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Transforming Engineering Education: A Case Study of Singapore University of Technology and Design (SUTD)[1]

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ABSTRACT

Singapore University of Technology and Design (SUTD) was identified as one of the foremost 'emerging leaders in engineering education' by a global benchmarking study on engineering education (Graham, 2018). SUTD is a research-intensive university and was established in collaboration with Massachusetts Institute of Technology (MIT) and Zhejiang University in 2009. SUTD's educational approach is unique and innovative in several ways. For instance, it adopts a T-shaped (Rogers & Freuler, 2015), interdisciplinary curriculum so that students have a solid foundation and broad perspective of engineering in the context of humanities, arts and social sciences. SUTD delivers this through design-centric, project-based learning teaching methods. Undergraduate students are given multiple opportunities to work on authentic and hands-on problems in the form of design projects, industry internships, and research/learning engagements throughout the course of study. SUTD students are reputed for their adaptability and intrinsic motivation (Graham, 2018), and multiple indicators suggest that they are sought by employers. The global recognition as an emerging leader further supports SUTD's educational approach. In this paper, we discuss SUTD's educational approach in its undergraduate programs, and reflect on the lessons learned and future directions.

Key words: Engineering Education, Educational Approach, Interdisciplinary Curricula, Design-centric, Project-based Learning

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INTRODUCTION

Rapid globalization, fourth industrial revolution, massification of higher education (Altbach, 2016, Chapter 1), and unprecedented situations like the Covid-19 pandemic requires higher education to continually evolve to keep up with the changing needs of the volatile, uncertain, complex, and ambiguous (VUCA) world (Kamp, 2016, 11). This means that our engineering graduates need to be equipped with 21st century practice-oriented, interdisciplinary knowledge and skills including: (1) Ways of thinking, (2) Ways of working, (3) Tools of working and (4) Living in the world. (ABET, 2020, Criteria 3; New LinkedIn Research, 2020; The Future of Education and Skills Report, 2018; Kamp, 2019, 2; Voogt & Roblin, 2010, 299–321). Consequently, there needs to be a change in the traditional lecture-based and discipline-oriented engineering education. This paper presents SUTD's educational approach in engineering education to this end.

SUTD'S EDUCATIONAL CONTEXT

SUTD is a research-intensive university established in 2009 in collaboration with Massachusetts Institute of Technology (MIT) and Zhejiang university as the fourth, autonomous university in Singapore. SUTD's vision and mission is to advance knowledge and to nurture technically grounded leaders and innovators who serve societal needs (Magnanti, 2018). As a new establishment, SUTD has had the opportunity to shape its educational approach from scratch, combining the best of the East and West. The MIT collaboration offered support in institution building, research collaboration, curriculum development, faculty development, and dedicated programs to nurture student leadership and innovation skills, while the Zhejiang collaboration offered SUTD a significant student exchange program and several elective courses that would allow *"students to explore the Chinese culture and economy"* (Graham, 2018).

Unlike traditional engineering education which focuses on disciplinary subjects like Mechanical, Electrical and Civil Engineering, SUTD took an outside-in approach and considered the industrial requirements of engineering education to redefine its programs and curricula to focus on "Product, Systems, Services" (Fisher, 2020). The departments offering the undergraduate programs were named to reflect this interdisciplinary approach as the following:

- Engineering Product Development (EPD) Pillar
- Engineering Systems Design (ESD) Pillar
- Information Systems Technology and Design (ISTD) Pillar
- Architecture and Sustainable Design (ASD) Pillar

- Science Math and Technology (SMT) Cluster
- Humanities, Arts and Social Sciences (HASS) Cluster

The "clusters" focus primarily on the first-year curriculum and common subjects in the upper years and "pillars" on the specialized subjects in the upper years.

SUTD started enrolling its first batch of students in 2012, and to date has graduated 1535 engineering students and 414 architecture students from its undergraduate programs. It enrolls 450 new undergraduate students annually with 80% of students in Engineering and 20% in Architecture. SUTD's education aims to be inclusive and has 40% women in its UG education. SUTD engages 140 international faculty members with a good mix of members from Singapore (30%), the rest of Asia (25%) and from Europe and the US (40%) (Graham, 2018; Sockalingam & Pey, 2019a; Intake, Enrolment and Graduates by Institutions, 2020).

