topics linked to modules that they had performed well in.

> I had to check my marks with my top three preferred topics [S7].

> Transport Science has been one of my strong modules over these 2 years [S9].

An interesting factor noted by one respondent was the confidence in their ability to perform well; this response noted that one of the key influences was 'how well I know I would perform

in such a topic' [S10]. This highlights the potential importance of self-efficacy in the capstone projects, defined by Bandura (1977) as belief in one's own ability to succeed.

The key takeaway from the open-ended description of motivation for topic selection is the strong affective connection that students felt with various topics. This was coupled with the recognition of the ways that their prior experiences and preparation through their course influenced their decision – either positively or negatively, e.g., academic performance in certain subjects, vacation work experience, and/or relationship with academic staff.

Influence factor rating

The results of the ratings for the influence factors are shown in Figure 2. At first glance, the following observations are evident: factors related to the project specifications (i.e., clarity of available information, laboratory work, fieldwork, desktop studies) have the widest spread, with the latter three having approximately equal numbers of 'important' and 'unimportant' responses. The relationship between the topic and enjoyment of subjects had a purely positive inclination with all students indicating that this was either important (42%) or very important (58%) to them.

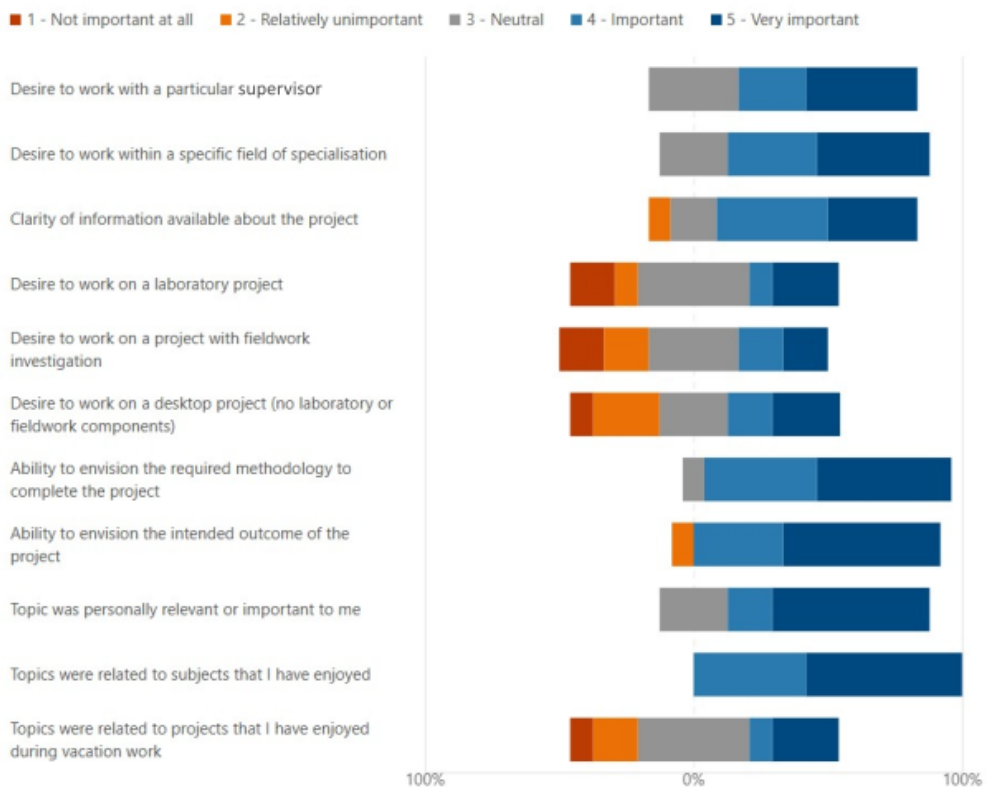

Figure 2: *Summary of responses of influence factors influencing project selections*

To allow further analysis of the responses, a weighted average rating was calculated using a weight ranging from –2 for 'Not important at all' to 2 for 'Very important'. The value thus gives an indication of the nett importance relative to the zero-neutral value. These results were then ranked in order of overall importance, as presented in Figure 3.

