CERN IdeaSquare Journal of Experimental Innovation, 2021; 5(1): 32-39
DOI: https://doi.org/10.23726/cij.2021.1291

ORIGINAL ARTICLE

Design innovation integrating deep technology, societal needs, radical innovation, and future thinking: a case study of the CBI A^3 program

Christine Thong,[1*] Andreea Cotoranu,[2] Aaron Down,[1] Kirstin Kohler,[3] Catarina Batista,[3]

[1]Swinburne University of Technology, John St Hawthorn, VIC, 3122, Australia; [2] Pace University, One Pace Plaza, New York, NY 10038, USA; [3] University of Applied Sciences Mannheim, Paul-Wittsack- Straße 10, 68163 Mannheim, Germany
*Corresponding author: cthong@swin.edu.au

ABSTRACT

There is a recognized need for innovators with design capability to translate deep technology into applications that consider desirable futures and positive societal impact. Challenge Based Innovation A^3 (CBI A^3) is an interdisciplinary program that aims to develop such capability in university students' using an integrated curriculum featuring design skills combining four domains: deep technology, societal needs, radical innovation, and future thinking. This paper describes the CBI A^3 program and discusses exploratory research using a mixed methods approach of observations, reflections, and before and after surveys measuring growth in student confidence. Initial findings indicate CBI A^3 program achieves its learning objectives, recommending further in-depth research to validate findings and broaden understanding of specific tools and curriculum approaches for both professional practice and educational settings.

Keywords: Design inquiry; deep technology; futures thinking; higher education; radical innovation; self-efficacy; societal need.

Received: March 2021. Accepted: June 2021.

INTRODUCTION

Deep technologies, such as those developed at CERN, have great potential although aligning a specific technology with a human or societal need or desire can be challenging (Mesa et al., 2019). Without this alignment, new products, whether physical or digital objects, environments, services, systems, or experiences, may lack relevance and value in a market. Design approaches can assist with this alignment since design, as a discipline, is concerned with synthesising human desirability, technical feasibility, and economic viability into tangible product forms (Doorley et al., 2018). There is a need for innovators with design capability to translate deep technology into applications that consider desirable futures and positive societal impact.

Relevant design-based approaches, such as design thinking, social innovation, and user-centred design, are commonly taught in tertiary education systems globally. However, design approaches are often taught independently of one another: one course focuses on technology, another focuses on social innovation, and so forth, leaving students with no guidance on integrative and interdisciplinary approaches needed by future innovators to address complex, real-world challenges. (World Economic Forum, 2020).

A few universities around the globe address design capability for deep technology translation through IdeaSquare, CERN's Challenge Based Innovation (CBI) initiative. All CBI programs use design-inspired methods and CERN technology to meet United Nation's Sustainable Development Goals (UN SDG); however, each takes a different approach.

This paper explores the CBI A^3 program established in 2017 by Design Factory Melbourne at Swinburne University of Technology in Australia in collaboration with IdeaSquare, CERN and run in partnership with other Design Factories. Design Factories are platforms with aligned values around creating the conditions for innovation and interdisciplinary collaboration on applied projects, thereby forming the Global Design Factory Network. Design Factories from four different countries participate in CBI A^3; Design Factory Melbourne at Swinburne University, Australia; inno.space at Hochschule Mannheim, Germany; New York City Design Factory at Pace University, U.S.A.; and Porto Design Factory at Politéchnico do Porto, Portugal. CBI A^3 aims to foster competency in radical design innovation and in future-focused design outcomes concerned with technology and societal needs. The research question addressed in this paper is: "To what extent does CBI A^3 program foster design skills in relation to deep technology, societal need, radical innovation and future thinking?"

THEORETICAL BACKGROUND

Deep technology is understood as technology from advanced engineering and science, emerging from long-term R&D, with the capacity to address complex human challenges (Chow, 2019). Deep technology often remains unexploited and needs a champion to drive commercial translation, identify and explore market and new product opportunities early, and manage investment risk associated with high expense and inherently long timeframes (e.g., ten years) (Mesa et.al, 2019). Deep technology has the potential to change markets radically, address complex societal challenges, and produce great financial value for society (Alphabeta, 2020). Thus, successful future innovators must apply design skills that integrate technology, societal need, radical innovation, and future thinking.