SUTD'S EDUCATIONAL APPROACH

There are several features of SUTD's education (Figure 1) which makes its undergraduate program unique and distinctive. More than the individual features, it is the combination and interplay of these features that add to the innovativeness and the success of SUTD's education. Graham (2018) has

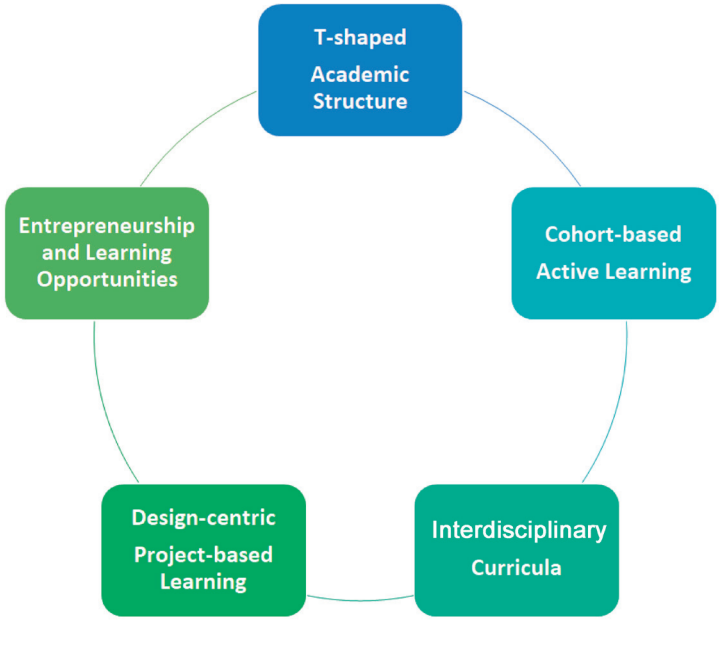

Figure 1. Features of SUTD's Engineering Education.

broadly identified these features as (1) design and maker-based learning, (2) a collaborative culture (3) a multidisciplinary approach and (4) a breadth of student experience. We have added one more feature to it; the T-shaped academic structure.

T-shaped Academic Structure

To build a solid foundation in Science, Technology, Engineering, Arts and Mathematics (STEAM) subjects as recommended by the T-shaped engineering education (Rogers & Freuler, 2015), SUTD requires all students to complete a common first year called "Freshmore". In the Freshmore year, students deepen their fundamentals in STEM subjects and Humanities, Arts and Social Sciences (HASS) before choosing to specialise in a major in the subsequent years. This "liberal science" approach (Walker, Petit & Hawkins,1968) is typically not common in Asian engineering schools. This is important in Singapore's context, since students could come from different specialisations (e.g., science, arts streams of education) and different routes including junior colleges or polytechnics (Fisher, 2020) which means a wide diversity among students. The graduation requirement of 22% HASS component in engineering education is also a distinctive feature in preparing user-centric engineers.

Cohort-based Active Learning

In general, SUTD adopts student-centric, active learning teaching methods. The Freshmore class size is typically of 50 students, with a high faculty to student ratio (e.g., 1:11) so that students receive personalized attention (Fisher, 2020; Graham, 2018). Each class is taught by a teaching team of two faculty instructors and a graduate/undergraduate teaching assistant. Unlike universities such as Aalborg that adopt a specific pedagogical form like problem-based learning (Kolmos, Fink & Krogh, 2004), SUTD does not limit itself to any specific active learning teaching methods. Faculty are encouraged to use relevant and appropriate teaching methods that allow for active and peer-to-peer learning, and so SUTD's teaching methods across modules can be varied. Some examples of teaching methods used at SUTD for active learning include flipped learning (Rai, 2020), game-based learning (Kurniawan *et.al*., 2019), crowd-sourcing as pedagogical tool (Song *et.al*., 2020), design thinking (Silva *et. al*, 2016), using simulations, and robots to teach programming (Kurniawan *et. al*, 2018) and using Augmented Reality (AR)/ Virtual Reality (VR) to teach mathematics (Keegan *et. al*., 2020), and architecture (Agility in Education, 2019).