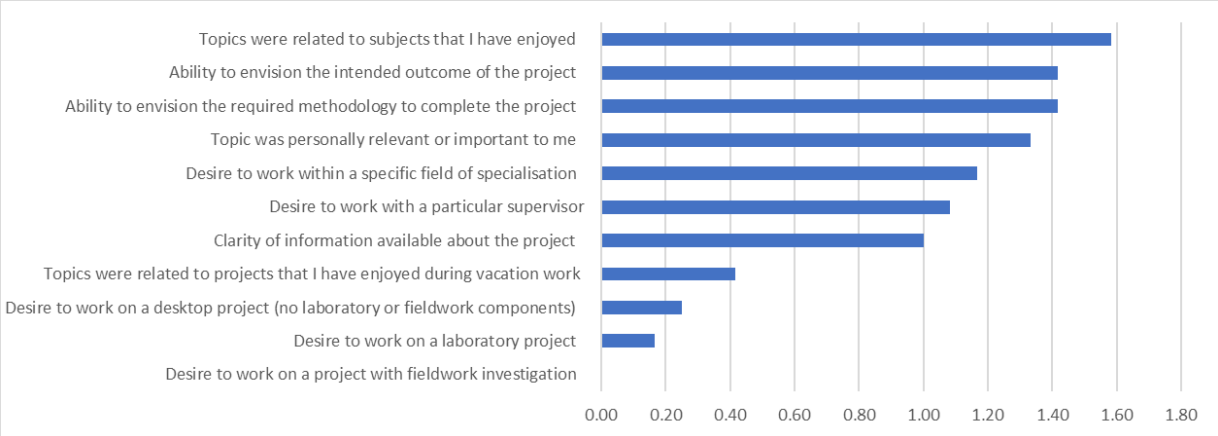

Figure 3: *Weighted average rating of influence factors*

The revised presentation of the results emphasises that the most important influence factor was whether the topic was related to the subjects that the students had enjoyed prior to making the selections. In the CAS model framing, this was indicated as being a primarily affective orientation as it is primarily linked to how students feel about themselves or a subject. This is likely underpinned by a cognitive aspect, as this feeling may well be linked to academic performance or aptitude and can also be linked to the self-efficacy concept introduced in the prior open responses.

The second most important factor was a tie between the ability to envision both the required methodology to complete the project and the intended outcome of the project. These are linked to what Hart & Polk (2017) referred to as a student's 'comfort-level' [*sic*] with a project in the selection process, which is determined by students' previous knowledge and experience. In the CAS framework, these were categorised as encompassing all three domains, with the methodology having a stronger systemic orientation (a student has a sense of the process and tools required) and the outcome having a stronger cognitive orientation (a student can envision the solution). All of this is underpinned by an affective sense of the student's confidence (affective dimension) in their own ability to tackle the project. Again, the self-efficacy component of the student's belief in their ability to succeed comes through as a strong motivation for their topic selection.

The third highest overall rating score was awarded to ‘topic was personally relevant or important to me’, which was linked to an affective sense of feeling and being. This aligns with the results from the thematic coding which showed that one of the key drivers was personal interest in a topic and connects to the idea of ‘emotional investment’ by students in capstone projects (Parker, 2017, p. 41) and the importance of ensuring that topics ‘excite and engage’ students (Hart & Polk, 2017, p. 1422).

The systemically oriented influence factors related to project specifications (laboratory work, fieldwork and/or desktop studies) which were noted as showing the broadest spread in Figure 2 have the lowest weighted averages (Figure 3). This was not necessarily because these were not important, but rather because, as noted in the thematic coding, these specifications created a stronger polarisation, with some students specifically desiring some of these aspects balanced by those who were actively seeking the opposite.

One of the surprising results was the relatively low importance placed on the desire to work with a particular supervisor. This was noted in the thematic coding as one of the drivers, although the prevalence was lower than expected. Similarly, the rating of the influence factors also showed this as ranking in the middle of the available factors with a large portion of neutral responses. Sentiment in the department had largely been that this was one of the most important factors that students considered, in line with international research on what students' value in supervisors (Davis, 2020). This does not mean that it was *not* an important factor: the biggest motivation was the subjects students enjoyed, which in turn might be impacted by a combination of the lecturer (affective) and subject matter (cognitive).