The UK Design Council (2021) has recently acknowledged that "Design builds a bridge between technological research and innovation and their application to social practice". Verganti (2009) states that the intersection of design and technology domains is necessary to create radical shifts in product meaning and performance since user-centred design alone is not a strong enough catalyst for radical innovation. However, user-centred design may maximise the potential of a radical product innovation (Norman & Verganti, 2014). Lande and Leifer (2010) further define design's capacity for radical innovation, suggesting design thinking and future thinking are modes of generating breakthrough innovation, the difference being time horizons. Technology application for social good is gaining traction, with specific programs emerging such as: Stanford's Ethics, Society, and Technology Hub (Stanford University, 2021), EU funded ATTRACT Phase 2 (2021), Harvard Computer Society (2020) Tech for Social Good, and the SGInnovate (2020) Deep Tech for Good initiative. The value of integrating design with technology and social innovation is supported by Sambasivan (2019) suggesting "*…a more generative and fruitful approach to designing technologies for social good by asking critical questions in design*". While these programs integrate design skills with some of CBI A^3's four domains (technology, societal needs, future thinking, and radical innovation), none integrate them all.

The idea of integrated curriculum has many interpretations and models; however, all make meaningful associations across different domains and view learning as holistic, real-world and interactive (Anderson, 2013). Integrated curriculum has many benefits for students, including increased self-confidence and motivation, deeper learning, and higher academic scores (Drake & Reid, 2018). While Fogarty (1991) offers the seminal 10 level continnum for integrated curriculum, Drake and Reid (2018) present a simplified continuum using universal descriptors more suited to higher education. Their simplified continuum levels are 1) *Fusion*: a 'traditional' single subject is infused with other concepts, 2) *Multi-disciplinary*: a theme unites learning, but discipline boundaries remain distinct 3) *Interdisciplinary:* a specific skill/s, catalyses learning across different disciplines with boundaries present but less important, and 4) Transdisciplinary*:* a challenging issue is at the centre of learning and disciplinary distinctions dissolve.

Description of the CBI A^3 program

CBI A^3 draws on both interdisciplinary and transdisciplinary models for integrated curriculum (Drake & Reid, 2018) as demonstrated in Fig. 1. From our research, CBI A^3 is the first program to integrate this combination of design inquiry, deep technology, societal needs, radical innovation and future thinking into one experience. Corresponding to the interdisciplinary model, the central inquiry is design skills to catalyse learning across the four domains. Design skills refer to skills used in design occupations; they are most commonly associated with application in sectors of the economy and strongly associated with innovation (UK Design Council, 2018). Corresponding to the transdisciplinary model, a societal challenge is set based on UN SDGs, which strengthens the societal needs component of learning. However, the CBI A^3 program more closely follows the interdisciplinary model, as it maintains some level of disciplinary distinction to support clear communication, scaffolding and expectations across the range of different stakeholders involved with the course.

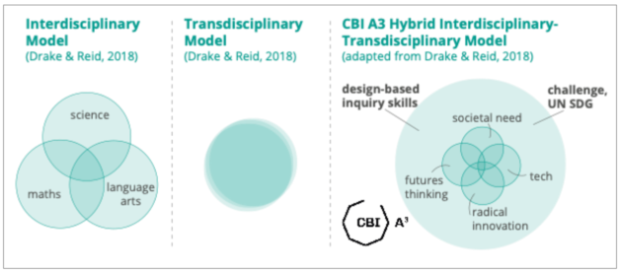

Fig. 1. Models of integrated curriculum visualised.

CBI A^3 is a higher education course for students from a range of different disciplines including design, business, humanities, science, and engineering. Students are typically at Master's level, with some final year Undergraduates students. Each institution integrates CBI A^3 as an elective subject, awards credit equivalent to approximately 600hrs, and defines its own assessment requirements. All other aspects of the CBI A^3 program curriculum remaining consistent and partnering institutions form a teaching team to collectively supporting student learning.