For the learner-centric pedagogy to work, SUTD's learning spaces are designed to fit the cohort-based, small-group teaching and learning model. Academic spaces such as FabLabs, Makerspaces, and Library add to the open and collaborative learning spaces. The sense of connectivity offered by the cohort-based learning and access to learning space in the Freshmore year provides a unique "residential learning" environment for SUTD students and this further fosters social integration and bonding which helps to build peer-to-peer support, collaboration and cooperation (Graham, 2018).

Interdisciplinary Curricula

The interdisciplinary nature of SUTD's curricula is multi-dimensional, and built into the (1) courses offered, (2) choice of electives offered to students, (3) nature of design-centric project-based learning, and (4) ways of teaching and learning. Many of the courses offered at SUTD are application oriented, and interdisciplinary in nature. For example, the Freshmore module "Computational Thinking for Design" combines "Computational Thinking" and "Architectural Design" and is taught by both ISTD and ASD faculty in teaching teams. During their course of study, all SUTD students must select electives from other pillars allowing them to have breadth, which aids their own self-directed interdisciplinary learning. In addition, SUTD undergraduate students engage in more than 20 design projects that range from disciplinary to multi/inter disciplinary. The Capstone projects in the final year require students to specifically team up with students from mixed pillars, further making the teaching and learning to be interdisciplinary (Capstone Design Showcase 2020).

Design Centric, Project-based Learning

While projects are common in engineering education, they are typically used as end-of-course assignments. In contrast, SUTD adopts a design-centric, project-based learning approach where undergraduate students are exposed to various projects repeatedly. As noted, students engage in over 20 projects in their course of study and these projects can be categorized as 1D, 2D, 3D and 4D as defined by the Big-D framework (Figure 2). 1D projects are design projects within a subject/module (disciplinary), 2D projects

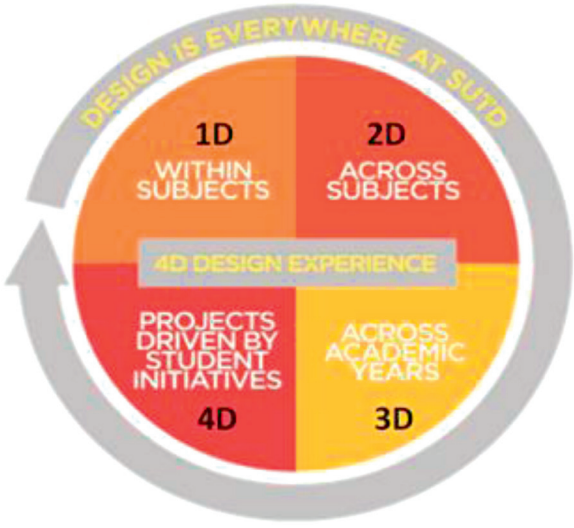

Figure 2. SUTD's Big-D Framework of Design Projects.

are across subjects/modules (interdisciplinary) and 3D projects are projects that cut across the academic terms and years. Students may also engage in their own design projects outside of their curriculum to pursue their passion, and these are referred to as 4D design projects (Graham, 2018; Sockalingam & Pey, 2019b, 20; Wood *et al*., 2012). This is done to ensure that students have wide and repeated exposure to authentic and experiential learning in teams (Krajcik, & Blumenfeld, 2006).

An example of a 1D project is the use of Lego set activities or virtual lab simulations in a biology class (Rai & Zhu, 2018) of the Nature World module. An example of a 2D projects in the Freshmore year requires students to put together, concepts and skills learned in Physics, HASS, Math and Chemistry coursework (Otto, *et al*. 2014) to design a bio-fueled rocket. An example of a 3D project is to design health technology devices by working with clinicians and patients to understand the needs, and medical standards and regulations to develop a prototype to test and design a health device (Dawn, 2019; Karuuppasamy, 2019). Such projects can also be in the form of Capstone projects (Sng *et al*., 2016).

