FIND THE GAP: AN APPROACH FOR VISUALIZING AND ANALYSING DESIGN COMPETENCIES IN A UNIVERSITY WITH INTERDISCIPLINARY CURRICULUM

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ABSTRACT

Design education needs to be continually investigated and improved to stay relevant. The Singapore University of Technology and Design (SUTD) is a leading university focused on all elements of technology-based design. The overarching motivation of our research is to enhance design education curriculum at SUTD. Our research objectives are (1) to understand how design competencies are implemented in SUTD's curriculum and courses (2) to identify gaps in teaching of design competencies at SUTD. We analyse competencies in 28 design courses at SUTD. We develop the visualization and analysis of 12 skills grouped under two abilities from the Design competency assessment framework. Our main contributions are: (1) We present an approach to map the design competencies that are taught across design courses at a university with an interdisciplinary curriculum, (2) We present an approach for mapping design competency progression based on ITAE (Introduced, Taught, Assessed, Expected) categorization, (3) Based on the above, we provide preliminary findings on two skill gaps in the curriculum, substantiated with insights from interviews with course coordinators.

Keywords: Design education, Design process, Design learning, Education

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1 INTRODUCTION

Design education is considered significant to equip students with the skills to address societal and global challenges. Several studies have highlighted the potential of design education to support students' problem solving and innovation skills. However, education needs to be continually investigated and improved to stay relevant. Design education, especially, is 'struggling' to keep up with the rapid changes in the VUCA (Volatile, Uncertain, Complex, Ambiguous) world (Meyer and Norman, 2020). Creating an innovative and cross-domain graduate is the new goal of many educational programs, but challenges remain in creating a framework that facilitates this objective (Nae, 2017).

The Singapore University of Technology and Design (SUTD) is a leading research-intensive university focused on technology and all elements of technology-based design. Its mission is to advance knowledge and nurture technically grounded leaders and innovators to serve societal needs. SUTD's pedagogy is characterized by interdisciplinary curricula and design-centric project-based learning, where students from different disciplines work in teams to solve real-world challenges (SUTD Vision, 2011).

The integration of design throughout the curriculum is a unique feature of SUTD, but students often fail to recognize the underlying design process as a generic approach to identify and address challenges. One possible reason is issues in the curriculum, due to which students are unable to understand the relationships between the design content of various courses. This is a general issue in design education at the university level and merits further investigation. Competency-based education is increasingly being embraced as a solution for higher education that has the potential to address curriculum issues, by developing a structure of stackable credentials (Johnstone and Soares, 2014). We postulate that a design curriculum of a university should have

- *Coherence*: Design related courses should contribute to forming a unified, purposefully designed whole,
- *Links*: Design related courses should build on or complement each other,
- *Progression*: Design related courses should have a clear structure and progressive/continuous learning outcomes based on design competencies.

While SUTD is known for its interdisciplinary education and is considered an emerging leader in engineering education (Graham, 2018), it is important to further clarify, refine and strengthen Design teaching at SUTD. The overarching motivation of our research is to enhance design education curriculum at SUTD. Therefore, the first step is to conduct a thorough investigation of the current status of design teaching in courses across the curriculum at SUTD.

Our research objectives are (1) to understand how design competencies are implemented in SUTD's curriculum and courses (2) to identify gaps in teaching of design competencies at SUTD. We analyse competencies in 28 design courses at SUTD. We develop the visualization and analysis of 12 skills grouped under two abilities from the Design competency assessment framework (Thandlam Sudhindra and Blessing, 2021). Our main contributions are:

1. We present an approach to map the design competencies that are taught across design courses at a university with an interdisciplinary curriculum,
2. We present an approach for mapping design competency progression based on ITAE (Introduced, Taught, Assessed, Expected) categorization,
3. Based on the above, we provide preliminary findings on two skill gaps in the curriculum, substantiated with insights from interviews with course coordinators.

2 BACKGROUND

Design education is significant as it supports students' problem solving and innovation skills (Carroll et al., 2010; Wright and Wrigley, 2019). Design challenges students to find answers to complex and difficult problems and fosters students' ability to act as agents of change. It develops students' creative confidence by engaging them in hands-on projects that focus on building empathy, promoting a bias toward action, encouraging ideation, and fostering active problem solving (Carroll et al., 2010). An increased interest in STEAM (Science, Technology, Engineering, Arts and Math) integration in the curricula has led to the learning of scientific and technical concepts through design (English, 2018).