The CBI A^3 program community cooperates remotely, which entails work with coaches from CERN and online collaboration platforms. Students work in teams at their own institutions over a period of six and a half months. Global community is typically established through a two-week design intensive at IdeaSquare CERN, where students engage in CERN site visits, work with local stakeholders, absorb new ways of thinking and work intensively on their projects.

A range of topics and tools form a uniquely curated curriculum aiming to scaffold learning in design skills, technology, societal needs, radical innovation, and future thinking, relevant to the UN SDG challenge posed by CBI A^3. Conceptual and theoretical foundations, as well as practical tools and guided exercises, are curated for each area, with some original tools developed for CBI A^3. Tab. 1 identifies learning support for each area, organised according to phases of the CBI A^3 course.

Table 1. Curriculum map for phases 1 and 2 of CBI A^3 supporting design skills and the four domains. Regular text denotes topic areas that cover theory, practices/tools and activities. *Italics* denotes a tool or activity only. *Denotes original to CBI A^3.

Areas of learning support	Phase 1 topics + tools	Phase 2 topics + tools
Design Skill	Design Thinking Strategic Design Speculative Design Technology-driven Design	Circular Design Socially Responsible Design Speculative Design Sustainable Design Principles User-centred Design
Technology	*CERN Technology cards** Global Technology Trends *Ideation workshops** Technology-driven Design	*CERN Technology cards** Cybersecurity Journey maps *Morphological charts* Technology Development + roadmaps
Addressing Societal Needs	Design Thinking *Ideation workshops** *Opportunity cards** Value proposition + canvas	Behaviour Change Circular Design Diegetic Prototyping Journey Maps Sustainable Design Principles Socially Responsible Design Stakeholder engagement Systems Thinking User-centred Design
Radical Innovation	2-week intensive experience at IdeaSquare CERN* Exponential Thinking *Ideation workshops** *License to Dream* Multiverse Thinking *Newspaper headlines* *Thing of the future* Wizard of Oz prototyping	Diegetic Prototyping Speculative Design
Design for the Future	Forecasting + Future Scenarios Multiverse thinking *Newspaper headlines* Speculative Design *Thing of the future*	*2030 Future Canvas** Diegetic prototyping Speculative Design *Implementation Roadmap**

Aligned with Drake and Reid's (2018) interdisciplinary model, distinctions among the four domains are maintained, with design skills acting as the integrating agent. However, the boundaries are blurred as some topics and exercises inherently support multiple areas of learning, for example speculative design simultaneously supports design skills, radical innovation and future thinking. Aligned with Drake and Reid's (2018) transdisciplinary model, components of design thinking, as the integrating feature, help students discover needs and ask relevant questions.

The CBI A^3 program has two phases. *Phase 1* defines project direction as shown in Fig. 2. Each year one specific UN SDG is selected, for example, "SDG 3. Good Health and Wellbeing", and student teams capture local problems relating to the selected UN SDG using 'opportunity cards' as a learning tool. Student teams also prepare CERN 'technology cards' as a learning tool for understanding technology in their own terms. Opportunity and technology cards are used with customised ideation workshops to explore a wide range of radical ideas for 2030 design outcomes. This approach allows students to find meaningful connections between technology and societal needs, out of which they choose their own direction for *Phase 2*.

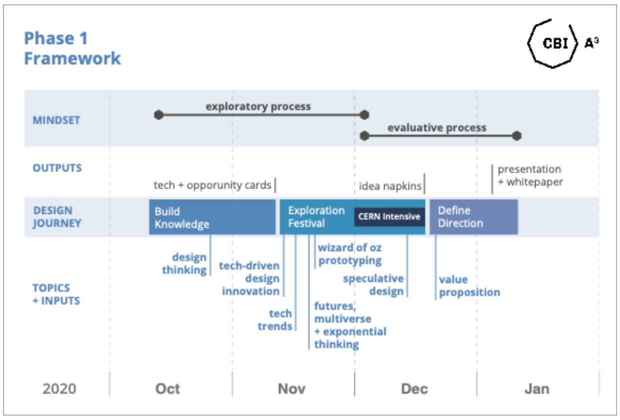

Fig. 2. Phase 1 Framework for CBI A^3 Program.