The Capstone projects are formulated in collaboration with companies, industries and small to medium enterprises. These complex, real-world problems require students from different pillars (or degree programs) to formulate holistic solutions to the posed real-world situation. This helps students to develop practical professional skills related to ethics, intellectual property and project management, while dealing with other real-life external factors including national/international policies and laws, and rules and regulations in designing their solutions. In academic year 2020, we had 63 Capstone projects with 44 participating organizations (Capstone Design Showcase 2020).

Entrepreneurship and other learning opportunities

At SUTD, we believe in the holistic education and provide varied opportunities for students to excel beyond the curriculum. For instance, one fifth of the curriculum is dedicated to HASS subjects. Every academic year includes an Independent Activity Period (in January) and weekly, two afternoons (Wednesday and Friday) are dedicated to student led activities such as the Undergraduate Practice Opportunity Program (UPOP), Undergraduate Teaching Opportunity Program (UTOP) and Undergraduate Research Opportunity Program (UROP). Nearly 10% of the capstone projects are entrepreneurial and to date, SUTD undergraduates have initiated 46 start-ups. In addition, all students need to complete a 16-week industry internship and are encouraged to participate in overseas summer programs.

LESSONS LEARNED

Since its inception in 2009, and its first class in May 2012, 1535 engineering students and 414 architecture students have graduated from the six batches of undergraduate programs at

SUTD (Intake, Enrolment and Graduates by Institutions, 2020). SUTD's engineering education was accredited in 2017 by the Engineering Accreditation Board (EAB) in Singapore (Yang, 2017). In 2018, about 94% of SUTD graduates were employed within six months, and the trend of high employment has been maintained through out the last four years. SUTD graduates have been employed in more than 70% of the key industries in Singapore, which signifies a recognition that SUTD graduates are versatile in adopting to the demands and expectations of various industries. In addition, 5% of undergraduates have started their own companies and approximately 10% have pursued further studies in other prestigious universities post-graduation (SUTD data).

The national "Graduate Employment Survey (GES)" conducted annually among the autonomous universities in Singapore indicates that SUTD graduates have held a higher employment quotient over the last four years. Also, SUTD graduates have commanded a higher starting salary compared to their peers from the other local universities (Graduate Employment Results, 2018). Another national survey - "Graduates Education and School Experience Survey" found that SUTD graduates ranked SUTD high on interdisciplinary, teamwork, creativity and innovation as key differentiating factors in comparison to their peers from their respective universities.

Anecdotally, we have also received positive feedback and comments from industrial collaborators and employers that SUTD graduates are Industry-, World- and Future-ready. We are encouraged that SUTD's innovative degree Programs are gaining traction and are well received by the industry. This is also resonated in the feedback from the teams of faculty and staff members.

These data points provide evidence that SUTD graduates and employers value and trust SUTD's education to deliver a world-class education, that offers a competitive career prospect in Singapore and possibly beyond. The MIT *Global State of the Art in Engineering Education* report (Graham, 2018) found that SUTD was recognized to be the most recommended among the set of emerging leaders for engineering education (Figure 3).

Success Factors

Looking back, SUTD's success can be attributed to (1) sound pedagogical underpinnings of SUTD's education, (2) people and culture and (3) global collaborations. According to Fink (2013), the six elements of the educational processes that lead to significant learning are: foundational knowledge, application, integration, human dimension, caring and learning. SUTD's engineering education and pedagogy incorporates these elements of significant learning in terms of providing foundational knowledge, equipping students with learning to learn skills and providing opportunities to apply and integrate what they have learnt in collaborative communities using a design thinking approach, which provides an empathetic perspective of care and human dimension. SUTD's pedagogy is also deeply

