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A Self-assessed Study Skills Inventory for First-year Engineering Students to Improve Preparedness for University

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ABSTRACT

CONTEXT

Students retain the study skills they develop at high school when they begin their university studies, which impacts their academic performance, particularly during the first year. The high attrition rates in first-year engineering programmes during and after the COVID-19 pandemic may have been partially caused by the increased amount of time that students spent learning online. Social seclusion, the use of the internet, cell phones, and social network addictions could also have contributed. This problem has increased the need for students to improve their study skills, particularly in the first year, which is the most significant for their academic success in university.

GOAL

To improve first-year engineering students' preparedness for university studies, we aim to develop a research-informed, self-assessment inventory tool on study skills. This tool enables students to identify study habits that they might overlook but which potentially hinder their academic performance. They receive immediate guidance to relevant learning resources based on their self-assessment results, to help enhance their study skills.

APPROACH

We used a design-based research (DBR) approach in three iterations: 1) a prototype inventory was designed, based on a review of existing STEM-oriented inventories, 2) a pilot test of the functionality was conducted with a small group of first-year engineering students, and 3) refinements were made to the inventory for use with an entire student cohort. At each iteration, we collected feedback from first-year engineering students, their teachers, and mentors.

OUTCOMES

The main feedback from participants in the DBR phases included: 1) prioritisation of six categories for first-year engineering students — time management, note-taking, memory, concentration, examination preparation, and stress management skills, and 2) the need for an individual student visual profile to illustrate the student's study skill levels relative to a representative cohort average score, with zones for improvement.

PRELIMINARY CONCLUSION

Our preliminary conclusion, at the time of writing this paper, suggests that students generally have positive experiences with the tool, particularly as an aid to develop self-awareness of their study skills. The current scores can serve only as guidance for students about their possible strengths and weaknesses in the selected categories. Further results from our ongoing data collection will yield a more robust tool for students, and provide educators with a clearer picture of first-year engineering students' study skills status post-COVID.

KEYWORDS
Study skills, first-year experience, post-COVID STEM education.

Introduction

First-year experience is the most critical for undergraduate students' retention at university, as it is a pivotal time for first-year students to explore their identity and plan their career goals (Hubbard, 2022; Tinto, 2012). A challenge for first-year undergraduate students is to adapt from high school to university in relation to significant changes in academic expectations (Ramos-Sandoval & Ramos-Diaz, 2020; Venezia & Jaeger, 2013), learning environments (Yasvin et al., 2015), and learning patterns (Song & Vermunt, 2021). In engineering education, the academic expectations are to prepare graduates to be future engineers, such as promoting their intellectual development from previously memorised and absolute knowledge in high school to making contextual judgements and constructing effective solutions for real-world applications (Felder & Brent, 2004). Learning environments significantly change from a familiar and supportive high school context to a larger and more impersonal university setting, often with larger class sizes, small group seminars, lab sessions, and less personalised attention from teachers (Cottrell, 2019). More independent study, self-regulation and active learning are required and contribute to persistence and success in university (Conley, 2007; Cottrell, 2019; Hubbard, 2022; Mayhew et al., 2016).

Previous studies suggest that academic support for improving students' basic study skills, such as time management, note-taking, and concentration skills, is particularly helpful for transitioning successfully from high school to university in the first year (Aquines Gutiérrez et al., 2022; Conley, 2007; Morris, 2011; Williams et al., 2020). The study skills developed by students in high school are retained at the university level (Takeuchi, 2022). Also, support for improving study skills is recommended to be provided as early as possible (Kuh, 2008; Tinto, 2012). As the COVID-19 pandemic has increased students' online learning and hybrid learning time and modes, it has also increased the need for students to improve their study skills (Kortemeyer et al., 2023). For instance, studies have reported a high reduction in students' concentration due to factors such as long periods of online study, social seclusion, increased use of the internet, cell phones, and streaming media, and social network addiction during the COVID-19 pandemic (Arifiati et al., 2020; Silva et al., 2021) Students failed to manage their time effectively, often procrastinating and staying up at night to meet deadlines at the last minute during the pandemic (Napoles et al., 2023). These shortcomings translated into higher-than-average attrition rates and poor academic performance. The attrition rates of first-year engineering students increased on average from 5% in 2019 to 9% post-COVID in 2022 at all New Zealand Universities (Education Counts, 2024).

Existing research-informed study-skills inventories, such as Congos' Study Skills Inventory (DCSSI) (Congos, 2011b) and the Learning and Study Strategies Inventory (LASSI) (Weinstein et al., 1987) were initially designed more than two decades ago for a wide range of secondary and tertiary-level students. They were general, that is, not age- or context-related. They were not designed to provide direct, immediate instructions or tailored learning resources that can help engineering students, for example, confront the challenges of adapting to university during their first year. We need a refined study skills inventory that aligns more closely with the requirements of first-year engineering students, to help them succeed in their early academic journey as we emerge from the impact of COVID-19.

The goal of this study is to design and develop a research-informed self-assessment inventory tool on study skills tailored to first-year engineering students. This tool enables students to identify areas of study skills needing improvement within a short duration (e.g., within 10 minutes), to receive immediate guidance to relevant learning support, and to reuse it freely to self-assess their study skills throughout their degrees. For engineering educators, particularly first-year teachers and tutors, the tool can offer a clearer picture of the nature and extent of incoming students' study skills. Potentially, this could aid in reducing attrition rates by helping students address inadequate study skills and by fostering long-term study habits, which can benefit their future studies and careers. Also, the findings will extend engineering education researchers' understanding of the existing evidence about the impact of study skills on academic performance in engineering education (Aquines Gutiérrez et al., 2022; Naqvi et al., 2018; Pinxten et al., 2016).

Background

In this section, we offer our definition of study skills, review previous studies on first-year engineering students' study skills, and existing study skills inventory tools.

Study skills in this paper

Many terms have been used in the research literature to describe study skills, such as academic skills, learning habits, learning strategies, and learning techniques. Although different studies categorise study skills differently, there are common and core skills that are "indispensable" to learning at the university level (Congos, 2011a, p.14). For example, Cottrell (2019) proposes that self-efficacy, academic skills, people skills, and task management skills are the four main categories of study skills. Congos (2011a, p.13) notes note-taking, time management, test preparation, self-testing, and memory as essential study skills that can help achieve better grades. In this paper, study skills refer to the acquired "abilities, habits, understanding and attitudes" that students use to learn more effectively and perform well academically (Cottrell, 2019, p.20). As this study aims to develop a self-assessment tool that can provide students with feedback rapidly, it will not encompass every category of study skills discussed in the literature but will focus on the most relevant skills for first-year engineering students.

Previous studies on first-year students' study skills

Many studies have investigated the link between study skills and academic performance. Pinxten et al. (2016) found a positive correlation between study skills and engineering and science students' grades during their first year at European universities. Similarly, Aquines Gutiérrez et al. (2022) indicated a strong relationship between early learning habits and academic performance among first-year engineering students in Mexico. Lekharu et al. (2024) also highlighted the statistical significance of poor study skills in contributing to low academic grades among undergraduate medical students across India. However, Naqvi et al. (2018) reported no statistically significant correlation between study skills and GPAs in engineering, business, and computing students in Oman.

Several studies have shown that participation in study skills orientation courses boosts academic success and retention among first-year students. Soulsby (2002) designed an orientation course for engineering students, resulting in a 10% increase in retention after the first year. Windham et al. (2014) also found that completing a study skills course in the first year improved retention and academic scores compared to those who did not participate. Wernersbach et al. (2014) demonstrated that study skills courses enhanced not only study skills but also self-efficacy and persistence. Sera and McPherson (2019) found similar improvements in pharmacy students' learning skills through a first-year study-skills course on effective reading, note-taking, time management, and test preparation. McMillan et al. (2023) noted rising interest in a hybrid study skills orientation programme, which helped ease students' transition.

Essential study skills have been identified for first-year engineering students. Soulsby (2002) found that awareness of learning styles, time management, textbook reading, exam preparation, stress management, using library resources, and having career goals were significant for success in engineering programmes. Morris (2011) suggested that a lack of study skills, such as note-taking, organisation, time management, and reflective thinking, posed major barriers to passing exams and assessments. It also reported that nearly half of the student participants had never had any orientation or training in study skills. Pinxten et al. (2016) highlighted the importance of time management, concentration, and persistence/motivation skills for first-year engineering and science students in achieving academic success. Naqvi et al. (2018) revealed gaps in critical and creative thinking, time management, and test preparation among engineering, business, and computing students, despite good memory skills. Williams et al. (2020) emphasised that learning strategies like self-testing using practice questions, reviewing learning materials and notes

regularly, note-taking while reading, studying with peers, watching lecture recordings and reorganising notes are crucial for the success of first-year STEM students.

Existing study skills inventories

Commonly used research-based inventories for study skills are Dennis H. Congos' Study Skills Inventory (DCSSI) (Congos, 2011b) and the Learning and Study Strategies Inventory (LASSI) (Weinstein et al., 1987). Table 1 displays a comparison of study skills categories assessed in DCSSI and LASSI. Both inventory tools have been widely applied to investigate students' study skills at the university level, particularly in STEM and medical disciplines (Lekharu et al., 2024; Madhavi et al., 2014; Naqvi et al., 2018; Pinxten et al., 2016; Sera & McPherson, 2019). DCSSI is an online and free tool, and LASSI requires a licence purchase. It takes more than 15 minutes to complete the DCSSI assessment and more than 25 minutes for LASSI. Both tools are more suited for research-oriented purposes rather than regular self-assessment use, which ideally should be completed within 10 minutes, in our view, and provide immediate personalised guidance.

Table 1 Categories of study skills in DCSSI and LASSI.

DCSSI (Six categories, 51 items)									
Time management	Concentration	Test preparation	Reading	Memory	Note-taking	-	-	-	-
LASSI (Ten categories, 77 items)									
Time management	Concentration	Test strategies	Information processing	Anxiety levels	Learning attitude	Learning motivation	Self-testing	Select main ideas	Study aids

Existing online inventories for the self-assessment of study skills developed by universities were designed for students in general, regardless of undergraduate or graduate levels, academic year, or disciplinary background (Cardiff University, n.d.; Center for Teaching and Learning at Stanford University, n.d.; The Learning Center at Washington University in St. Louis, n.d.). The categories of study skills frequently included in these tools are time management, reading, writing, note-taking, memory, concentration, exam preparation, digital skills, and more. These inventories were initially developed before COVID-19. They may not adequately account for changes in university students' study skills needed to adapt to post-COVID learning circumstances, such as increased online learning time, decreased on-site lecture attendance (Kortemeyer et al., 2023), decreased concentration spans (Arifiati et al., 2020), and issues with problem-solving skill development due to over reliance on Generative AI tools (Bastani et al., 2024).

After reviewing previous studies on first-year engineering students' study skills and existing study skills inventory tools, we identified the need for a rapid-response, self-assessment inventory for study skills. This aims to help first-year engineering students identify potential habits that may lead to learning difficulties, particularly due to the significant transition from high school to university settings in the post-COVID era. Students will also be rapidly directed to useful learning resources based on their responses to the inventory questions.

Methods

In this section, we introduce the design-based research (DBR) approach we used as a framework for our methods, and the iterative DBR phases that guided our design and development of the self-assessment inventory.

The DBR approach is defined as a "systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based

on collaboration among researchers and practitioners in real-world settings and leading to contextually-sensitive design principles and theories" (Wang & Hannafin, 2005, pp.6-7). DBR is often applied in a long-term, ongoing research process that involves iterations of observation, design, implementation, and redesign, aiming to develop practical solutions for educational problems (Swan, 2014, p.148). We applied the DBR approach to ensure that our study skills inventory could address the needs and preferences of first-year engineering students in post-COVID learning environments. The iterative nature of DBR can help generate empirical evidence on the impact of the tool on students' learning habits.

We followed the iterative DBR process in three phases to analyse and define the problems, design and develop the tool, evaluate the tool by collecting feedback, and then adapting the design for the next phase according to these suggestions. In the preparation phase, we reviewed the previous research on first-year engineering students' study skills to identify the educational problem (i.e., the need for a fast-response, self-assessed inventory tool on study skills for first-year engineering students) and reviewed existing study skills inventory tools for potential solutions. These have been elaborated in the previous Backgroundsection.

After the preparation phase, in Phase 1, a prototype design was conducted to visualise our initial ideas about the features and workflows of the study skills tool. Regarding the key study skills categories summarised from the literature review and criteria for engineering accreditation (ABET, 2024; ENZ, 2022), the study skills category pool contained self-awareness, time management, reading, note-taking, memory, concentration, exam preparation, digital/eLearning skills, writing, presenting, stress management, teamwork, critical thinking, problem-solving, and research skills. We designed ten items for each category in the pool by adapting assessment items in DSSCI and LASSI tools for first-year engineering education. We used a 5-point Likert scale to measure students' responses for each item in the survey tool. After students respond to all the items, they will receive summary scores for each category. Then, we ran a discussion session among first-year engineering course teachers and student representatives to investigate what study skills categories, assessment items, features, and learning support should be included in the tool.

After we redesigned the prototype tool according to the feedback from the first-year teachers and students, in Phase 2, we developed the tool using the Qualtrics survey platform, ran a functionality pilot test with a small group of first-year students and their mentors, and collected further feedback. In Phase 3, we revised the tool according to the feedback and sent invitations to all first-year engineering students (approximately 1000 students) to use the tool at the beginning of the semester, which is at the time of writing this paper. Students can use the tool more than once. Participants' responses and usage data will be collected to help us understand the first-year cohort's study skill levels. Focus group discussion sessions will be held at the end of the semester to help us understand a) students' reflections on their study skills, b) any changes in students' skills during the semester, and c) to improve our tool in future studies.

Results and Discussion

We aimed to design a self-assessment tool in which students could answer and receive results and recommendations about learning resources within approximately 10 minutes. Thus, we invited a reference group of first-year engineering course teachers and student representatives to prioritise five to six categories of the most important study skills for the first-year study and share the reasons based on their learning or teaching experiences. The six study skills categories prioritised for the tool in our pilot version were time management, note-taking, memory, concentration, exam preparation, and stress management. The teachers' and students' justification of their votes for the six categories will be discussed at the conference.

Incorporating the six study skills categories selected in Phase 1, we developed the tool using the Qualtrics survey platform and integrated learning resources in consultation with experienced student learning support advisors for each category. In the pilot tests conducted in Phase 2, the general feedback received from a small group of first-year students and their mentors indicated

that the survey tool was easy to access, and the questions were easy to answer and complete within five to ten minutes. However, they found the numerical scores for each category difficult to interpret and wanted to compare their scores with those of their peers. Therefore, we created a radar spider graph to display students' study skills scores across six dimensions (see an example in Figure 1). In this graph, students can view their own scores, represented by blue solid lines and the average scores of the cohort, represented by black lines. This allows students to clearly identify where they stand in relation to their peers. In addition, the graph includes a red-shaded area with dotted lines to suggest areas for improvement, and green dashed lines to represent optimal scores. By visually mapping their current standing against these ideal levels, students can better understand which areas they excel in, and which require more attention.

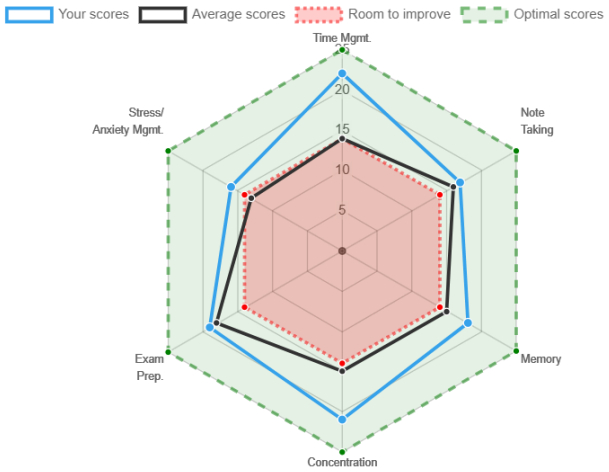

Figure 1 A radar graph to demonstrate a study-skills profile.

At the time of writing this paper, data is being collected from first-year students in Phase 3 during the current university semester. Data analysis will be conducted once this phase of data collection is complete. The data analysis plan involves calculating descriptive statistics to summarise the cohort's study skills levels across six dimensions, followed by clustering analysis to identify patterns of student groups. Correlation analysis will explore the relationships between students' study skills and academic performance. Qualitative data from focus group sessions will be integrated with the quantitative survey results to offer a deeper understanding of students' reflections and expectations on their study skills.

We have received some positive feedback, such as "*I liked it.. the questions made me reflect on myself and helped me to figure out what I can improve on... even as I was answering the questions, I was like 'ohhhh true... I can do this to improve myself*", "*Thanks for valuing my education; I really appreciate it!" and "I like the graph:)".* A few comments recommended including digital skills and problem-solving skills. They emphasised that engineering courses generally require more problem-solving and understanding compared to majors like English. More results will be shared at the conference. This will be used to inform the ongoing refinement of the self-assessment tool in future DBR iterations.

Preliminary Conclusions

This paper explains the design process of a self-assessed study skills tool for first-year engineering students through three DBR iterations. Our preliminary observations are that the tool has gained some positive feedback from a small group of first-year engineering students, and that it is helping improve their self-awareness of study skills. With the completion and analysis of the data being collected at the time of writing, we hope to have results that will provide a clearer picture of first-year students' study skills post-COVID, how they correlate with students' academic performance, and the tool impacts any changes in students' study skills. At this stage, it is premature to establish the reliability and validity of the tool. This is a goal that we are working towards with the ongoing data collection and revisions. All the scores and results that students receive from the tool can only

serve as indications or suggestions about students' potential strengths and weaknesses of selected study skills. We acknowledge the limitations of the feedback that we received from the sample of our engineering students' cohort. We are aware that the present research findings might be applicable only to investigate study skills of the first-year engineering students in our faculty.

This project contributes to the principles and practice of first-year engineering education by providing a research-based foundation for developing an engineering-focused study skills inventory. Our goal is to support not only academic success but life-long learning, and to increase student retention rates. Future data collection from students and staff will inform the ongoing refinement of the tool to benefit a broader range of engineering students.

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