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2.1 Design education curricula

The creation and structure of a design education curriculum is of critical importance, as it impacts what students learn and how well they design. Instructors naturally play a central role in any curricular or pedagogical fine-tuning and developments (Huizinga et al., 2014; Quam, 2019). The CDIO (Conceive-Design-Implement-Operate) is an initiative for curriculum reform to ensure that students gain knowledge, skills and attitudes relevant for undergraduate engineering education (Crawley et al., 2014).

However, there are significant issues both in the creation as well as the structure of educational curricula. Firstly, experts have cited that the very definition of design is contentious, raising the critical issue of lack of clarity in curriculum documents, which has implications for pedagogical implementation (Christensen et al., 2019). Secondly, neither the creation of a design curriculum, nor the evaluation of existing curricula is well documented. Usually, once established, a program's curriculum is rarely reassessed as a whole, but instead updated by adding or modifying courses in an existing curricular structure. As a consequence, the design components in a curriculum are typically based on the experience and opinions of a select group of faculty members, and limited to a few courses. Studies have stated that when a college or university design department looks to re-examine its design curriculum, there are few vetted resources to refer to (Quam, 2019).

2.2 Learning progression and competency benchmarking in design education

Studies conducted show the positive influence of a competency-based education and learning modules in various disciplines (Getha-Taylor et al., 2013; Johnstone and Soares, 2014). Competency-based education (CBE) is a 'customizing-learning' initiative that "reorients the educational process toward demonstrated mastery and the application of knowledge and skills in the real world." The overall focus of this model is to bridge the gap between the workplace and post-secondary education by developing a structure of stackable credentials that one must attain (Johnstone and Soares, 2014).

Learning progressions are the meaningful sequencing of teaching and student learning expectations accounted for across disciplines, student developmental stages, and grades (Plummer and Maynard, 2014). Learning progressions provide a scope and sequence for teachers to develop student knowledge and skills as they progress (Barnhart and van Es, 2015). Education experts state that by its very nature, learning involves progression (Heritage, 2006). Learning takes place when more complex skills are built on foundational skills, and progressions describe how skills might be demonstrated in early, intermediary, and advanced forms. It is critical for teachers to be able to identify skills, in order to intervene at the appropriate levels of challenge and scaffold the learning of their students. Thus, descriptions of how skills progress over time are crucial, so that classroom tasks can be effectively developed for students. This "progress" can be visualized as a roadmap to support instructional planning.

Since curricula are often written in discrete topics or year levels, it creates an illusion that these are separate sets of knowledge or skills. In fact, topics need to be linked. The idea of "coherence" is implicit in the notion of learning progression. It is not sufficient for instructors to know only the curriculum being taught in their class—they should also understand what the students learned before, and what they will need to engage with after, to ensure deep learning (Kim and Care, 2018).

Companies worldwide opine that university graduates often do not develop skills necessary for a changing and dynamic world. Thus, education systems need to deliberately incorporate the explicit teaching of competencies. Previous studies have highlighted how professional competencies could be aligned to the attributes used in curriculum maps that link learning experiences and assessments to the intended learning outcomes (Oliver et al., 2007). Studies also identify competency gaps in the education of engineers based on skills required in practice, to develop new interventions (Jovanovic and Tomovic, 2008; Petrović and Pale, 2021).

A critical issue in the current practice of design education is the lack of progression benchmarking. How would instructors know how much students have learnt, or what kind of design problems they are able to address and what kind of methods can be used? This not only affects teaching and learning, but also hampers the recognition of design as more than ideation and human-centeredness. Especially, it has been pointed out that design education curriculum needs to evolve with constantly changing industry needs (Meyer and Norman, 2020). The current environment in higher design education calls for more consideration of the linkages between curriculum development, skills capabilities and industry, particularly in light of recent economic pressures in a VUCA world (Andrews et al., 2019).

Design is often considered as an open-ended and implicit activity. However, research has pointed out the need to make design processes and methods more explicit, to aid learning (Van Dooren et al., 2014).