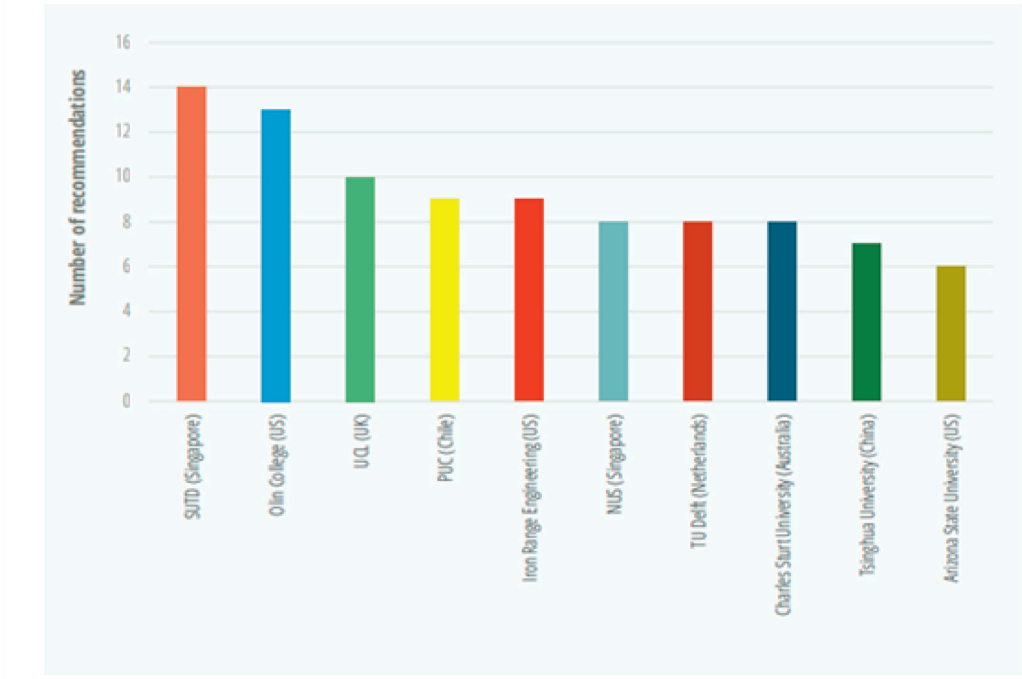

Figure 3. Recommended Emerging Engineering Universities in the World (Graham, 2018).

ingrained in Kolb's experiential learning model (Kolb, 2014) and various aspects of active learning (Prince, 2014). Several studies report the benefits of such methods in leading to deep learning, and these can be the possible reasons for the positive outcomes of SUTD education (Prince, 2014). MIT's involvement in starting SUTD from the scratch has been a crucial factor for the successful establishment of SUTD's educational approach.

The second reason for the successful implementation is the people and culture (Magnanti, 2012; Graham, 2018). From the start, there has been a careful selection of students, faculty and staff members in terms of not only competencies, but also the fitness with the open and collaborative structure at SUTD. Working in collaborative and fluid teams is the norm at SUTD, and the various interactions and opportunities allow for creative, innovative projects to emerge from the community as ground up projects rather than top-down initiatives. This can be in the form of UROP, UTOP projects or capstone projects, and the collaborative work helps the teams to go beyond academic learning to alternative learning opportunities. The small size of the university, and teaching and learning in teams forge a community spirit and brings people together building effective and functional teams. SUTD's leadership has also been a critical factor in this.

The third element is collaboration with other partner universities like MIT, Zhejiang, Singapore Management University, Duke-NUS, Aalto and industrial partners, which makes SUTD's engineering education global and helps to deliver timely and relevant interdisciplinary modules and projects to prepare our students for employment and higher studies. In other words, the critical factors for SUTD's achievements which provide a fertile ground and optimal environment for SUTD's pedagogy model have been the individuals at SUTD, community at SUTD and partners/collaborators of SUTD (Graham, 2018; Magnanti, 2012).

Challenging Factors

Although SUTD has been successful in delivering its education, it has not been without challenges. Two challenges have been increasing student enrollment, and supporting students in adapting to student-centric educational approach. We have tried to address these challenges and continue to seek for ways to improve.

The annual student enrollment at SUTD is around 450 students in its undergraduate program. While SUTD is planning to increase the enrollment number, the challenge that we face is contextual. This includes the low birth rate in Singapore and the limitations in enrolling international undergraduate students. In addition, there is also a growing number of local universities in Singapore, which means multiple educational options for local students. Two of the older universities, National University of Singapore and Nanyang Technology University, are placed high in world rankings and this possibly creates a point of comparison, especially in terms of opting for an established university versus a new university. SUTD is addressing this through various outreach activities, and scholarship opportunities to attract more students. In addition, SUTD is introducing innovative programs such as the Design and Artificial Intelligence (DAI) program to attract more students.