The weighted average rating of the influence factors from Figure 3 was combined with the dominant CAS domain expressed in each factor identified in Table 1 to determine the average weighting of each of the three domains. The results are mapped in Figure 4. This confirms that in this model, affective considerations come to the fore when students are selecting their project topics; the sense of self and people-orientation is key with how a student *feels* about a topic presiding above what they *know* about it.

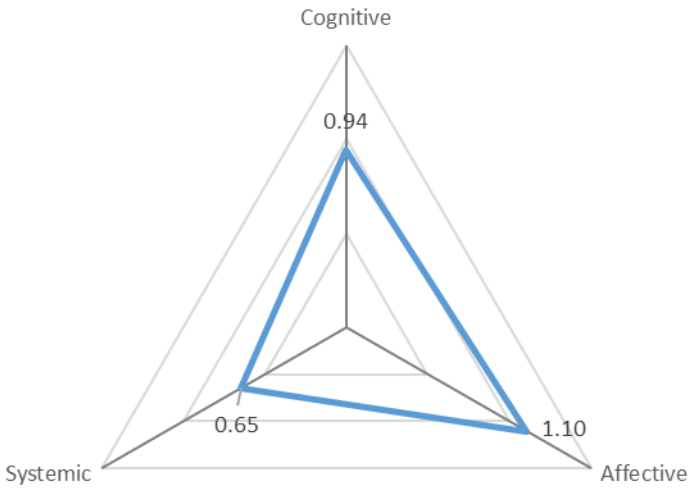

Figure 4: *Average result of CAS mapping considering dominant domain addressed in each influence factor*

The survey was intended as a tool to understand why students chose the topics that they did, and what was important to them in this process. The first two questions were designed as complementary means of sourcing information on this by first giving respondents the freedom to describe their experience and thought processes and then requesting input on pre-selected factors. A triangulation exercise comparing the codes identified in the open-ended responses, and each respondent's dominant CAS domain based on their influence factor ratings, showed strong alignment between these two questions, thus increasing confidence in the findings.

Influence of allocation system

The final section of the survey aimed to understand to what extent, if any, the allocation system used for topics influenced the students' selection. The current topic selection process has several restrictions placed on students (notably allowing only two topics per supervisor) and uses prior academic performance as input in the allocation system. This section was included with the awareness from the broader research context that different departments in the faculty use widely varying allocation systems. The research was particularly interested in how the use of prior academic performance impacted the freedom that students felt they had in their selection, and the extent to which this constraint provided benefits to either the students or academic staff when allocations were conducted. The aim was that this could inform improved allocation procedures that take the student perspective into consideration.

The question was asked in two parts with a yes/no question ('Did the topic allocation procedure used in the department affect your choices?') and the optional space to provide additional reasons for the answer. It was clear from the responses that the allocation procedure used in the department did indeed affect their submitted choices. This impact was noted in two ways: (1) an interest in more than two topics that were listed by one supervisor, and (2) the influence of the academic ranking. Selected quotes giving further insight on the latter component are noted:

> I couldn't disregard the fact that some students will have a first choice over mine and I had to keep in mind who I will be competing with to secure my desired topic [S4].

> I couldn't pick the topic I wanted to do the most as I knew someone stronger academically wanting to do the same one [S5].

> A topic I wanted to choose as my first choice was hotly contested. People with better marks than me had chosen it as their first choice. This forced me to go with something else as my first choice [S6].

Even if students did indicate that the allocation system influenced their choices, some of the comments reflected positively on the overall fairness of such:

> That being said, the rules you have in place are understandable [S3].

> Personally, I would have the system be set up differently. However, overall, I believe it's mostly fair [S5].

> The procedure encouraged me to think strategically and ensure that all my choices were topics I could still learn from and contribute to meaningfully [S8].

The findings suggest that students are strategically adjusting their selections based on the allocation system. This provides impetus to ensure that this system performs optimally without undue impact on the student or staff experience of the project, and that any constraints or considerations are rationally driven. This provides the basis of the second part of this study which quantitatively reviewed the performance of several alternate allocation strategies, presented in the following section.

Alternate allocations and implications (quantitative analysis)

The topic allocated to a student is the 'heart' of the research project, and the qualitative results showed a strong affective motivation in the selection of preferences. Students noted that the

allocation system does have an influence on their selections, particularly in the way that academic performance is used. It is thus worthwhile to consider how various allocation systems might result in more students getting higher preference topics, whilst other systems might be more oriented to suit the requirements of academic staff. This allows the exploration of student agency and whether or not the use of prior academic performance is a value-adding element of the process. This second part of the investigation turns to the systemic and cognitive aspects of the project allocation procedures to understand how this can support the affective nature of the importance of the topic to students.