Phase 2 resembles a more traditional design process, where different design details are explored, tested and developed to address the societal and human needs articulated in *Phase 1*. In this phase, students progress from exploratory processes to evaluative processes before documenting and communicating their design outcomes for 2030 (Fig. 3). An 'implementation roadmap' is one tool used, where students consider resources, stakeholder engagement, partnerships, further R&D, and a specific future scenario. Design outcomes are communicated using digital or physical means to demonstrate design intent, as shown in the Fig. 4 example. Functional prototypes are not expected, given that students are designing for approximately ten years into the future.

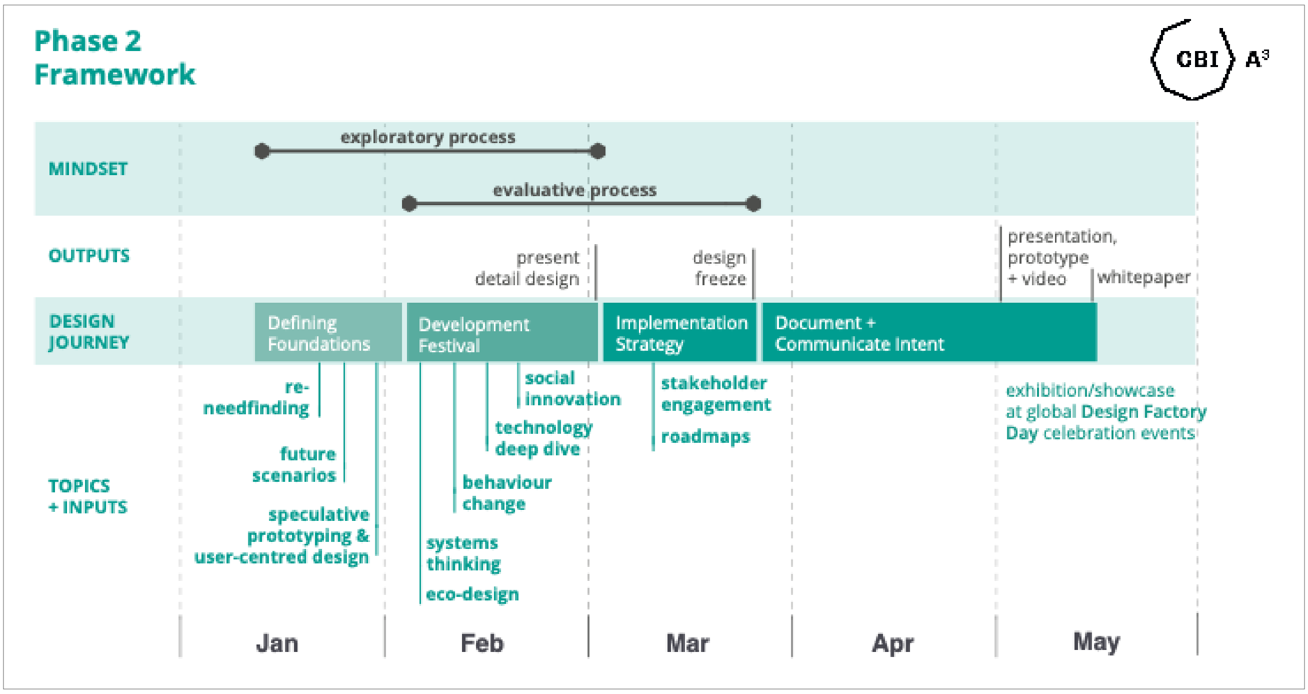

Fig. 3. Phase 2 Framework of CBI A³ Program.

Fig. 4. Student project outcome example: the *Halo*, a future airport screening system for elicit and biohazardous substances.

METHOD AND DATA

This inquiry is exploratory and aims to gather insight into whether CBI A³ is indeed achieving learning in its uniquely integrated curriculum design approach. In this paper, we use a mixed methods approach consisting of qualitative and quantitative assessments. Qualitative insights were gathered through teaching team observations and student responses to open ended survey questions. Quantitative data, representing changes in student confidence in their ability, provided insight by comparing answers from before and after the program.