A second challenge is helping students to adapt to SUTD's educational approach. Pre-university education in Singapore is structured and teacher–led and this means that students may not be prepared for the student-centric active and collaborative learning approaches at SUTD (Fisher, 2020). To help undergraduate students acquire the essential skills and mindset for innovation, entrepreneurship, working in teams, and communicating using design thinking and technology, SUTD has introduced a course on "Introduction to Design Thinking and Innovation" that all undergraduate students complete in Term 2. The Office of Undergraduate Studies has also put together various initiatives to support the students in their learning journey - for example, support services that aids learning in the form of maker spaces, eLibrary, learning management system etc. Our graduate teaching assistants and faculty members are trained in student-centric, active learning teaching methods through various faculty educational development initiatives so that they can better support their students (Sockalingam, *et al.*, 2020).

Future Plans

Moving forward, we plan to continually improve the programs and courses to support Singapore's national growth thrusts like Smart Nation and Future Economy and prepare graduates for the future economy. Our immediate focus for the coming years is on four strategic areas of Healthcare, Aviation, Cities and Artificial Intelligence. For instance, all undergraduate students will now take one of the data analytics or Artificial Intelligence (AI) related subjects such as AI, Machine learning or Data Analytics. Given the Covid-19 pandemic, we are also planning to expand on our strategic area of Healthcare.

The pandemic situation has also created a new area of thrust – online/blended learning. While SUTD's educational approach has always emphasized technology-enabled learning, the Covid-situation has created the need for more online and virtual learning. Our faculty members are increasingly using technology to aid active, interactive, and immersive learning through simulations, augmented and virtual reality. For instance, a group of faculty and teaching assistants conducted an online collaborative project-based learning initiative with our partner, Changi General Hospital for our health care program (Siew *et. al.*, 2020).

While much of the focus in the early phase has been about setting up the university programs, courses and educational approach, we are now maturing and gradually moving into evaluating the various aspect of SUTD education through Scholarship of Teaching and Learning (SOTL) (Sockalingam & Pey, 2019a). Several of our faculty and staff members are evaluating their own educational practices and studying the effectiveness of their educational approach. Continuing to review and reflect, on SUTD's educational approach is part of our efforts to refine SUTD's educational approach.

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REFERENCES

"ABET Criteria for Accrediting Engineering Programs 2020-2021". 2020. https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2020-2021/.

"Agility in Education". 2019. https://www.sutd.edu.sg/SUTD/media/SUTD/The-Singapore-Architect-Agility-in-Education.pdf.

Altbach, Philip. G. 2016. *Global Perspectives on Higher Education*. JHU Press.

"Capstone Design Showcase 2020". 2020. https://www.sutd.edu.sg/CapstoneShowcase.

Fink, L. Dee. 2013. *Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses*. John Wiley & Sons.

Fisher, D. 2020. *Education Crossing Borders: How Singapore and MIT Created a New University*. MIT Press.

Graham, Ruth. 2018. *The Global State of the Art in Engineering Education*, MIT School of Engineering. http://news.mit.edu/2018/reimagining-and-rethinking-engineering-education-0327.

"Graduate Employment Results." Singapore University of Technology and Design. 2018. https://www.sutd.edu.sg/Admissions/Undergraduate/Graduate-Employment-Results/2018.

"Intake, Enrolment and Graduates by Institutions." Data.gov.sg. 2020. https://data.gov.sg/dataset/intake-enrolment-and-graduates-by-institutions.

Kamp, Aldert. 2016. Engineering Education in the Rapidly Changing World: Rethinking the Vision for Higher Engineering Education. TU Delft, Faculty of Aerospace Engineering, Delft.

Kamp, Aldert. 2019. Science and Technology Education for 21st Century Europe: CESAER Discussion Paper. DOI 10.5281/zenodo.3582544.