As noted previously, the broader context of this research is a review of final-year project practices across the engineering departments in the institution. One of the observations was that departments followed a variety of topic allocation procedures with the one described in the current context representing one approach. Key differences were related to the use of prior academic performance and whether or not supervisors were able to give input into the final selections. The practices ranged widely from systematic rule-based allocations incorporating academic rank order, to optimisation-based allocations with an aim of maximising student and supervisor preferences. One department conducted a manual allocation aiming to ensure that each supervisor received a balance of 'strong' and 'weak' students according to prior academic performance. These were used to select alternate allocation strategies and performance metrics for further testing.

Allocation systems tested

The testing of the allocation systems was conducted using the student topic selections in the Civil Engineering department from 2021 to 2025, comprising a total of 296 students. Cohort data and full details of the procedures followed for each allocation system are available in a supplementary report available on request. Four allocation systems were considered:

1. **Unique first rank:** status quo, i.e., unique choices, first-choice conflicts, followed by academic rank order.

2. **Strict academic rank:** students are academically ranked, and topics are allocated based on remaining availability.

3. **Monte Carlo (MC) optimisation (random):** MC simulation (20 000 iterations) with random allocation order and optimisation of the number of first-, second- and third-choice allocations.

4. **MC optimisation (with marks):** MC simulation with optimisation considering both academic performance and topic preference.

Three of the allocation systems incorporate academic performance to some extent; the MC optimisation (random) aims to consider the effect of removing this aspect entirely. It is noted that a change in the allocations could change the student selections and thus the validity of 'testing' alternate allocations is limited, with the results thus only able to give broad indications of potential changes.

Allocation systems results: student perspective

The performance metrics of the allocation systems that were considered related to the student perspective of satisfaction were the percentage of students receiving a first-choice topic, the percentage of students receiving a top-three choice, the number of students with no topic allocated (and thus needing to participate in a second round of allocations), and the number of top-quartile students with a 'suboptimal' (below third-choice) allocation. The aggregated results for the five years of data are shown in Table 2, with the best and worst value for each metric highlighted green and red respectively. The full results detailed per year and per metric are given in the supplementary report noted previously.

The system using strict academic rank performs worst in terms of the percentage of students receiving their first-choice or a top three topic, although in the latter case it performs similarly to the unique-first-rank allocation system. Unsurprisingly, the optimisation allocations perform best in awarding students one of their top three choices, with the random system only marginally better than that where marks are considered (difference of 4 students in absolute terms). However, the indiscriminate nature of the random optimisation results in this system having the most top-quartile students with suboptimal allocations.

The status quo system (unique first rank) performs well at awarding a first-choice topic (same as optimisations), as well as ensuring that top quartile students are highly likely to be awarded a top three choice. Optimisation offers improvements in a top three allocation to all students, and if marks are included in this process, this can be done with minimal additional

risk of top students receiving low selections as well as an improvement in the number of students receiving topics in the first round of allocations.

Table 2: *Performance metrics of alternate allocation procedures from the student perspective (2021–2025)*

Allocation system	First choice topic awarded (%)	Top 3 choice topic awarded (%)	No topic awarded in first round	Top quartile students with suboptimal allocation
Unique first rank	58	76	18 (6%)	5 (2%)
Strict academic rank	47	74	9 (3%)	1 (0%)
MC optimisation (random)	58	83	14 (5%)	13 (4%)
MC optimisation (with marks)	58	82	9 (3%)	6 (2%)

Allocation systems results: staff perspective

A key consideration in topic allocations from the staff perspective relates to the perceived ability of the student to work independently and perform well in the project. Prior academic performance is usually used as a proxy for this, which is why this features prominently in most existing allocation systems used. There is a prevailing perception that 'high demand' supervisors get 'better' quality students and thus get better research done and/or are required to spend less effort to supervise the students.