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Recent research points out the value of frameworks of design competencies to better articulate the depth and validity of ‘design doing’ to help future design practitioners to better understand and communicate the value of what they have learnt (Fass et al., 2018). While there is significant research in the field of Design Science and on learning progressions within specific disciplines, there is very limited research linking project-based learning, the design process, and learning progressions (Annetta et al., 2018). The Skills Framework for Design (SkillsFuture Sg, 2019) marks an important step by providing a list of design skills and competencies for the Design Sector, but considerable effort is still required to develop design competency levels across school types, higher education and into professional workstreams.
A review of the literature outlined in previous sections reveals the many issues in teaching and learning of design education that need investigation. Especially, it is significant and timely to investigate the state of design education at SUTD, and to develop improved models of design education to address evolving needs.

3 METHOD

3.1 Design education at Singapore University of Technology and Design

SUTD’s academic structure and curriculum is strongly interdisciplinary, based on an ‘Outside-In’ approach that is grounded in technology and design, and a combination of practice and theory. SUTD is structured into interdisciplinary pillars and clusters - Architecture and Sustainable Design (ASD), Engineering Product Development (EPD), Engineering Systems and Design (ESD), Information Systems Technology and Design (ISTD), Design and AI (DAI) and Humanities, Arts and Social Sciences (HASS) (Figure 1). SUTD offers five undergraduate programs. Each program comprises eight terms of study, wherein terms 1, 2 and 3 are common to all students, followed by five terms in a selected pillar. Units of teaching are referred to as a “course”, which typically lasts one term. Course coordinators are responsible for planning and managing the teaching material in courses.

3.2 Selection of courses and collaboration with faculty members across SUTD

As advised by the senior leaders, heads of pillars and course coordinators themselves, an initial set of 18 courses was first selected by the research team, based on the design content of the courses, ensuring that courses from each pillar, cluster, and term at SUTD were included. Ten courses were added to the research study, on further analysis. Primarily, two types of courses were considered in this research: key design courses (labelled TxDx, T=term number), such as the introductory design course (T2D2), and the capstone course (T8D1), both of which are mandatory for all enrolled students (2) Design based courses, that impart disciplinary theoretical knowledge that students apply in design projects in the courses (labelled TxCx, T=term number). The courses included in the research study and the clusters or pillars they are associated with, are illustrated in Figure 1. Course coordinators of the selected courses were onboarded as collaborators or co-investigators in the research project. A project kick-off meeting was conducted to introduce the research objectives and methods to all course coordinators. Course coordinators provided the research team with the pre-requisites, learning objectives and other information relevant to their courses.

3.3 Design competency framework

We employed the Design Competency Assessment framework (DesCA) (Thandlam Sudhindra and Blessing, 2021) to analyse the design competencies covered by the selected courses. The DesCA framework, currently under development as part of a PhD research project, aims to (1) support educators in identifying design competencies, (2) facilitate the teaching, learning and assessment of design competencies in higher education. DesCA defines a design competency as a combination of skills, knowledge and attitudes. Definitions and examples of these are provided in studies by Thandlam and Blessing (2021) and Thandlam et al (2022). In its current form, DesCA includes over 100 skills, 80 knowledge components and 65 attitudes mapped to 12 'abilities' that represent phases of a design process. The design competency components in DesCA, i.e. skills, knowledge and attitudes, were compiled on the basis of their use in the context of design discipline.

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	ASD	EPD	ESD	ISTD	DAI	HASS
T8	T8D1					
		T8C1				
T7		T7C1		T7C2		
T6		T6C6		T6C2		T6C1
T5	T5C2		T5C3		T5C1	
T4		T4D1; TC41			T4C2	T4C3
T3	T3D1; T3D2; T3D3; T3C1; T3C2; T3C3; T3C4					
T2	T2D1; T2D2; T2C1; T2C2					
T1	T1D1; T1C1; T1C2; T1C3; T1C4					

Figure 1. Courses in research project, showing courses selected from all pillars, clusters and terms at SUTD (T= Term number; D=Key design course; C=Design-based course)

3.4 ITAE categorization of competencies

We adapted Crawley et al's (2014) categorization of learning outcomes for the CDIO (Conceive, Design, Implement, Operate) syllabus for engineering education, to classify whether competencies were being Introduced (I), Taught (T), Assessed (A) or Expected (E) in a course (Definitions in Table 1). These were mutually non-exclusive or multiple-selection categories, meaning that course coordinators could select more than one ITAE category for any particular skill, knowledge or attitude.