Kang, Keegan, Sergey Kushnarev, Wong Wei Pin, Omar Ortiz, and Jacob Chen Shihang. 2020. Impact of Virtual Reality on the Visualization of Partial Derivatives in a Multivariable Calculus Class. *IEEE Access* 8: 58940–58947.

Karupppasamy, Subburaj. 2019. An Approach to Incorporate Experiential Learning in Medical Device Design and Innovation Course. *EduSCAPES*. Edition 3, pp. 43–510. https://www.sutd.edu.sg/SUTD/media/SUTD/Eduscapes-2019.pdf.

Koh, Dawn. 2019. Design Method to Solve Healthcare Challenges in the Community. *EduSCAPES* Edition 3, pp. 36–40. https://www.sutd.edu.sg/SUTD/media/SUTD/Eduscapes-2019.pdf

Kolb, David A. 2014. *Experiential Learning: Experience as the Source of Learning and Development*. FT press, 2014.

Kolmos, Anette, Flemming Kobberøe Fink, and Lone Krogh. 2004. The Aalborg model: problem-based and project-organized learning. In *Aalborg Model: Progress, Diversity and Challenges*, pp. 9–18. Aalborg Universitetsforlag.

Krajcik, Joseph S., and Phyllis C. Blumenfeld. 2006. Project-based learning. In: The Cambridge Handbook of the Learning Sciences. (2006). R. Keith Sawyer (ed). Cambridge University Press.

Kurniawan, Oka, Norman Tiong Seng Lee, Subhajit Datta, Nachamma Sockalingam, and Pey Kin Leong. 2018. Effectiveness of Physical Robot Versus Robot Simulator in Teaching Introductory Programming." In *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, pp. 486–493.

Kurniawan, Oka, Norman Tiong Seng Lee, Nachamma Sockalingam, and Kin Leong Pey. 2019. Game-Based versus Gamified Learning Platform in Helping University Students Learn Programming. *Personalised Learning. Diverse Goals. One Heart*: 159.

Magnanti, Thomas. L. 2012. "Speech by SUTD President at the Inauguration of the Singapore University of Technology and Design." Singapore University of Technology and Design. https://www.sutd.edu.sg/About-Us/News-and-Events/Press-Releases/2012/5/Speech-by-SUTD-President,-Professor-Thomas-Magnant.

Magnanti, Thomas, L. 2018. Building a New Academic Institution: The Singapore University of Technology and Design. In *Accelerated Universities*. pp. 103–127. Brill Sense.

New LinkedIn Research: Upskill your Employees with the Skills Companies Need Most in 2020. https://www.linkedin.com/business/learning/blog/learning-and-development/most-in-demand-skills-2020.

Otto, K, Bradley Adam Camburn, Kristin L. Wood, Giacomo Nannicini, Roland Bouffanais, Elica Kyoseva, Jean Wan Hong Yong, Dario Poletti, Robert E. Simpson, and Aditya Prasad Mathur. 2014. "Integrated 2D Design in the Curriculum: Effectiveness of Early Cross-Subject Engineering Challenges." In *2014 ASEE Annual Conference & Exposition*, pp. 24–763.

Prince, Michael. 2004. "Does Active Learning Work? A Review of the Research." *Journal of Engineering Education* 93, no. 3. pp. 223–231.

Rai, Bina. 2020. A Team of Instructors' Response to Remote Learning due to Covid-19: A 10.012 Introduction to Biology Case Study." *Journal of Applied Learning and Teaching* 3, no. 2.

Rai, Bina. and Yajuan Julia Zhu. 2018. The Design and Evaluation of Virtual Laboratory Simulations for Biology Non- Majors. EduSCAPES. Edition 2. Pp. 33–35. https://www.sutd.edu.sg/SUTD/media/SUTD/2018-SUTD-Pedagogy-Newsletter_1.pdf.

Rogers, Peter, and Richard J. Freuler. 2015. "The "T-shaped" Engineer." In *American Society of Engineering Education (ASEE), Proceedings of the Annual Meeting, Seattle, WA, June*.

Siew, William, Evan Sidhi Peradijaya., Bina Rai and Xiaojuan Khoo. 2020. Re-imagining COVID-19 through Digital Learning and Innovation by Design. Edition 4. pp. 45–48. https://sutdpedagogyday2020.weebly.com/uploads/1/3/1/6/131600715/eduscape_edition_4.pdf.

Silva, A, João Vilas-Boas da Silva, Marco Leite, and Ricardo Simoes. 2016. "How Background Affects Design Output: Teaching Product Development to Mechanical Engineers, Industrial Designers and Managers." In *2nd International Conference of the Portuguese Society for Engineering Education (CISPEE)*, pp. 1–6.

Sng, Karen, K. Blake Perez, Sherman Tan, Bradley Camburn, Bige Tuncer, and Kristin Wood. 2016. Capstone Design Course Experiences: Multi-disciplinary Approach to Innovation Challenges. Proceedings of the ASME 2014 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDETC/CIE 2016 August 21–24, 2016, Charlotte, NC, USA.

Sockalingam, N, and Pey Kin Leong. 2019. Benchmarking Educational Development Centres in Singapore. *EduSCAPES.* Edition 3, pp. 23–30 https://www.sutd.edu.sg/SUTD/media/SUTD/Eduscapes-2019.pdf.

Sockalingam, N, and Pey Kin Leong.2019. Big-D at SUTD. *EduSCAPES.* Edition 3, pp. 17–22. https://w ww.sutd.edu.sg/SUTD/media/SUTD/Eduscapes-2019.pdf.

Sockalingam, N, Cheah Chin Wei, Lee Chee Huei, Nilanjan Raghunath, Norman Lee, Oka Kurniawan, Yajuan (Julia) Zhu and Pey Kin Leong. 2020. The SUTD - AHE Educational Fellowship Programme: Garnering International Recognition for Excellence in Higher Education Teaching for SUTD. *EduSCAPES*. Edition 4. pp. 14–20. https://sutdpedagogyday2020.weebly.com/uploads/1/3/1/6/131600715/eduscape_edition_4.pdf

Song, Chaoyang, Jianxi Luo, Katja Hölttä-Otto, Warren Seering, and Kevin Otto. 2020. "Crowdfunding for Design Innovation: Prediction Model with Critical Factors." *IEEE Transactions on Engineering Management*. https://arxiv.org/pdf/2007.01404.pdf.

"The Future of Education and Skills: Education 2030", 2018. https://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf.

Voogt, Joke, and Natalie Pareja Roblin. 2010. "21st Century Skills." *Discussienota. Zoetermeer: The Netherlands: Kennisnet*. 23, no. 03 (2010). http://opite.pbworks.com/w/file/fetch/61995295/White%20Paper%2021stCS_Final_ENG_def2.pdf.

Walker, Eric. A, Joseph M. Pettit, and George A. Hawkins. 1968. Goals of Engineering Education, Final Report of the Goals Committee. Engineering Education. American Society for Engineering Education. https://www.asee.org/documents/publications/reports/goals_of_engineering_education.pdf

Wood, Kristin L., Rajesh Elara Mohan, Sawako Kaijima, Stylianos Dritsas, Daniel D. Frey, Christina Kay White, Daniel D. Jensen, Richard H. Crawford, Diana Moreno, and Kin-Leong Pey. 2012. "A Symphony of Designettes-Exploring the Boundaries of Design Thinking in Engineering Education." In *American Society for Engineering Education*. American Society for Engineering Education.

Yang, Calvin. 2017. "SUTD Degree Courses Fully Accredited," https://www.straitstimes.com/singapore/education/sutd-degree-courses-fully-accredited.

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Lim Seh Chun is the Associate Provost for Student Affairs at the Singapore University of Technology and Design (SUTD). Before joining SUTD, Professor Lim spent more than 30 years with the National University of Singapore during which he held a number of management appointments including Head of Mechanical Engineering, Deputy Dean of Engineering and an Associate President. He is known for his work on the development and construction of wear-mechanism maps. He is a Fellow of the Institution of Engineers, Singapore, the Institution of Mechanical Engineers, UK, and the Institute of Materials, Minerals & Mining, UK. He is also a registered professional engineer in Singapore and a registered chartered mechanical engineer in the UK.