Observations by the teaching team were documented at the end of the course and by reflection during monthly teaching meetings. The responses to open ended questions were gathered from a survey that included six qualitative questions, to capture insight into the learning experience offered by CBI A³. At the beginning of the program, students were asked to describe their *motivation for taking the course*, *expected value in undertaking the course*, and *what they expected to be the most challenging aspect*. Correspondingly, at the end of the course, students were asked *what motivated them during the course*, *what was the most valuable learning they received*, and *what they found to be the most challenging aspect*. Qualitative responses were deductively coded using five categories of design skill and the four domain areas, as shown in Table2.

We designed the above-mentioned questionnaire to capture student confidence in their ability to execute CBI A³ tasks. An individual's belief in their capability is important for persistence in innovative practices (Gerber et al., 2012), and we aim for students to persist in solving CBI A³ types of challenges in the future. Our way of measuring student confidence is inspired by Bandura's (1977, 2006) concept of 'self-efficacy'. However, this study does not claim to conform to the defined way of measuring self-efficacy but rather it adapts this method in order to capture changes in student confidence in their abilities as a means of reflecting on their learning.

We capture students' perception of their own ability to perform on a set of tasks through14 questions mapped to design skills and the four topic domains as shown in Table 2. Approximately half of the questions explored general design skills covering activities from all the stages of design process defined in the Double Diamond (UK

Design Council, 2019): discover, define, develop, and deliver. The four domains are covered in the other questions, with each question addressing a particular domain, to better understand how each domain is being fostered.

Table 2. CBI A^3 survey questions mapped to design skills and four domain areas.

Areas of learning	Activities	Questions I feel confident in my ability to…
Design Skill	Discover	ask relevant questions (Q7) source relevant experts and resources as needed by a project (Q8)
	Define	define complex challenges with clarity (Q5) make rational and inclusive design decisions (Q1)
	Develop	develop ideas through prototyping (Q2) generate a diverse range of ideas (Q3)
	Deliver	communicate design ideas clearly (Q6)
Technology		deliver design solutions using technology responsibly (Q11) use technology to develop relevant design solutions (Q12)
Societal Needs		deliver design solutions that are relevant to society (Q13)
Radical Innovation		discover real societal needs (Q14) explore radical ideas (Q4)
Design for the Future		deliver design solutions relevant for the future (Q9) envisage and frame future scenarios (Q10)

In order to translate student responses into a measure of confidence, we adapted Carberry et. al.'s (2018) work in developing a survey measure for Innovation Self-Efficacy, the closest exemplar for design innovation. We started each question with "I feel confident in my ability to…" and used a five-point Likert scale, with five being *very confident* and one being *not confident* (Schar et al., 2017, Pink et al., 2017, Carberry et al. 2018). We did not use the surveys for absolute ratings of high or low because constructing rating validity would not have been possible with such small sample size. Of course, other variables besides the CBI A^3 course may influence changes in student confidence; however, questions were tailored to the specific context of the CBI A^3 challenge.

RESULTS

We administered the survey with our 2019-20 cohort of students. Participation was voluntary and 12 from 13 students completed both surveys. These 12 students of varied gender and study discipline: computer science (2), health science (1), information systems (1), information technology (4), medical engineering (4) design (4), were from four teams at three universities in Australia, Germany, and the USA.

Average scores of all 14 questions were taken for before and after survey results to ascertain growth in student confidence in the cohort. At the beginning of the program, the average confidence score was 3.77, compared to 4.36 at the end of the program, increasing by 0.59 points. Before and after confidence levels for each individual question is captured in Fig. 5. The following section explores results in relation to design skills and the four domain categories for growth in student self-confidence, student reflections, and teacher observations.

Design skills

For questions related to general design skills, student confidence increased on average by 0.71 points, the highest increase of all learning areas, showing this skill as focal in students' perception. In qualitative reflections, there is no explicit mention of design skills in the before survey, although innovation is identified. In the after survey, there is an increase in design themes, with explicit mention of design such as '*innovative process of design'* and specific components of design thinking practice such as '*…embracing failure and learning from them is a valuable thing as it 'opens your eyes' to things you wouldn't have previously thought about'*. Observations from teachers support successful learning in various design skills, with a sharp increase in skills to rapidly explore, prototype and communicate ideas after a few days immersed at IdeaSquare CERN. When evaluative processes require design decisions, we see students struggle with judgement on what addresses the challenge best. At the end of the program, teachers observe sophisticated communication of complex design concepts, that clearly identify design intent, value for society, and justification of decisions to diverse audiences.