The first aspect of the review looked at historical performance data for 2021 to 2024 for students who had completed the research project (238 students). This was interrogated to explore correlations of prior academic performance and project allocation to final project mark, as well as relationships between supervisor 'demand' and final project mark. These showed only a weak correlation between prior academic performance and final project mark (Pearson correlation of 34%), and somewhat surprisingly no correlation (13%) between a student receiving a higher preference topic and their ultimate performance in the project. When looking at supervisor demand, defined as the number of students selecting a particular supervisor divided by the number of topics offered by that supervisor, and student performance, the results showed a Pearson's correlation of 48% to prior academic performance. This highlights that the high-demand lecturers had only a moderate correlation with being allocated well-performing students. Interestingly, there was a stronger correlation between supervisor demand and final mark (57%), making this a stronger influence on student final mark than the student's own prior academic performance. This may be an indication that certain supervisors were awarding

higher marks which might in turn have been influencing demand if students were aware of these tendencies, although causality cannot be demonstrated in these results.

The second aspect of allocations considered from the staff perspective was the perception of fairness and the idea of balancing the relative number of academically strong and weak students assigned to each supervisor. Thus, the range of average marks and extent to which an allocation system was able to achieve 'equal' averages of students could be seen as an important performance metric in allocations. To test this, the average mark of the students assigned to each supervisor was determined for the four allocation systems and student cohort (296 students) described previously. The overall cohort average was subtracted to give a *relative* indication of each supervisor's average. The aggregated results of the distribution of averages for the supervisors considered in the 2021 to 2025 allocations are shown in Figure 5. The systematic rank-based allocations resulted in the widest spread of averages with more staff receiving clearly separate groups of 'stronger' and 'weaker' students of up to ±10% deviation from the overall student average. This effect was more marked in the strict academic rank allocation than the unique-first-rank system. The optimisation procedures significantly reduced the spread with a range of only ±6% from the overall student average. Similar overall performance is noted whether marks are included or not. This shows that whilst the optimisations have been set up to maximise the student satisfaction metrics, these can simultaneously result in a better outcome from the staff perspective too.

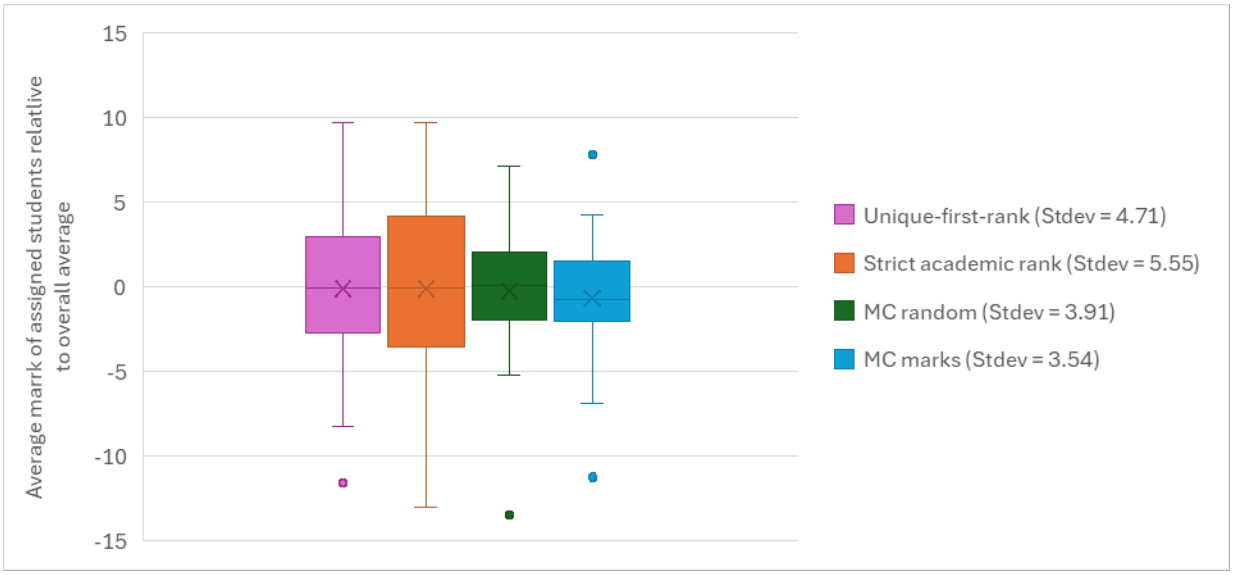

Figure 5: *Distribution of relative average of the students assigned to each supervisor for each of the four allocation systems (aggregated results for 2021–2025 shown)*