Table 1: Definitions of Introduced (I), Taught (T), Assessed (A), Expected (E)

Category	Implication	Teaching & Learning activities
Introduced (I)	Must be at least mentioned or imparted informally	Introduced in class at very basic level and no formal lecture or activity.
Taught (T)	Must be an explicit competency taught in the course	Formal lecture or activity, delivered to all students in course. Students practice and receive feedback.
Assessed (A)	Must be an explicit competency assessed in the course	Embedded in rubric or influences grading rubric. Students' performance is assessed. May be graded or ungraded.
Expected (E)	Expected competencies	No teaching at all, students are expected to know these from a previous course or general knowledge.

3.5 Design competency workshops and 1-on-1 sessions with course coordinators

The DesCA framework was explained to course coordinators in workshops as well as in 1-on-1 sessions. At each of these sessions, a researcher introduced the framework, its objectives, and components to the course coordinators. The researcher assisted course coordinators in interpreting the framework, and indicate competencies fostered in their courses. Course coordinators had the liberty to modify the given competencies or add more that they considered relevant to their courses.

3.6 In-depth interviews with course coordinators

We finally conducted one-hour interviews with course coordinators to investigate their opinions on (1) their experiences of teaching design, (2) their perception of students' experiences of learning design in their courses. Interviews were audio recorded and transcribed. Thematic analysis was conducted, and relevant codes were generated.

4 RESULTS

In this paper, we present the visualization and analysis of 12 skills grouped under two abilities from the DesCA framework. The analysis is based on competency data from 28 courses.

4.1 Design competency overview maps

Based on course coordinators' input, the key competency skills, knowledge, and attitudes introduced and taught in each course were mapped using radial diagrams. In the examples shown in Figure 2, we

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map the skills under ability I “Define/articulate the project” and ability II “Understand the challenge & frame the problem”. Skills in the courses are shown in an ascending order, with the first course in term 1 shown in the innermost polygon, and the last course in term 8 shown in the outermost polygon. For the ability “Define/ articulate the project”, most skills are fostered in several courses across the curriculum (Figure 2a). However, for the ability “Understand the challenge & frame the problem”, more gaps may be seen, especially for the skills S06, “Communicating & engaging within the team” in the early years and S07, “Deriving user requirements/ constraints”, which are evidently missing in many courses in the early years (Figure 2b).