Designing for technology

At completion of the program, students' confidence in their ability to use *technology to develop relevant design solutions* was 4.33 points (increased by 0.54) and student confidence to *deliver design solutions using technology responsibly* was marginally higher at 4.42 points (increased by 0.49). The qualitative perception of CERN technology aspects being a challenging component of the course decreased; technology was mentioned four times in the before survey, and only mentioned once in the after survey. This correlates with teacher observations that students have two spikes in learning regarding technology: one after the two-week immersive at IdeaSquare, CERN, and the other in the final stages of design development. At both stages, CERN coaches are more involved and we see improvements in the students' ability to explain technological concepts with greater detail and correct terminology, and to adopt technology appropriately in their design process. In the after survey one student identified '*the idea of working with CERN technology to create realistic solutions with more flexibility than designing for the present day'* as a motivating factor, also demonstrating domains intersecting.

Designing for societal needs

Students' confidence to *deliver design solutions that are relevant to society*, increased by 0.71 points to 4.50, which was one of the highest confidence scores. Interestingly, the other question asking students' self-confidence to *discover real societal needs*, decreased by 0.12 points. This was the only question to show a decrease and went from the highest rated in the before survey to the lowest rated in the after survey. Teacher observations support the latter, as students found it hard to identify relevant human needs in relation to the societal issues at hand. Although the score decreased, learning regarding societal needs still occurred. Qualitative responses, in the after survey showed societal needs was no longer mentioned as a challenge, and increased as a motivating factor, with student comments such as "*I was motivated by the idea that we could craft an innovation for health*" and "*work for the good of the society*".

Proposing radical innovations

Students' confidence to *explore radical ideas* increased by 0.53 points, however it was the (equal) lowest scoring area in the after survey, and not explicitly mentioned in the qualitative responses. In qualitative responses, students identified to '*think outside the box'*, *'creative thinking', and 'design thinking'* as both valuable and challenging aspects of learning, which may relate to radical innovation as students' perception of what is radical and to what extent this differs (if at all from) from creative thinking or design thinking is highly subjective. Radical innovation is featured mostly in *Phase 1* during exploratory processes, and teachers observe that exponential thinking and licenses to dream approaches highly influence 'unlocking' students' mindset to generate ideas that are more radical. Teachers also observe the further into the future design work is aimed for and create the ease with which students generate radical ideas. This correlates with teacher observations in *Phase 2* of the CBI A3 where radical expression decreases as design ideas evolve for implementation in 2030.

Designing for the future

Students' confidence to *envisage and frame future scenarios* increased by 0.46 points to a score of 4.25 and confidence to *deliver design solutions relevant for the future* increased by 0.63 points to a score of 4.42. Future themes featured minimally in the qualitative student responses, with only one mention under valuable learning in the before survey, and one mention each for motivations and challenging aspects in the after survey '*it was challenging to go beyond what was possible/feasible and think of something new'*. As identified in previous teacher observations, designing for the future seems to unlock students' engagement in radical and creative thinking, however working with future scenarios in course stages of evaluative processes seems to provide a layer of complexity and uncertainty that students to grapple with before ultimately being able to clearly propose future scenarios their design work exists within, with strong justification based on other future forecasting studies.