Discussion

The aim of the study was to gain insight into the influencing factors motivating student capstone project topic selections. As noted, more understanding around this would assist academic staff in providing projects that engaged students and created an effective experience through which students would be able to demonstrate their proficiencies and preparedness for independent work at the level required for a successful graduate. The study also aimed to explore alternate allocation strategies and compare impact from the student and staff perspectives. Understanding the importance of the project topic to students would encourage the creation of allocation strategies that would ensure that the maximum number of students could work on topics of higher-order preference without compromising staff expectations. If students are unmotivated and uninterested in the topic, this could detrimentally impact their ability to meaningfully engage in the opportunity to showcase their acquired competencies. Conversely, 'A successful capstone project energizes all the participants' (Brackin et al., 2011, p1172).

The identified motivations were viewed through the lens of the cognitive-affective-systemic (psychomotor) domains from the holistic model of education, learning and student support. The results showed that the affective realm was dominant, with personal interest, excitement, and relationship to 'enjoyment' of prior academic experience coming to the fore. This aligns with observations from Parker (2017), who noted that the affective response is a key contributor to 'engagement and professional identity formation during the university-to-work transition' (p. 41) during the capstone project experience, and highlighted the emotional investment that students make in a project. The importance of affective aspects of project definition are also highlighted in that successful projects are 'viewed as worthwhile' (Cheville, 2010, p. 3) and 'have a "cool" factor' (Brackin et al., 2011, p. 1165) and supported by Christensen & Rundus (2003) where a link is made between better performance and more authentic topics.

The affective experience was supported by a cognitive element, particularly in relation to prior academic performance (a student might 'enjoy' a subject or topic because they did well in it). Systemic considerations had the lowest overall priority, however, which was largely due to preferences either in favour of or against specific skills-related aspects such as laboratory work. Some students specifically sought out these topics for the skills they would provide or based on aptitude for practical work (for example), whereas others did the opposite. This

highlights the importance of ensuring that there are a range of topics that cater to various preferences and abilities. The literature noted that projects linked to industry, employment opportunities or fields of specialisation – all systemic factors – ranked highly in student interest (Hart & Polk, 2017; Ward, 2013; Latorre & Meier, 2023). By contrast, in the current exploration, these did not feature prominently in either the ranking of influence factors or open-ended discussion detailing motivation for topic selections.

In reviewing a wider cohort, prior academic performance showed only moderate correlation to final project performance over a period of four years. This is an important consideration given the emphasis placed on this when considering student aptitude for specific topics, and the use of prior academic performance in topic allocations. Interestingly, the preference of the topic that the student is awarded showed no correlation to performance, i.e., students with a first-choice topic were no more likely to perform better than those with a tenth-choice topic. This lack of correlation does not, however, indicate that the project topic is *not* important, as performance is largely cognitive (related to the student's academic ability) and systemic (related to assessment procedures), whereas much of the experience of the capstone project is affective.

One aspect of the allocation system which was shown to be a key constraint on students when making their topic selections was the practice of using prior academic performance in a way that systematically awards higher performers topics higher on their selection list. There are advocates for and against this practice: proponents argue that the capstone project is the only chance students get to choose what they want to do based on their own merits, and top students may be rewarded for their previous hard work by being able to pick a topic (or at least having a high likelihood of receiving their top preferences). On the contrary, a particular concern noted with this system is that it tends to fail the weaker students as they are likely to be undertaking a topic that may be at the bottom of their list (or they are second rounded) with a young lecturer with limited experience in supporting student projects. From a practical perspective, in the specific context studied, lower ranked students may be more likely to discontinue with the project after the initial allocations are completed once the first semester results are finalised. This may incentivise ensuring that higher ranked students have some priority in the allocation of topics, particularly where these are in high demand.