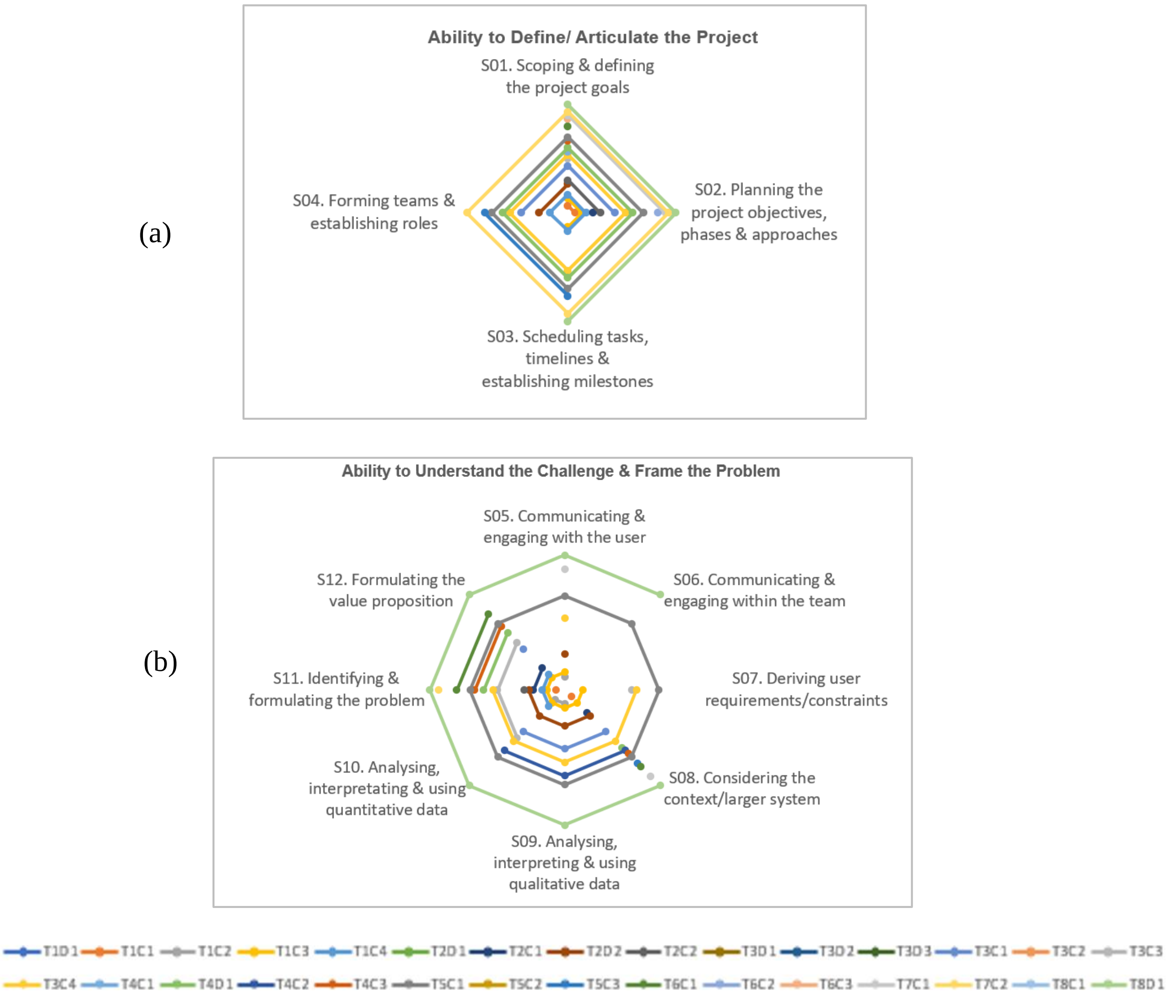

Figure 2. Design competency maps for skills in the abilities (a) Define/ articulate the project, (b) Understand the challenge & frame the problem

4.2 Design competency progression maps based on ITAE categorization

We compiled the ITAE categorizations of skills, knowledge and attitudes indicated by course coordinators. As the categorization allowed multiple selection, we employed a four-cell heatmap to represent the competency components that are introduced, taught, assessed and/or expected, in each course. Competency data from the courses was organized in ascending order of the term of the course to visually represent students’ competency progression. Figure 3 shows the ITAE categorization for the skills under ability I “Define/articulate the project” and ability II “Understand the challenge & frame the problem”. As can be seen from the figure, while the skill S03 “Scheduling tasks, timelines & establishing milestones” is expected in a course in term 1, and assessed in courses in terms 1, 2 and 3, it is only formally taught in a course in term 4. Similarly, the skill S06 “Communicating & engaging within the team” is expected in courses in terms 1 to 4 but is only formally taught in term 5, in a pillar-based course.

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Pillar	Course Number	I. Define/ articulate the project															
		S01. Scoping & defining the project goals				S02. Planning the project objectives, phases & approaches				S03. Scheduling tasks, timelines & establishing milestones				S04. Forming teams & establishing roles			
Freshmore	T1D1																
Freshmore	T1C1	I				I							E				E
Freshmore	T1C2																
Freshmore	T1C3	I	T	A		I				I		A					E
Freshmore	T1C4	I				I				I				I		A	E
Freshmore	T2D1			A	E			A	E								
Freshmore	T2C1						T	A									E
Freshmore	T2D2			A		I				I					T		
Freshmore	T2C2	I				I							E				
Freshmore	T3D1			A					E								
Freshmore	T3D2			A					E								
Freshmore	T3D3			A					E								
Freshmore	T3C1	I				I				I				I			
Freshmore	T3C2			A				A				A					E
Freshmore	T3C3	I							E				E				E
Freshmore	T3C4	I					T		E	I			E	I			E
EPD	T4C1	I							E				E				
EPD	T4D1		T	A			T	A			T	A					E
DAI	T4C2																
HASS	T4C3	I							E				E				E
DAI	T5C1	I	T	A		I	T	A		I	T	A		I	T		
ASD	T5C2																
ESD	T5C3								E		T	A			T	A	
HASS	T6C1	I							E				E				E
ISTD	T6C2			A								A				A	
EPD	T6C3	I						A				A					E
EPD	T7C1	I	T	A								A	E			A	E
ISTD	T7C2		T	A			T	A			T	A		I			E
EPD	T8C1																
Capstone	T8D1	I	T	A	E	I	T	A		I	T	A					E

(a)

Pillar	Course Number	II.Understand the challenge & frame the problem																															
		S05. Communicating & engaging with the user				S06. Communicating & engaging within the team				S07. Deriving user requirements/ constraints				S08. Considering the context/ larger system				S09. Analysing, interpreting & using qualitative data				S10. Analysing, interpreting & using quantitative data				S11. Identifying & formulating the problem				S12. Formulating the value proposition			
Freshmore	T1D1			A	E											A				A	E								E				
Freshmore	T1C1														T	A										I							
Freshmore	T1C2	I																I				I											
Freshmore	T1C3		T	A					E	I	T				T	A		I		A		I		A			T	A			T	A	
Freshmore	T1C4								E														T	A			T	A		I	T		
Freshmore	T2D1															A	E											A	E				E
Freshmore	T2C1						T	A							T	A										I	T	A		I	T	A	
Freshmore	T2D2		T	A			T	A			T	A			T	A											T	A			T	A	
Freshmore	T2C2				E																					I							E
Freshmore	T3D1			A	E				E			A	E								E			A	E				E			A	
Freshmore	T3D2			A	E																								E			A	
Freshmore	T3D3			A	E																								E			A	
Freshmore	T3C1													I					T				T					A			T		
Freshmore	T3C2			A												A												A				A	
Freshmore	T3C3				E				E	I							E						T	A		I		A		I			
Freshmore	T3C4		T	A					E	I				I					T	A			T	A			T	A					
EPD	T4C1																E		T	A			T	A		I		A					
EPD	T4D1				E				E				E				E		T	A					E		T	A			T	A	
DAI	T4C2										T	A			T	A			T	A			T	A								A	
HASS	T4C3								E						T						E				E		T			I			
DAI	T5C1	I	T	A	E	I	T	A	E	I	T	A		I	T		E	I	T	A		I	T	A		I	T	A		I	T	A	
ASD	T5C2																																
ESD	T5C3														T	A																	
HASS	T6C1								E						T						E				E		T			I			
ISTD	T6C2																											A				A	
EPD	T6C3	I							E			A																					
EPD	T7C1		T												T	A																A	
ISTD	T7C2				E																						T	A					
EPD	T8C1																																
Capstone	T8D1	I	T	A		I	T	A					E	I	T	A		I	T	A		I	T	A		I	T	A		I	T	A	

(b)

Figure 3. Mapping progression of design competencies based on ITAE categorization in SUTD courses (I=Introduced, T=Taught, A=Assessed, E=Expected) (a) Define/ articulate the project, (b) Understand the challenge & frame the problem

4.3 Preliminary findings from interviews with course coordinators

In interviews with course coordinators, we asked open-ended questions to understand their perspectives on the key challenges faced by students. We found that both "Scheduling tasks & timelines" and "Communicating & engaging within the teams" emerged as themes in the analysis of the interviews.

4.3.1 Scheduling tasks & timelines

We found that 11 out of 21 course coordinators stated "Scheduling tasks, timelines & establishing milestones" as a skill that students struggle with. Course coordinator F09 described the issue of students needing the skill to juggle tasks in many courses, "*I think the biggest challenge is perhaps time because the students are also learning a lot of theory at the same time related to biomedical and healthcare engineering. So, the (design) project is something they have to work on the side, outside class. So, depending on how busy they are…that may impact the amount of time that they have to work on the design project….they get very stressed with the three other electives that they're taking*" (F09, T3C1, T6C3). Course coordinator F07 further explained the need for students to build the skill of

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scheduling tasks and timelines, "*I think stress management or time management (is what students need the most) …. we actually introduced the project very early on, but some groups just didn't get down on it at the early stage… they leave things to the last minute…*" (F07, T3C1).

4.3.2 Communicating & engaging within the team

A number of course coordinators also brought up the students' challenges of communicating and engaging within the team. As pointed out by a year 1 coordinator, "*…So I can see that in some of my groups, (students) didn't have time to bring up (their team members) on their work and yeah, the members are not communicating enough with each other…*" (F07, T3C1). This skills gap was felt by Capstone instructor F27 as well, who elaborated the need for building communication skills as "*Capstone encompasses five to seven students in the group. And it happens in most cases that one or two students might be more vocal in the group and a few others might be too silent. So, it ends up being a group that's dominated by just one or two students. And their thoughts always get reflected. And the other students who are more silent and reserved tend to lose their prominence in the team. So, I think this balance between the different team members and getting them to cohesively work together and appreciate each other's comments and…be more open, is kind of a challenge in capstone*" (F27, T8D1).

5 DISCUSSION AND CONCLUSION

In this paper, we presented our approach to map design competencies in a university with interdisciplinary curriculum, and to analyse progression in design competencies based on ITAE categorization. The key advantage of our approach of design competency mapping is that it helps in the visualization and analysis of design competencies across the curriculum. This is especially beneficial for universities with multi- or inter-disciplinary curricula, as it facilitates a common language and understanding of competencies acquired from courses from diverse disciplines. While previous studies identified competency gaps in education vis a vis job market to improve university curricula (Jovanovic and Tomovic, 2008), the significance of our study is that it specifically investigates design education at a university with an interdisciplinary curriculum.

5.1 Design competency overview maps

Our design overview competency maps encapsulate the skills, knowledge or attitudes fostered across courses in a university, using the Design Competency Assessment framework (DesCA). The overview map helps in providing awareness of the current competencies fostered across courses in the university. Thus, it serves as an overall 'blueprint' for the university's scope of delivering competencies through individual courses. It serves as a communication tool amongst faculty members and helps in improving coherence and links between the courses in the curriculum.

5.2 Design competency progression maps

Our Design competency progression maps provide a greater degree of detail of the specific competency components that are fostered in the courses. Our progression map based on the ITAE categorization is especially valuable as it facilitates comparison of course coordinators' expectations of competencies in students in each course, vis a vis whether these were Introduced (I), Taught (T), Assessed (A) or Expected (E) in any of the previous courses, thus helping in the identification of gaps in teaching and assessment of design competencies. While the CDIO uses the ITU to categorize learning outcomes, our categorization pertains to competencies, and includes the categories of "Assessed" and "Expected", instead of CDIO's generic "Utilized" category (Crawley et al., 2014). This helps in providing a deeper understanding of how the competency is fostered in the course and facilitates the visualization of the progression of competencies across the curriculum.

5.3 Preliminary findings on skills gaps

We presented preliminary findings on two skills gaps, "Scheduling tasks & timelines" and "Communicating & engaging within the teams" in the curriculum based on the analysis of 28 courses and substantiated by insights from interviews with course coordinators. While other studies have also reported on the issues of time management skills and communication skills of engineering students (Petrović and Pale, 2021), our identification of this skill gap is significant in the context of design education curriculum, as it could help in the strategic placement of remedial interventions. In the future, there is potential to delve deeper into a more detailed examination of the identified skills gaps.

5.4 Research implications

This research has significant implications, primarily in the following areas:

- Our approach supports in **sustaining the university's design philosophy and vision** in courses. By providing an underlying structure that is based on design competencies aligned to the design process, it helps in providing a common framework and prevents bias towards specific disciplinary forms of design. It could help in aligning courses and ensure that the undergraduate curricula authentically reflect the skills required in the profession.
- Our approach facilitates the visualization of **multiple competency progression pathways across the curriculum**, indicating nodes, key transition points, primary and secondary tracks from which students could gain relevant competencies.
- It provides a **holistic approach to curriculum development and management**. Our approach is significant as it allows a comparison of the competencies taught in courses across the curriculum and helps in identifying gaps and opportunities in the curriculum. This could facilitate a roadmap for new courses/ minors /programmes or updating existing courses.

Our research is significant for understanding, developing, and delivering design education, especially in the context of interdisciplinary curricula, as it investigates coherence, links and progression in the curriculum, i.e, courses are linked based on time, design content and competencies.

This study has several limitations. As our sample comprised only a selection of the courses with design content at SUTD, in its current form it only presents a partial representation of the competencies currently taught at the university. Errors in course coordinators' input or processing during research could impact our visualizations and analyses. Although our research documents current competencies in design education, we recognize that competencies are subject to change over time and require continual investigation. Future work involves a validation of the visualizations with faculty members, as well as comparison to students' perceived design competency acquisition. While we are examining coherence and links in the design curriculum as part of our overall research, discussing these at length is beyond the scope of this study. This research on understanding and analysing competencies in interdisciplinary design education at a university is the first of its kind in Singapore and beyond. Our approach and findings are relevant not only for SUTD, but for a wider audience of educators and institutions interested in design education.

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