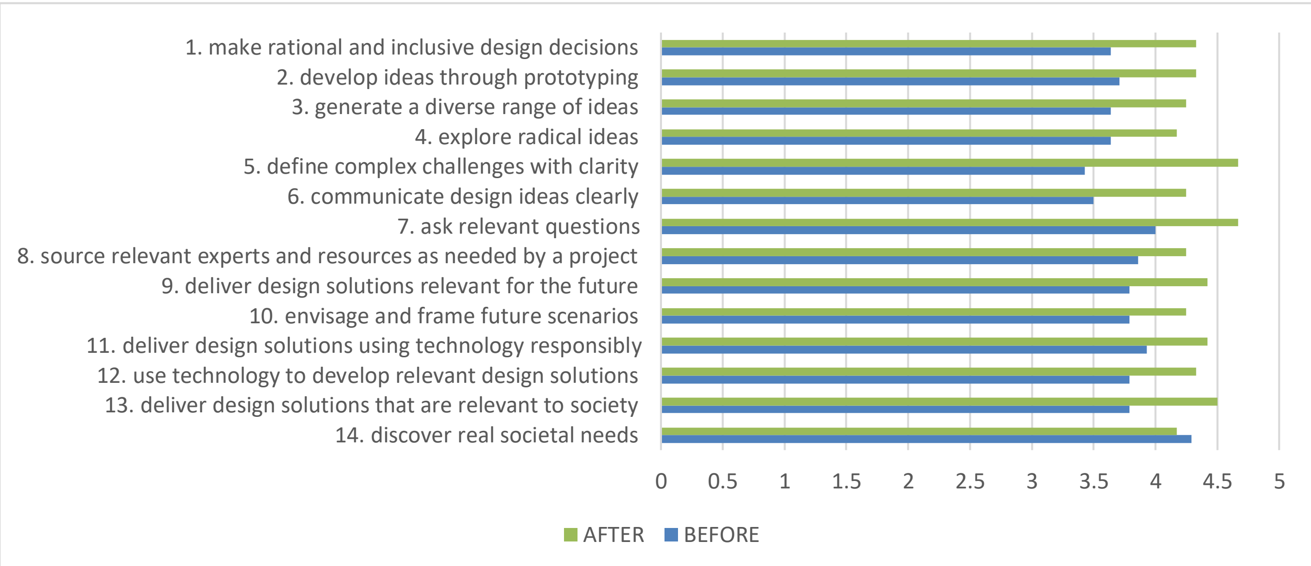

Fig. 5. Before and After Self-efficacy results for all questions surveyed.

DISCUSSION AND CONCLUSIONS

The exploratory study of CBI A^3 integrated curriculum indicates student learning is indeed being achieved in relation to design skills applied to technology, societal need, radical innovation and futures thinking. In answering the research question, to what extent is learning occurring in these areas; capability developed across these domains is not equal. After the course, confidence averages related to design skills was highest, then technology, future thinking, societal needs, and lastly radical innovation. The qualitative responses also indicate inter-connected learning across some domains.

The study is limited by being based on perception of learning, small cohorts, and overview of the CBI A^3 integrated curriculum. Further, more in-depth qualitative research would be useful to validate the initial findings and expand understanding of CBI A^3 by investigating the effectiveness of specific tools, learning material, and learning environments, especially those developed originally by CBI A^3. For example, how effective is the 2030 future canvas as a design tool? How effective are the different learning topics to support problem solving for UN SDG's? What influence does the two-week immersion at IdeaSquare CERN have? Semi-structured interviews with students, graduates, teaching staff and CERN stakeholders would provide richer data, and longitudinal studies would uncover how graduates are applying their skills as professionals.

Further research should also illuminate how specific tools may be adopted by other researchers, educators and practitioners. Those concerned with policy and best-practice for deep technology translation should have greater knowledge on utilising and investing in resources to leverage design-based skills to translate deep technology more effectively for societal good.

However, currently one might infer that CBI A^3 integrated curriculum is broadly achieving the desired learning, so may provide inspiration for other universities to adopt. A CBI A^3 course could be established as part of any master program due to the interdisciplinary nature. It would be particularly suited to master's degrees concerned with design, social innovation, technology or other disciplines wishing to increase their efforts towards UN SDG's. Scaled up, CBI A^3 could become a new dedicated master's degree on socio-techno design, attractive to students with the passion to change the future of our planet.

ACKNOWLEDGEMENTS

The authors would like to thank all student participants in the research and all stakeholders who have supported the development of CBI A^3 in particular all CERN and CBI A^3 coaches who have volunteered their time to support student learning and experience.

REFERENCES

Alphabeta (Australia part of Accenture), 2020, Australia's Deep Tech Opportunity: Insights from the Cicada Innovations Journey, A report undertaken on behalf of Cicada Innovations.