The results of the allocation system testing showed that the systematic academic rank-based procedures performed poorly both from the student perspective (i.e., the percentage of students

awarded a first-choice or top three choice topic), and from the staff perspective (i.e., creating a balance between the academic abilities of students assigned to each staff member). The optimisation algorithms performed best in terms of the number of students awarded top-choice preferences, and in creating a more even balance between staff by reducing the range and variability of the average assigned mark. The outcome of such optimisation will depend on the weight assigned to various factors and the selected optimisation criteria. The sense of a lack of transparency in the use of optimisations was noted by staff in suggestions to use such a system; if it can be demonstrated that both student and staff metrics are improved, and if there is clarity on the criteria used to select the optimum allocation, this should alleviate these concerns. The performance of the optimisations with and without marks were on par; thus, if transitioning from a systematic, rule-based allocation explicitly based on marks, use of the optimisation together with marks might be a more palatable option that still gives some credit to top academic performers. However, given the lack of clear correlation between prior academic performance and project performance, the idea of using prior academic achievement in allocations should be more loosely treated to allow more students the advantage of the option to complete a project that they have expressed a strong interest in.

Concluding remarks

The capstone project represents a large investment of time and energy for students and for staff acting as supervisors and coordinators of these projects; these should thus be structured to add as much value as possible to all affected parties. For students, this may mean working on a highly preferred topic, whereas for supervisors, this may mean working with highly motivated and capable students.

Students are most interested in topics which show practical relevance to industry and a relationship to current social and cultural issues. This creates a sense of excitement and engagement, increasing the value of the project to the students and giving them the best possible opportunities to showcase their competencies as professional graduates. The ability to envision both the required methodology to complete the project and the intended outcome of the project were indicated as key influencing factors. This highlights the importance of self-efficacy and the preparatory experiences, both academically and from vacation work, that influence a student's perception of their own skills and grasp of academic (cognitive) concepts.

Allocations of topics to students should give more credence to the subjective student viewpoint, particularly as the affective component of holistic education is dominant in the capstone project experience. Current procedures tend to focus on rewarding high achievers (cognitive focus) which transfers into strong systemic allocation. Placing more emphasis on being able to award more students a higher-preference topic should take precedence over rewarding prior academic performance, especially if correlation of prior academic performance is weak, and given the probable disadvantage to 'weaker' students of using such. Ultimately, there is no 'best' way to conduct allocations, and this will depend on a balance of perspectives and what importance is assigned to various aspects of the staff and student perspective.

References

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review, 84*(2), 191–215

Bloom, B.S. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals - Handbook I: Cognitive Domain.* New York: Longmans.

Brackin, P., Knudson, D., Nassersharif, B., & O'Bannon, D. (2011). Pedagogical implications of project selection in capstone design courses. *International Journal of Engineering Education, 27*(6), 1164–1173. https://www.ijee.ie/articles/Vol27-6/03_ijee2493ns.pdf

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brühlmeier, A. (2010). *Head, heart and hand: Education in the spirit of Pestalozzi.* Cambridge: Open Book Publishers.

CDIO. (n.d.). *Conceive-Design-Implement-Operate*. https://www.cdio.org/

Cheville, A. (2010), Designing successful design projects. *Proceedings of the 2010 ASEE Annual Conference and Exposition*, Louisville, Kentucky, 2010. https://doi.org/10.18260/1-2--16783

Christensen, K., & Rundus, D. (2003). The capstone senior design course: An initiative in partnering with industry. *Proceedings - Frontiers in Education Conference*, FIE. 3, (2003), S2B12–S2B17. https://doi.org/10.1109/FIE.2003.1265941

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education (7th ed.).* Routledge.

Davis, D. (2020). The ideal supervisor from the candidate's perspective: What qualities do students actually want? *Journal of Further and Higher Education*, *44*(9), 1220–1232. https://doi.org/10.1080/0309877X.2019.1669772

Engineering Council of South Africa [ECSA] (2023). Qualification Standard for Bachelor of Science in Engineering / Bachelor of Engineering: NQF Level 8 E-02-PE Revision 7: 24 August 2023.

Hart, R. A., & Polk, T. W. (2017). An examination of the factors that influence students' capstone project choices. *International Journal of Engineering Education*, *33*(5), 1422–1431.

International Engineering Alliance (2021). *Graduate Attributes and Professional Competencies (Version 2021.1).* https://jabee.org/doc/IEA-Graduate-Attributes-and-Professional-Competencies-2021.1-Sept-2021.pdf

Kruger, K., Wolff, K., & Cairncross, K. (2021). Real, virtual or simulated: Approaches to emergency remote learning in engineering. *Computer Applications in Engineering Education, 30*(1), 93–105. https://doi.org/10.1002/cae.22444

Latorre, E., & Meier, E. L. (2023). Evaluating student project choice, course satisfaction, and performance between community service, internal projects, and industry-sponsored projects in a multidisciplinary industry-sponsored capstone program. In *Proceedings of the 2023 ASEE Annual Conference & Exposition*. Baltimore, Maryland, USA, June 2023. https://doi.org/10.18260/1-2--43425

Lewis, C., Wolff, K., & Bekker, B. (2021). Supporting project-based education through a community of practice: A case of postgraduate renewable energy students. *World Transactions on Engineering and Technology Education*, *19*(1), 35–40.

Liu, G. (2023). Capstone projects: A dynamic balance between undergraduate curricula and industrial needs. In *Proceedings of the ASEE Southeast Section Conference.* Arlington, Virginia, USA, March 2023 https://doi.org/10.18260/1–2-44990

MacRobert, C. J. (2025). Simplifying slope stability: What should be taught at the undergraduate level? *6th International Conference on Geotechnical Engineering Education: Charting the path toward the future,* Nancy, France, July 2-4, 2025*,* 137–148

Parker, R. (2017). How do you feel: Affective expressions from computer science senior capstone projects. *2017 International Conference on Learning and Teaching in Computing and Engineering (LaTICE) IEEE, 35–42.* https://doi.org/10.1109/LaTiCE.2017.14

Parker, R. (2018). Interest-based capstone team formation. In *Capstone Design Conference (CDC)* 1-4. https://capstonedesigncommunity.org/sites/default/files/proceedings_papers/Parker_CDC18.pdf

Rasul, M. G., Lawson, J. J., Howard, P., Martin, F., & Hadgraft, R. (2015). Learning and teaching approaches and methodologies of capstone final year engineering projects. *International Journal of Engineering Education*, *31*(6), 1727–1735.

Schreve, K. & Wolff, K. (2023). First year engineering drawings summer school: Back to basics case study. *Proceedings of the 6th Biennial Conference of the South African Society for Engineering Education*. Muldersdrift, Gauteng, 11–13 July 2023, SASEE. 194–206

Sithole, A., Chiyaka, E. T., McCarthy, P., Mupinga, D. M., Bucklein, B. K., & Kibirige, J. (2017). Student attraction, persistence and retention in STEM programs: Successes and continuing challenges. *Higher Education Studies*, *7*(1), 46–59. http://dx.doi.org/10.5539/hes.v7n1p46

Steiner, M.W., Kanai, J., Hsu, C., & Ledet, E. (2015). Preparing engineering students for professional practice: Using capstone to drive continuous improvement. *International Journal of Engineering Education, 31*(1), 154–164.

Stresau, K. S., & Steiner, M. W. (2020). A framework for developing a deeper understanding of the factors that influence success and failure in undergraduate engineering capstone design experiences. In *2020 ASEE Virtual Annual Conference Content Access*. https://doi.org/10.18260/1-2--33948

Tait, A. (2000). Planning student support for open and distance learning. *Open Learning: The Journal of Open, Distance and e-Learning*, *15*(3), 287–299. https://doi.org/10.1080/713688410

Ward, T. A. (2013). Common elements of capstone projects in the world's top-ranked engineering universities. *European Journal of Engineering Education*, *38*(2), 211–218. https://doi.org/10.1080/03043797.2013.766676

Way, A., Wolff., K., Combrinck, R., & Van Wyk, A. (2024). Portfolios for the development of self-efficacy in engineering education. *World Transactions on Engineering and Technology Education. 22*(3), 190–195. https://www.wiete.com.au/journals/WTE%26TE/Pages/Vol.%2022,%20No.3%20(2024)/06-Way-A.pdf

Whalley, J., Goldweber, M., & Ogier, H. (2017). Student values and interests in capstone project selection. In *Proceedings of the Nineteenth Australasian Computing Education Conference (ACE '17)*. Association for Computing Machinery, New York, NY, USA, 90–94. https://doi.org/10.1145/3013499.3013508

Wolff, K., Hattingh, T., & Smith, L. (2025). Global challenges, local responses: Exploring curriculum reform in South African engineering education. *Journal of Engineering Education, 114*(3), e70006. https://doi.org/10.1002/jee.70006