Anderson, D.M., 2013, Overarching Goals, Values, and Assumptions of Integrated Curriculum Design, SCHOLE: A Journal of Leisure Studies and Recreation Education, 28(1): pp.1-10. DOI: 10.1080/1937156X.2013.11949690.

ATTRACT, 2021, ATTRACT phase 2 Developing breakthrough technologies for science and society, Retrieved 8th May 2021: https://attract-eu.com

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

Bandura, A., 2006, Guide for constructing Self-efficacy scales. In Self-Efficacy Beliefs of Adolescents, Pajares, F. & Urdan, T.S. (eds.) Information Age Publishing: Greenwich, pp. 307-337.

Carberry, A. R., Gerber, E. M., & Martin, C. K. (2018). Measuring the innovation self-efficacy of engineers∗. *International Journal of Engineering Education*, *34*(2), 590-598.

Chow, J., 2019, What is Deep Tech? Deep Tech Defined, DeepTechWired, Retrieved 9th May, 2021: http://deeptechwire.com/what-is-deep-tech/

Doorley, S., Holcomb, S., Klebhan, P., Segovia, K. & Utley, J., 2018, Design Thinking Bootleg, Guide produced by D.School at Stanford University.

Drake, S.M. & Reid, J.L., 2018, Integrated Curriculum as an Effective Way to Teach 21st Century Capabilities, Asia Pacific Journal of educational Research, 1(1): pp. 31-50.

Fogarty, R., 1991, The mindful school: How to integrate the curriculum, Skylight publishing, Inc.: Palatine, IL.

Gerber, E., Martin, C.K., Kramer, E., Braunstein, J., & Carberry, A.R., 2012, Work in Progress: Developing an Innovation Self-efficacy survey, 2012 Frontiers in Education Conference Proceedings, 2012, Seattle, pp. 1-3.

Harvard Computer Society, 2020, Tech for Social Good, Retrieved 8th May 2021: https://socialgood.hcs.harvard.edu

Mesa, D., Thong, C., Ranscombe, C. & Kuys, B., 2019, Integrating the product development process in scientific research. Bridging the research-market gap, Proceedings of the Design Society: 22nd International Conference on Engineering Design (ICED19), Delft.

Norman, D.A. & Verganti, R., 2014, Incremental and Radical Innovation: Design Research vs. Technology and Meaning, Design Issues, 30(1): pp. 78-96.

Lande, M. & Leifer, L., 2010, Difficulties student engineers face designing the future, International Journal of Engineering Education, 26(2): pp. 271-277.

Pink, S., Rieken, B., Bjorklund, T., & Sheppard, S., 2017, What Makes an Inquisitive Engineer? An Exploration of Question-Asking, Self-Efficacy, and Outcome Expectations among Engineering Students, Proceedings of the American Society for Engineering Education Annual Conference and Exposition, 2017 Columbus, OH.

Sambasivan, N., 2019, The remarkable illusions of technology for social good, Interations, 26(3): pp. 64-66.

SGInnovate, 2020, SGInnovate Launches Deep Tech for Good Initiative, Retrieved 8th May 2021: https://www.sginnovate.com/news/sginnovate-launches-deep-tech-good-initiative

Stanford University, 2021, Ethics, Society, and Technology Hub. Retrieved May 8th 2021: https://ethicsinsociety.stanford.edu/ethics-society-technology-hub

UK Design Council., 2018, Designing a Future Economy. Retrieved 13th June 2021: https://www.designcouncil.org.uk/sites/default/files/asset/document/Designing_a_future_economy18.pdf

UK Design Council., 2019, What is the Framework for Innovation? Design Council's Evolved Double Diamond. Retrieved 23rd March 2021: https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond

UK Design Council., 2021, Beyond Net Zero: A Systemic Design Approach. Retrieved 8th May 2021: https://www.designcouncil.org.uk/resources/guide/beyond-net-zero-systemic-design-approach

Verganti, R., 2009, Design-Driven Innovation: changing the rules of competition by radically innovating what things mean, Harvard Business Press, Boston, USA.

World Economic Forum, 2020, The Future of Jobs Report October 2020, Retrieved 9th May 2021: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf