Abstracts and Full Papers

18th World Conference on Continuing Engineering Education

June 6-10, 2022

University at Buffalo
The State University of New York
USA

Proceedings of 18th World Conference on Continuing Engineering Education

ISBN: 978-1-7327114-2-6

Published by International Association for Continuing Engineering Education (IACEE)
www.iacee.org

in association with
University at Buffalo School of Engineering and Applied Sciences
&
SUNY Center for Professional Development
New York, USA

ABSTRACTS

1

Women retention in STEM Higher Education

Dr. Patricia Caratozzolo[2], **Dr. Angeles Dominguez[1]**, Dr. Esmeralda Campos[1], Dr. Claudia Lizette Garay-Rondero[3]

[1]Institute for the Future of Education, Tecnologico De Monterrey, Monterrey, Mexico, [2]Institute for the Future of Education, Tecnologico De Monterrey, Mexico City, Mexico, [3]Institute for the Future of Education, Tecnologico De Monterrey, Madrid, Spain

Science, Technology, Engineering and Mathematics (STEM) Higher Education (HE) has many objectives, such as promoting learning, fostering students' motivation to continue studying, and cultivating students' regard for the role of science and technology in society. Research has proven there is a gender gap in STEM HE due to several factors, such as the traditional role of women in society and the lack of female role models and mentors in STEM areas, to name a few. Several international organizations have emphasized the importance of addressing the gender gap in STEM HE explicitly. Addressing the gender gap in HE is part of the UN's Sustainable Development Goal 4, specifically for target 4.3, which refers to ensuring equal access for women and men to tertiary education, including university. According to the Organization for Economic Co-operation and Development (OECD), the gender gap in STEM HE enrolment is different for fields of study; the field of natural sciences, mathematics and statistics has reached gender parity, while for engineering and information and communication technologies (ICT) the gender gap persists. It is noteworthy that among the mentioned fields, there may exist differences between countries and areas of study, such as biology and physics within the natural sciences. The OECD highlights the importance of removing stereotypes and implementing policies for reducing the gender gap in different fields of study. HE institutions can implement several strategies to address the gender gap in STEM areas through different processes: attraction, access and retention. Within the retention process, some universities may identify guidance, completion and other similar terms. Retention of engineering students is an important issue that academic institutions must address to avoid dropout by creating an inclusive and supportive environment. Academic institutions and policymakers must inform each other about the strategies to guide women in STEM careers and avoid academic dropout. We identify the need to conduct a literature review focused on the retention strategies that universities worldwide have adopted to guide and retain women in their STEM programs. The main contribution of this panel to society is to inform about best practices for women retention in STEM careers.

2

Women in Engineering and Sciences: an initiative to include a gender perspective and equal opportunities in a Higher Education Institution.

Dr. Adriana Vargas-Martinez[1]

[1]Tecnologico De Monterrey, Monterrey,

Women in Engineering and Sciences is an initiative in which the main objective is to be an organization responsible for ensuring gender equality to promote and increase the participation of women in strategic positions, decision-making initiatives, and relevant actions in a Higher Education Institution. This initiative is divided into five central committees.

- Governing Committee: This Committee is in charge of generating and executing an action plan to empower women inside the Higher Education Institution, diagnosing and identifying the take in women's action at this educational level.
- Mentor Committee: The main objective is to design programs to strengthen and empower women's professional and personal development.
- Liaison Committee: Promotes the creation of a highly connected women ecosystem to develop joint projects between Industry and Academia.
- Promoting Committee: Pursues to guide and inspire students interested in engineering or sciences through workshops, events, and activities involving a personalized accompaniment process.
- SHE-STEM Chair: Promotes leaders and tutors new STEM researchers by supporting gender perspective and social responsibility research.

The initiative aims to reduce gender breaches and ensure equal opportunities inside a Higher Education Institution with the above committees.

3

The role of OWSD Mexico in narrowing the gender gap.

Dr. Linda Lara-Jacobo[1], Dr. Patricia Caratozzolo[2], Dr. Alejandra Chavez-Santoscoy[3], Dr. Rebeca Garcia-Garcia[3], Dr. Alma Hernandez-Mondragon[4], Maribel Garcia-Barrientos[5], Cristina Perez-Trejo[5]

[1]Science Department, The University of Ontario Institute of Technology, Oshawa, Canada, [2]Institute for the Future of Education, Tecnologico de Monterrey, Mexico city, Mexico, [3]Escuela de Ingeniería y Ciencias, Tecnologico de Monterrey, Monterrey, Mexico, [4]Program on Science, Technology and Society, Center for Research and Advanced Studies of the National Polytechnic Institute, Mexico City, Mexico, [5]Universidad Autonoma Metropolitana, Unidad Xochimilco, Mexico City, Mexico

Mexico is a country with a complex dimension and intricate social characteristics. Less than half of working-age women participate in the job market, while men active in the job market are 82%. Then, from the whole, 60.6% of women from 3 to 29 years old are receiving a formal education, while only 44% of women have access to health services. The rate of young women who are not in employment, education, or training (NEET) is 33%, 18 points higher than the OECD average. Mexican women are four times more likely than men to be NEET. Specifically, about the UN SDG#4 that refers to Quality Education. In Mexico, six out of ten women between 15 years old and more, do not have elementary education.

Regarding UN SDG#3, corresponding to health and wellbeing, it has been estimated that less than half of women are affiliated with a health institution. Despite the progress made, gender equality in Mexico is dependent on the change in a series of structural social organizations. That is why a Mexican OWSD Chapter could provide a positive force for accelerated changes and permanent reduction in the gender gap, particularly in science and technology areas. It could also actively promote the access of more women to scientific and technological areas and gain of leadership and access to power decision positions that could analyze the social and political challenges responsible for the gender gap while introducing changes. There are other female organizations in the country, mainly concentrated in the center of our country, so this Chapter could help in the visibility of Mexican regions where the gender gap is a significant problem. Assuming as personal the OWSD goals, this Chapter could promote recognizing the scientific and technological achievements of women scientists and technologists in Mexico. Encouraging collaboration and communication among women scientists and technologists in Mexico but also with the international scientific community as a whole; Increasing access of Mexican Women to the socio-economic benefits of science and technology; promoting the participation of women scientists and technologists in the sustainable and economic development our region, and finally, increase the understanding of the role of science and technology in supporting women's development activities.

4

Beautiful Patterns, a Diversity Awarded Project

Dr. Patricia Caratozzolo[1], **Ms. Leticia Almaguer[2]**, Dr. Abel Sanchez[3]

[1]Institute for the Future of Education, Tecnologico De Monterrey, Mexico City, Mexico, [2]Tecnologico de Monterrey, Monterrey, Mexico, [3]Massachusetts Institute of Technology, Cambridge, US

A gender-oriented lifelong learning educational proposal is a viable option for girls and young women in developing countries to prosper economically and have the possibility of social mobility in the constantly changing world of the Fourth Industrial Revolution. This study analyzes an initiative that builds the foundation for gender-oriented lifelong learning in secondary and high schools in Mexico and Latin America. Lifelong learning for girls and adolescents between the ages of 13 and 18 is concerned with keeping female students engaged in learning and developing the intrinsic motivation that will make learning an integral part of their lives when they leave school . In Mexico, there is a gap of 14 PISA points in math performance among boys and girls. The problem is that their attitudes towards learning and the aspirations for their future are markedly different, and that has a significant impact on their decision to continue studying and choose their career. It is a fact that, in developing countries, women represent a small proportion in the engineering labor market. If initiatives were designed for more girls and young women to be involved in gender-oriented lifelong learning educational programs, there would be more role models in engineering fields for young women to emulate, and a "virtuous circle" would be achieved. The Beautiful Patterns project was the winner of the 2021 GEDC Diversity Awards, at the WEEF-GEDC Conference. Beautiful Patterns seeks empower girls and young women through education. It is a one-week program - taught by women to women- for learning algorithmic thinking skills and computational tools. Female engineering students from MIT and TEC de Monterrey teach girls the importance of certain values, dispositions and attitudes that will be essential to motivate them to be involved in lifelong learning in engineering, rewarding their initiative and intellectual curiosity and helping them develop self-esteem. The program consists of a 5-day training camp, where girls and young women are encouraged to set their own learning goals and reflect on what they are learning, and what they need to learn to be economically active and productive in the future and throughout their lives.

5

Innovative CEE Instructional Solutions for Industry 4.0 Skill Needs

Dr. Gale Tenen Spak[1]

[1]*NJIT (Emeritus), Newark, USA*

This presentation will focus on illustrative higher education solutions and innovations that portent new effective instructional practices for faculty to consider as the academy continues to produce an educated and upskilled Continuing Engineering Education (CEE) workforce. This workforce will be diverse, equity-mined and inclusive and will have the ability to meet Industry 4.0 needs during careers spanning 60 years.

The pandemic has necessitated a new approach to learning, regardless of the level of education. The changes brought about by moving from face-to-face to remote instruction as well as Industry 4.0 workforce imperatives have posed conceptual and logistical challenges for both students and instructors. Guidance will be offered on redesigning content and assessment, determining the most appropriate mode of instruction and engaging learners. The construct of the “60-Year Curriculum” (60YC) will be explained and used as a backdrop through which three innovative CEE instructional practices and innovative solutions in higher education will be examined.
Historically, in the workforce, learning has sometimes been considered an add-on, easy to minimize or skip. But it is now recognized that every step of an employee’s career path should include life-long learning, with time given to acquire knowledge, practice new skills, and reinforce what has been learned. Recognizing that there will always be a continuous expansion of knowledge and an evolution of engineering practices, a framework will be described for an educational pathway which allows employees to attend a class and pursue their preferred method learning. The framework includes opportunities for CEE professionals to review, enhance, and acquire those competencies that allow them to extend and strengthen their knowledge to every changing established level of accomplishment demanded by Industry 4.0’s automation and AI advances.

Another concurrent shift in higher education programming involves the 60YC construct as a grand strategy of particular relevance to new instructional practices that involve promising trends and innovations that provide opportunities for developing and improving the knowledge and engagement of learners, and their ability, when appropriate, to affect changes in practice in the workplace. Stemming from this construct, three instructional and DEI implications for faculty will be explored: (1) Alternative credentials, (2) VR/AR/MX and (3) engineering degree registered apprenticeships.

The presentation will be adapted from the content of the co-authored chapter, “Effective Instructional Practices in Continuing Engineering Education,” in the book, “Continuing Engineering Education Handbook,” edited by Chuck Baukal and due to be published in Summer 2022.

6

Industry-academia partnerships in promoting analytics skills in engineering

Hongyue Sun[1], **Sabrina Casucci**[1], **Chi Zhou**[1], **Timothy Leyh**[2], **John Coles**[3]

[1]North Campus, Buffalo, USA, [2]TCIE, Buffalo, USA, [3]ACV Auctions, Buffalo, USA

Data analytics, the process that effectively transforms a data rich environment into a decision smart one, has been gaining an interest among practitioners in a variety of fields and industries. Many universities have established programs or courses in data analytics to meet the job market demand. However, there is a gap in preparing engineering students in a good shape for analytical skills, and in ensuring smooth industry-academia collaboration. In this panel, we put together experts from industry (ACV Auctions), industry-academia connection agency (UB TCIE), and academia to discuss topics such as the needs and current gap of analytics skills, how to design a course/training project, the important strategies for a successful industry-academia collaboration, the software needed, and the challenges/pitfalls in past experiences.

7

Looking Beyond Fiddlers Green College: Social Justice in Workforce Engineering Education Pathways

Mr. Jonathan Montoya, **Dr. Forest Peterson**
[1]University of California Irvine, Irvine, USA, [2]Stanford University, Palo Alto, USA

Often, research on the efficacy of postsecondary workforce programs does not convey their impact on true social mobility. The purpose of this study is to investigate through dual ethnographies project-based Career and Technical Education (CTE) workforce pathways in Silicon Valley. This study takes a step towards better understanding what constitutes the metrics that explain functioning pathways. The authors take a point of departure from three authors: Amaral et al. (2015) found that seven PBL essentials form good learning outcomes; Creghan and Adair-Creghan (2015) then showed a measurable outcome of PBL is higher attendance, to which Plasman and Gottfried (2020), using a case of Applied STEM CTE (AS-CTE), framed attendance as a predictor of the efficacy of a workforce pathway. In conclusion, the authors uncovered early evidence that social mobility may be added as a metric to a predictive ontology framework of pathway equity.

8

Core Principles for At-Scale Learning Platform Partnerships

Dr. James Hall[2], **Carissa Little**[3], **Dr. Gale Tenen Spak**[4], **PhD. Yakut Gazi**[1]

[1]Georgia Institute of Technology, Atlanta, United States, [2]Rochester Institute of Technology, Rochester, United States, [3]Stanford Center for Professional Development, Stanford, United States, [4]New Jersey Institute of Technology, Newark, United States

On November 2, 2021, the leading practitioners of non-profit global higher education, operating large scale online academic and professional education courses gathered in Atlanta to declare the core principles in any partnerships, platform or otherwise, in designing, producing, and delivering courses and programs. This proposed session brings together the authors of the Atlanta Declaration to discuss the background and the impact of this declaration.

Mid-2021, 2U announced the acquisition of edX, creating huge shockwaves in the online and professional learning space. The leaders of higher education felt the urge to respond to this significant change in the landscape by releasing a shared declaration of our non-negotiables and core principles of our work. This is an attempt to lay out how we would like our relationships to be shaped with the vendors and platform partners, as well as a recommitment to each other as the higher education community. These core principles in the declaration include: - commitment to access and affordability - commitment to quality - commitment to the protection of our learners and faculty - commitment to the production of new knowledge - commitment to each other and collegiality This session will feature the authors of the declaration to discuss the background and process of this declaration. The speakers will also discuss the impact of the declaration since the time of its release. The full text of the declaration is available: https://pe.gatech.edu/sites/default/files/atlanta-declaration.pdf

9

Expanding Reach of AI Curriculum Through All But Credit Professional Program

Mr. Steve Haraguchi[1]

[1]*Stanford University, Stanford, USA*

In mid-2019, Stanford was unable to meet heightened demand for online graduate AI courses, with student interest reaching over 200% of existing capacity. Unable to add seats to the graduate course catalog, the team at the Stanford Center for Professional Development created a new 'all but credit' professional education program that utilized regular graduate course lecture videos and assignments, and was supported by 'Course Facilitator' industry professionals who had previously taken the course. Unlike previous MOOCs and professional programs in the space, this new offering differed in that it remained focused on advanced, theoretical content and required 120-200 hour commitments over the course of ten-weeks. At launch, the program faced two key questions: 1) Was there a large enough professional audience that wanted to complete advanced, theoretical AI curriculum? 2) Would that audience be willing to complete such a substantial commitment in a non-credit program?

To date, the answer has largely been yes - over 2,500 professionals have completed courses in the program, and over 250 have completed three courses to earn a professional certificate. Challenging traditional notions of what limits should be placed on professional education assignments, several learners have gone on to publish work created in their courses, and/or present at leading AI conference workshops. The participant demographics have included many learners with master's degrees in other STEM fields, undergraduate/graduate students outside of Stanford taking professional courses as electives to round out their curriculum, and career software engineers whose roles increasingly require deep knowledge of AI. The success of this program demonstrates a few key ideas:

- There may be an underserved professional education market seeking highly advanced, graduate-level coursework.
- That audience may be willing to take courses with such rigor in a non-credit setting, especially when provided with lower cost and enhanced flexibility.
- While the arc of online education has bent towards in-studio production and enhancements, there is still room for multi-purpose use of traditional classroom video.

These learnings may inform CEE teams looking to expand their offerings and encourage them to consider approaches, topics, and methods of production that enable new cost-effective program models.

10

The Impact of the Climate Crisis on the Mental Health of Higher Education Students: A Case Study

Ms. Celeste Ceballos[1], **Mr. Carlos Aldama-Castro**[1], **Ms. Mary Cervera-Diaz**[1], Mr. Fernando Lambarria-Gomez[1], Ms. Mariana Paez-Frias[1], Dr. Patricia Caratozzolo[2]

[1]Tecnologico de Monterrey, Mexico City, , [2]Institute for the Future of Education, Tecnologico de Monterrey, Monterrey,

Historically, the climate crisis has been viewed as a solely environmental and economic issue, with little to no regard for its effect on mental health. Only the last decade has shown an increase in the analysis of the impact said crisis has on the emotional wellbeing of people. Nevertheless, much research remains to be done in this field.

Most of the available literature analyzing society's perception of climate change utilizes qualitative tools such as interviews and polls. In general, these studies have also focused on establishing a vocabulary adequate for the exploration of this subject; terms like anxiety, climate anxiety, ecoanxiety and solastalgia have been used and discussed. For the purpose of this study, the term ecoanxiety has been chosen, signifying a psychological uneasiness caused by worrying about climate change and the deterioration of the natural environment.

The present work in progress outlines the comprehension of this subject via a qualitative poll-based study, with the sample being composed of individuals of the student community of a Higher Education Institution (HEI). The preliminary results allow the researchers to analyze the presence, as well as the effects, of ecoanxiety in the aforementioned population.

11

Penn State's First Metaverse Node: A Design4Justice Cross-field Collaboration

Mrs. Sandra Allain[1], **Mrs. Lisa Sibilia**[2]

[1]Penn State University , University Park, USA, [2]YOUTOPIAN, Sparta, USA

How might the rise of the 3D web be a historical opportunity? A virtual reality space where users can interact with a computer-generated environment and other users. What if virtual reality was a pathway to greater accessibility? In this session we will discuss how virtual reality can be used to enhance in-person and online education and foster collaboration. Sandra Allain, Professor of Practice in the School of Engineering Design, Technology and Professional Programs at Pennsylvania State University and Lisa Sibilia, Co-CEO of YOUTOPIAN, an innovation leader in custom AI XR digital transformation and Penn State alumna, will share their collaboration and journey in the project based ENGR 497 Design4Justice course offered Fall 2021 as part of the Law, Policy and Engineering initiative. In this course students were tasked to explore the use of virtual reality to close the access to civil justice gap. Integrating virtual reality to the classroom brings forth both opportunities and challenges for students, instructors, and diverse stakeholders. Join the session to learn the journey of an industry-academic partnership that enabled engineering students and law students to explore the use of human centered design principles to pioneer a virtual reality scene for Penn State Law's Family Law Clinic and Veterans and Servicemembers Legal Clinic. During this session you will discover how virtual reality can accelerate research, retention, and provide opportunities to change lives across the academic and enterprise ecosystem.

12

Trends and challenges of the current civil construction education in Brazil

Dr. Fernanda Maria Ferreira[1]

[1]*Faculty Of Technology Of São Paulo, São Paulo,*

The research was intended to study the influence of Information Technology (IT) in the Civil Construction industry, developed through literature review and quantitative research to professionals in the civil construction area remotely due to the pandemic event in Brazil. Among the results obtained, a completely renewed industry can be seen, but for some respondents this still is not a Brazilian reality. During the execution of this research, it was also possible to perceive new professional trends such as the adaptation of civil construction professionals to new information technologies, aligned with the challenges of sustainability and environmental certifications, as in any other industrial segment we have our share of responsibility for the impact on the planet. Finally, the reality of remote teaching was analyzed, another new trend that has become another requirement for construction professionals, requiring digital skills due to the recent pandemic. Projects, budgets, schedules, various plans and meetings can be carried out remotely, which will soon become a requirement for young professionals entering the job market, therefore, facing a greater competition.

13

Preliminary research report into the nature of Engineering Learning Curricula and their embeddedness in Engineering Active Sustainable Practice (EASP)

Mr. Errol Ia Grange[2], **Mr. Anthony (Tony) Smith**[1], **Dr. Alfredo Soeiro**[3]

[1]University of Tasmania and IACEE, Launceston, Australia , [2]Cahoot Learning, Melbourne, Australia, [3]University of Porto, Porto, Portugal

Research Aim
To qualitatively research and investigate the extent to which and how Engineering Learning Curricula (ELC) incorporate and embed sustainability as central to the work of all engineers, be it in planning, practice or policy, within both the private and public sectors.

Research Focus
This research will reference sustainability by way of the UN 17 Goals and Fundamental Human Needs as a basis to scrutinize active teaching and learning content and practice as being core to engineering educational initiatives as described within a particular institution's engineering core curriculum.

IACEE's engineering academic member organizations, its member's institutions and other engineering institutions outside of the IACEE will be incorporated into this project. Initially this will be via the institution's external websites and for the purpose of an initial research paper to be delivered at the Buffalo Conference in June. The research will then continue in more detail after the conference.

The objectives of the research are to:

1. Identify curricula that are delivered to/undertaken by engineering students
2. Identify possible gaps within curricula activity
3. Examine the factors that enhance and inhibit use of sustainable structured curricula and learning thereof, so as to meet the needs of engineers post degree/diploma active practice.
4. Prepare three case studies of good practice in the use of structured sustainable engineering to meet the needs of learners.
5. In the long term to investigate the roles that regional industry, government and engineering learning providers are and how they can best play in meeting teaching/training needs of future and practicing engineers.
6. Utilize SERinA as a data base of examples of sound practice, both within degree/diploma courses and on-going engineering education.

Outcomes
Buffalo Conference paper with case study report findings which will be of use to and assist IACEE institutions and members. In the longer term this is to be of use to other institutions, corporate and government policy development, together with ongoing IACEE members and CEE providers, utilizing SERinA as a database of best practices.

14

Research on Neurodiverse Learning: A Pathway to Diversity in Engineering Education

Dr. Rachel Bonnette[1], **Dr. Sam Abramovich**, Dr. Adrienne Decker, Dr. Gregory Fabiano

[1]*University at Buffalo, North Campus, Buffalo, USA*

Underrepresentation in Engineering is a problem that requires an intersectional perspective to address, considering the many attributes that have additive and multiplicative effects. A key example is neurodiversity (i.e., the range of neurological differences across people, including conditions like autism and ADHD). In the United States, neurodiversity diagnoses can be variable, likely due to differences in early measures of achievement that are cultural expectations and access to resources, such as support services, testing, and psychologists. Anyone can be neurodiverse, and many of the groups that are most likely to struggle in Engineering programs and places of employment are those most likely to go without diagnosis and, therefore, without services. At the same time, neurodivergent youth, in particular those with autism, are both more likely to be interested in STEM programs than other fields, and bring with them valuable assets to Engineering, like systematic thinking and creativity. The result is that programs that are designed for neurotypical students often fail to meet the needs of neurodiverse students, resulting in considerable drop-out rates from Engineering programs and higher education. For this presentation, we consider the intersectional implications of students' neurodiversity in concert with other important factors to determine a more complete conceptualization of student needs and the corresponding considerations in building inclusive programs. We first present a literature review, which examines the ethical underpinnings of research on neurodiversity, including theories that can be applied (e.g., Universal Design for Learning, interdisciplinarity, and participatory design). Then we present existing findings on effective practices that could be used to support instructor ability to meet neurodiverse student needs (e.g., strengths-based approaches, professional development, research on classroom and online learning environments). We conclude with a discussion of implications for ongoing research and specifically share early experiences from a participatory design study for professional development for faculty who need training to support the needs of their neurodiverse students in Computer Science.

15

LEED environmental certification and the sustainable construction - case study Japan House São Paulo

Sra. Jacira F. S. Rosa[1], Dra. Fernanda Maria P. F. Ferreira[1]

[1]*Fatec - Faculdade de Tecnologia de São Paulo, São Paulo, Brazil*

Currently, there is great concern about the sustainable future of ecosystems and future generations, as well as the impact caused by human interference in the environment. In the various sectors of activities, the search for sustainable development revealed the need to implement mechanisms that encourage the rational use of resources and the definition of urgent measures to reduce these environmental impacts.

In this context, the construction industry is a prominent topic, as it consumes a large portion of natural resources, in addition to being a major generator of waste and high emissions of pollutants. In this way, environmental certifications for buildings emerge as a tool for the insertion of sustainable practices in civil construction, with the objective of implementing environmentally responsible design and construction practices and acting in the various stages of the process of sustainable construction. In the 1990s, the LEED “Leadership in Energy and Environmental Design” environmental certification for buildings appears in the United States of America, applied by the USGBC “USA Green Building Council”, with international operations. In 2007 the certification is implemented in Brazil through GBC Brazil “Green Building Council Brazil”.

Therefore, this article presents a discussion about some of the benefits of implementing LEED international environmental certification in Brazil, as well as reflecting on the importance of certification, its systems, and procedures to ensure the compliance of construction with sustainability goals. The general objective is the analysis of the main characteristics of a sustainable construction, through the case study of the commercial enterprise Japan House, located in the city of São Paulo, and designed by the architect Kengo Kuma, who obtained the maximum certification - the LEED Platinum.

The LEED environmental certification, its description, theoretical concept, certification process, and structure were essential for the understanding and further analysis of the case study. Through the analysis of the environmental certification of the enterprise, it was possible to verify how it is possible for a pre-existing building to achieve a performance of 92% in the transport category, high energy performance of 95% and a high performance in the waste category, notably higher than the global average, achieving total points and a performance of 96%, which guaranteed the project the maximum LEED Platinum certification, making it a sustainable construction at its highest level.
Keywords: Environment, Sustainable Development, Sustainable Architecture, LEED

16

University-Industry collaboration advances construction methodology: How academic research informs professional program design which in turn advances research

Mrs. Ronie Shilo[1]

[1]*Stanford University, Stanford,*

Virtual Design and Construction (VDC), which uses multidisciplinary digital models to create a virtual project prior to construction, facilitates better project planning and management, including improving scheduling, budget, and cost estimations. VDC was first introduced as a concept by Stanford Professor Martin Fischer, Director of the Center for Integrated Facility Engineering at Stanford.

The framework was developed through studying real construction projects and industry practices and analyzing project cost and outcomes where VDC was used. As VDC methodology developed, it has been taught to professionals in small groups in various companies and contexts.

Starting in 2019 a new model for teaching (and studying) VDC was launched. Since then, this pedagogical model made it possible to teach VDC methodology to over 600 professionals globally, through a deep partnership with participating companies and universities in Peru, Norway, and Switzerland. The resulting professional education program, delivered by the Stanford Center for Professional Development and collaborating universities Norwegian University of Science and Technology (NTNU), the University of Lima, and Swiss University of Applied Sciences and Arts (FHNW) is unique and innovative in a number of ways:

a) It includes a train-the-trainer component whereby Stanford faculty work with local practitioners experienced in VDC methodology to teach them how to deliver the program.
b) It includes a deep and extensive application component whereby as part of the 10-month program each participant worked to apply the VDC methodology to a construction project they were leading, and report back to their peers, and mentors.
c) Due to the deep collaboration with the local mentors and universities the program design, while fairly uniform across the different geographies, heavily emphasizes local construction projects and examples, thus making the learning very concrete and contextualized to the local dimensions of each program location.
d) Due to the scale of the program, it provides participants with an opportunity to form an extensive network of peers learning and applying VDC, and thus create an impetus to transform the local construction industries.
e) The program has informed further research on the topic. The data shared by participants, quantifying the impact of VDC on their own construction projects, helps Stanford faculty and PhD students understand the leading edge of the industry globally and improve VDC methodology and its application to new kinds of projects and roles.

This presentation will explore the academy/industry collaboration exemplified in this program and the way it has informed future research.

17

Human Resource Development for Young Researchers through International Science Collaborations

PhD. Tetsuo Oka[1]

[1]Shibaura Institute Of Technology, Saitama, Japan

As a forefront of science, the superconductivity is regarded as one of the most developed and promising researches and developments. Based on this technique, so-called “Mag-Lev” railway is to be established from Tokyo to Nagoya in Japan in near future less than a decade later. To nurture young researchers as future leaders in this science area, a project has been conducted through the international network with respect to the extreme technologies such as large current, intense magnetic field and super-high pressure, which were the factors the superconductivity based on. The project has been conducted for three years with an assistance of Japanese government, and three young researchers have stayed at European partner institutes, and resultantly published four collaborative research papers. The activity of international search networks has the effect enough to breed leadership of young researchers.

18

Developing Digital Capabilities to Catalyze Digital Transformation: A Case Study

Ms. Chunmei Zhao[1], **Ms. Anastasia Tavkhelidze**[1], Ms. Ronie Shilo[1]

[1]*Stanford University, Stanford, USA*

Digital technologies have impacted all walks of life and provide substantial new opportunities for companies to create and capture new value. To remain competitive over time, organizations need to "crack the code" of digital transformation.

One of the major roadblocks for organizations to accelerate digital transformation lies in the gap in digital mindsets and skillsets among their talent. Over the past few years, more and more companies see upskilling its workforce to elevate its digital capabilities as a critical pathway to achieving business success in the digital era we are living in. It is no longer something "nice to have," but a business imperative.

This presentation will take a close look at a professional education program, used as a lever to catalyze digital transformation within a large telecommunication company in the gulf region ("Company X"). Designed and delivered by the Stanford Center for Professional Development ("SCPD"), the program brought together a group of 50 middle managers who are from a diverse set of cross-functional units in the company, half are technologists and engineers and half in business and operational roles.

The program was delivered fully online from August to November 2021, incorporating multiple modalities including live virtual workshops, asynchronous self-paced courses curated from the Stanford Online catalogue, discussion sessions led by Stanford facilitators, and capstone project work and team presentation. The company is funding a selected few of the program capstone projects and tracking their implementation and results. The multi-modal approach enables dynamic interactions between Company X managers and Stanford faculty and while spurring multiple learning communities within the company. The program also takes a holistic approach by not only focusing on technological knowledge but also on people, process, innovation culture and practices, and keen on translating business and customer needs into technology solutions. The program was well received, with an overall rating of 5.61 out of the top score of 6.

This presentation will examine the content, delivery modalities, and pedagogical practices that bring this program to life. It will also examine the post-program impacts on daily business practices at Company X. In addition, building on this pilot work, Company X and SCPD are working closely to develop additional programs to provide more in-depth training to further support Company X's newly developed digital strategy and initiatives.

19

ISummerMX: An Intensive, highly immersive and itinerant experience to prepare global engineers.

PhD. David Huerta[1], **Ms Patricia Montaño**[1]

[1]*Tecnologico de Monterrey, Monterrey, Mexico*

For years international offices in higher education institutions have fostered student mobility by strengthening partnerships with universities abroad. However, to address the needs of a new generation of students and assist them in a broader understanding of the global and new technological challenges, international areas can play a more strategic and collaborative role. Along with faculty and industry actors, such offices can participate in reshaping the learning spaces where students can advance their technical competencies and develop the soft skills required to venture as young professionals in the global industry.

The presentation will showcase the journey of designing, planning and successfully implementing the innovative Aeronautic Industry Program created for international undergraduate engineering students, as part of an ambitious Tecnológico de Monterrey's wider initiative to rethink education, increasing flexibility as to how, when and where learning happens. Based on challenges and with a flexible structure, the program combines rich academic content with a memorable practical experience that exposes students to industry, preparing them to work collaboratively and efficiently in multicultural teams.

During the session, the strategic, administrative and operational imperatives associated with the development of the program will be discussed. By focusing on the process that led to the identification, generation and delivery of new forms of value participants will be encouraged to reflect on new ways to make international education for engineering students more desirable and effective.

20

“Developing More Innovative and Effective Leaders Through Design Thinking”

Mr. Michael Testani[1], Dr. Kailas Patil[2]

[1]Binghamton University, Vestal, USA, [2]Vishwakarma University, Pune, India

The world is becoming increasingly more complex as technology is advancing at a record pace giving rise to both new challenges and exciting opportunities for virtually every individual and all organizations across the globe. New technologies are dramatically changing our world at a rapid rate; which can significantly improve our standard of living; however, these advancements often result in very complex human-system interactions. Products and services should take fully advantage of these leading technologies to stay competitive while always considering the importance of the human-system relationship. Design Thinking provides a means to improve these relationships. Design Thinking is the convergence of people, business and technology that follows an innovative problem-solving framework used by thought-diverse teams to take on complex, real-world challenges to bring about signature experiences for customers and end-users. Design Thinking is a human-centered approach to innovation that creates a better future, and it has proven successful for several decades. Design Thinking has shown to be very effective at solving very complex human-centered problems. There are many benefits derived from Design Thinking, and it is being widely adopted by leading product and service providers around the globe spanning across both industry and academia. This paper and presentation will focus on the applications and benefits of Design Thinking in developing future leaders of innovation while drawing upon case studies from a cross-cultural collaboration between Binghamton University and Vishwakarma University who run a joint Center of Excellence in Design Thinking and Innovation.

21

National CEE register in Ukraine

PhD. Mykola Kiryukhin[1]

[1]Union Of Scientific And Engineering Associations Of Ukraine, Kyiv, Ukraine

Ukraine has good reputation in the world as engineering country (e.g., the largest aircraft Antonov-Mriya or components for US and European space launchers). The same time the level of qualification of individual Ukrainian engineer is terra incognita for his Western colleagues.

The objective of this article is to present the results of 10+ year activities of Union of scientific and engineering associations of Ukraine (USEAU) for implementation of Western standards for engineers in our country. The set of 50+ technical universities in Ukraine almost stopped their implementation of the Western education system on higher education stage. Continuing engineering education (CEE), which was one of the pillars for good Ukrainian engineering in Soviet Union period practically disappeared in the last 30 years.

USEAU, which is the oldest technical federation in the country created by Dmitry Mendeleyev 150+ years ago, made the decision to renew CEE in modern format. We started from application of the "methodology" of the successful case of creation of US STEM Coalition for the local conditions. Namely the Alliance "Engineers for Ukraine" (E4U) was established, and twelve top politicians (parliament members, former ministers, etc.), who got engineering diplomas in 70th, became the "lobbyists" of new initiative. It has four key principals:

- Each industrial sector has its own regulations with min public influence (limited by framework only);
- Companies from appropriate industrial sector are the initiators of certain CEE;
- CEE is applicable for the engineer, who has certain practical experience (min 3 years) and master's or bachelor's degree from university, which program was included into FEANI European Engineering Education Database;
- Leading technical university in cooperation with technical federation organizes the training and exam correspondingly.

The initiative is only on the initial stage and covers aerospace, automotive, machinery and metallurgy.

There are two novelties in proposed scheme:

a) It is planned to have multilevel training, which means covering all categories of engineers: from young graduate to technical director. And it is evident that training procedure should be different for different groups. One can image 3D scheme of proposed system as pyramid (in the axes: (i) quantity of certain category of engineers; (ii) qualification level; (iii) industrial sector);

b) National e-Register, which gathers and saves information about all trainings and related issues, like professional awards, etc. for specific engineer during all his/her working period (in prospective).

Independent evaluation of Ukrainian proposals is welcomed.

22

Assessing the informal Engineering Management Curriculum

Dr. Cecilia Martinez Leon[1]

[1]*North Campus, Buffalo, United States*

Academic undergraduate programs are designed to equip students with the “ability” to “employ” their engineering knowledge in their professional field. The question here is, how can higher institutions evaluate the effectiveness of their academic curricula in terms of employability? Employability is a multi-dimensional factor that must be adjusted to the demands of the industry requirements. Still, at the individual level, employability involves technical and soft skill sets in an era of Industry 4.0. The technical component is typically assessed in the immediate term and while students are still in their academic programs. However, soft (or people) skills are more challenging to measure. There is a lack of consensus on what skills fall within the soft side of employability, but these skills seem to continue to build up after graduation. This paper presents an approach to measuring the effectiveness of the overall academic experience in terms of employability. We looked at the career progression and job satisfaction of our Engineering and Management (E&M) alumni as our response variable. As an independent variable, rather than focusing on the technical aspect of our engineering program, we used the “informal” curriculum, i.e., extracurricular activities such as internships, co-ops, engineering team competitions, participation in leadership positions of student organizations, and study abroad, sports teams. The importance of these extracurricular activities has been recognized in some academic programs by making them graduation requirements. Still, it is unclear to what extent these extracurricular activities contribute to the development of employability skills that ultimately allow the application of the technical engineering skills of recent graduates. In this study, we conducted an alumni survey to assess the impact of extracurricular activities on E&M graduates. Based on the insights gained from the survey analysis, we present recommendations and areas for future research for enhancing the E&M curriculum.

23

10 years of IACEE Quality Program for Continuing Education: How have the Continuing Engineering Education Organizations Changed?

Dr. Soma Chakrabarti[1]

[1]*ANSYS, Inc., Canonsburg, USA*

This facilitated discussion forum presenters will be comprised of the original and some later users of the IACEE Quality Program for Continuing Education to revisit the Quality Program and its applicability in quality management for organizational excellence of continuing engineering education units.

A little more than 10 years ago, the IACEE Quality Program for Continuing Education booklet was released. Originated as the Development of Accreditation in Engineering Education and Training (DAETE) project, it was developed over five years with IACEE support and external funding through the U.S. Department of Education and the European Commission grants. The Program's standard is based on the European Foundation for Quality Management (EFQM) Excellence Model, adapted for applicability to CPD and Continuing Education (CE) organizations. Many universities participated in the process of implementing the model, self-assessing based on the criteria and shown marked improvement in performance and organizational excellence.

However, in the last 10 years and specifically in the last two years, many changes have taken place in the higher education sector. Continuing education units are no exceptions. In the light of these changes, is the Quality Program still valid for measuring and improving organizational excellence? Does it need some changes, too? Do we need to incorporate any criterion for the effect of digitalization? Do we need to put more emphasis on societal impact?

This hour-long session will be divided into three parts: (1) introduction to quality program; (2) changes in continuing engineering education sector in the last 10 years; (3) discussion on what changes we need to bring into the quality program assessment criteria and process. At the end of the session, the attendees will be able to deliver a concrete step towards making these changes in the program that will be more suitable for quality management of today's organizations.

24

Building a Training System for Future Leaders in Science, Technology and Business

PhD. Fan Jia[1]

[1]Sinopec Human Resource Department, Beijing,

Sinopec is the largest oil and petrochemical products supplier and the second largest oil and gas producer in China, the largest refining company and the second largest chemical company in the world. It has ranked the top five on Fortune's Global 500 List for ten consecutive years. Sinopec is committed to leading the development of the energy and chemical industry with innovation, taking young talents as a new force to build a world leading clean energy and chemical company, and creating conditions for the all-round development of young talents. Sinopec vigorously implements the "Zhaoyang (Morning Suns) Program" for 150,000 young talents. The program takes serving the enterprise development strategy as the goal, strengthening the career planning of new college graduates as the starting point, and continuously improving the growth potential of young talents as the core. The training program has been organized as an organic project building a university-company cooperative training system of early-stage training, following-up training and whole-process training. It has carried out beneficial exploration and practice in talent training mode innovation, production, knowledge and research coordination, and training operation management optimization. This has played an important role in cultivating a pool of future leaders in scientific, technological and business innovation, catalyzing a number of strategic and forward-looking key core technologies, and forming a number of new models of talent training.

25

Let's expand the acceptance of competency-based credentialing to fill workforce gaps

Ms. Amy Moore[1]

[1]*SUNY Buffalo, Amherst, United States*

This international panel will discuss industry-relevant credentials harmonious with in demand job skills. We will investigate the expansion of the fast-growing, flexible, learning opportunities that are helping fill skills gaps within the workforce and becoming more widely-adopted across the globe. Micro-, competency- based credentials are weaving their way into higher education and our expert panel will provide insight into utilizing these non-traditional degree programs to maximize learner potential and fill skill gaps for working professionals.

In order for continued advancement in the field of micro-credentials, we must understand the needs of industry, how they perceive competency-based credentials, and explore the measurements used to assess competency that are, in fact, delivering successful job performance.

This panel will include a range of perspectives, including, but not limited to, human resources, healthcare, business, energy, and information technology.

26

SUNY Online Degrees at Scale: Building Programmatic Pathways for Adult, Online Learners at Scale

Ms. Kim Scalzo[1], **Dr. Chuck Spuches**[2]

[1]SUNY System Administration, Albany, United States, [2]SUNY System Administration, Albany, USA

Three years ago, SUNY joined the "affordable degrees at scale" movement by launching SUNY Online Degrees at Scale (SO DaS), a system wide initiative designed to showcase SUNY's programmatic strengths and bring a targeted set of online programs from SUNY campuses to scale. SO DaS programs include both credit and non-credit programs and are intentionally structured into career pathways providing entry points for upskilling, continuing education, and career changes for post-traditional learners at the associate, bachelor's, and master's levels. Support for this initiative is provided by a team structured like an Online Program Manager within SUNY System Administration and includes program development and selection based on established criteria for quality and scale, digital advertising campaigns, admissions coaching for prospective students, success coaching for enrolled students, change management support for campus leaders, and course and instructional design support for faculty. This session will provide an overview of the original goals and pilot plan for the initiative, the range of financial models considered to enable re-investment and sustainability, current status and future plans. Specific details will be shared in four key areas, including strategies for program development, investments in marketing and recruitment, a wide range of partnership opportunities, and student and faculty supports provided to ensure that as we scale we do so with quality. Assessment has been an important part of this initiative and information will also be provided on the ways in which data are used to assess every aspect of the initiative and drive continuous improvement with the ultimate goal to drive new enrollments to SUNY campuses.

27

Creating Learning Environments to Expand Access and Student Engagement

Dr. Lisa Stephens[1]

[1]*University at Buffalo, Buffalo, US*

Campus faculty and staff are frequently called upon to provide context and advice when classroom facilities are designed or renovated. Several years ago, SUNY launched FLEXspace: the Flexible Learning Environments eXchange which has evolved into a respected, well-adopted community of practice and open educational resource/repository. Recently, EDUCAUSE made an investment in this community-driven portal to integrate the Learning Space Rating System (LSRS), a quantitative measure of active learning potential within learning spaces, including metrics for inclusion.

The FLEXspace Learningspace Integrated Planning Pathway (FLIPP) helps senior leadership make investment decisions by engaging faculty, AV/IT technologists, librarians, instructional designers and facilities planners to assist in making collective recommendations when tasked with advising/planning new facilities.

This presentation describes the FLIPP pathway which has proven successful at multiple colleges, universities and K-12 environments. The goal is to empower advisory groups with diverse perspectives and expertise to follow a step-by-step process that creates internal group alignment prior to meeting with external contractors and consultants. This alignment results from adopting and prioritizing core pedagogical values within budgetary constraints, including definition of acceptable alternatives when preferred solutions are potentially limited by resource or environmental constraints. Participants will leave with knowledge of how to navigate these freely available tools (FLEXspace and LSRS - including the new section on inclusive environments), and how to adopt and guide these efforts on campus.

28

Awareness of Assistive Technology Impact Students with Disabilities' Success at the College Level

Mr. Humberto Hernandez[1]

[1]D'Youville University, Buffalo, Erie

This paper was developed to investigate the impact of assistive technology in the students with disabilities' success within the context of college academia. The principal argument of this writing suggests that the lack of awareness of assistive technology by professors creates barriers that violate the rights of the individual with a disability under U.S. law. Several theories were explored that were relevant to learning and human development. Research methodology for this paper presented a comprehensive survey from the National Survey of Student Engagement. This assessment tool measured quantitative outcomes in college students-with-disabilities engagement. Key findings revealed strong connections to theories within the literature review and evidence of the impact that the lack of knowledge and awareness of assistive technology have in students with disabilities' success at the college level. Concluded remarks synthesized the overall findings linking assistive technology, class engagement theories, students with disabilities and instructors' awareness. Recommendations collectively expressed further research on this topic, application of the findings for institutional effectiveness, and encouragement of diverse, supportive, egalitarian, and equitable college environments.

29

Creating Lasting Economic Impact and Promoting Gender Equity in Africa Through Online Education

Dr. Kristin Palmer[1]

[1]*Winrock International, Bend, United States*

The African Scholarship Cohort (ASC) is an online educational outreach program designed on the Community of Inquiry (CoI) framework. ASC has provided over 37,000 scholarships to learners in every country in Africa. Learners are supported by 100 regional mentors and a robust community on WhatsApp. To date, courses have been primarily in business strategy, project management, and design thinking. This program has been running for the past six years with over 40 courses offered. Six books have been published on the program design, outcomes, and showcasing student work.

The ASC has provided lasting economic impact with participants creating and growing small and medium sized businesses. ASC has focused on providing extra support for women through a Women Entrepreneurs special interest group.

Why is it important to support learning in Africa, create economic impact, and promote gender equity? According to the United Nations, it is estimated that 42% of the youth population (< 25 years) of the world will be in Africa by 2030. If we aspire to meet the United Nations Sustainable Development Goals, we would be wise to support the youth population in Africa.

ASC is built on a backbone of the CoI framework. CoI has three components: teaching presence, cognitive presence, and social presence. Teaching presence (instructors connecting with students) is provided through mentors and the instructors in the online courses. Cognitive presence (course materials) is provided through online courses hosted on the Coursera platform. Social presence (sense of community and belonging) is provided through WhatsApp and in-person events.

This presentation will walk through the design of the program, outcomes, and recommendations for others looking to build supportive, engaging, online courses. These recommendations can be utilized for any type of content including engineering.

30

Designing New Engineering Course Curriculum for Teaching Sustainability

Dr. Tamer Atabarut[1], Prof. Dr. C. Ruhi Kaykayoglu

[1]*Bogazici University, Istanbul, Turkey*

The purpose of this study is to evaluate the university secondary data (information published on the university websites, program catalogues and brochures) to understand the current status of Turkish universities regarding the integration of sustainability in engineering education. A text mining methodology is used to gather information from different online and printed material. Obtained information and data indicate that the universities are considering sustainability seriously with both internal and external stakeholders of universities working towards embedding sustainability in engineering curricula. The curriculum applied in different universities will be compared among each other and also with available ones in different countries. Their highlights and gaps will be analyzed concerning the needs of the learners and the sectors. According to the findings of this study, recommendations for the existing curriculum will be done. Furthermore, a new course will be designed both for degree programs and for the continuing engineering education.

31

LOOKING BEYOND FIDDLERS GREEN COLLEGE: SOCIAL JUSTICE IN WORKFORCE ENGINEERING EDUCATION PATHWAYS

Ryan Lundell[1], **Mr. Jonathan Montoya**[2]

[1]Santa Clara University , Santa Clara , US, [2]University of California Irvine , Irvine, US

Too often, research into postsecondary workforce and engineering education focuses solely on curricula and ignores student matriculation to high-skill high-wage careers. The purpose of this study is to investigate this subject through dual ethnographies in Project-Based Learning (PBL) Career and Technical Education (CTE) workforce pathways in Silicon Valley. This study looks to better explain functioning pathways. The authors take inspiration from three publications: past research found that seven PBL essentials form good learning outcomes [1]; a measurable outcome of PBL is higher attendance [2]; to which Applied STEM CTE (AS-CTE) [3] framed attendance as a predictor metric of the efficacy of a workforce pathway. We ask which metrics help explain successful workforce CTE pathways. Our ethnography uncovers two distinct postsecondary PBL pathways and explores a new predictive metric of social mobility, which helps to reveal the pathways' struggle to support marginalized students' mobility into the high-skill high-wage building workforce. Despite these challenges, a Labor-Union-administered apprenticeship pathway showed promise in aiding social mobility. The authors uncovered early evidence that social mobility may be added as a metric to a predictive ontology framework of pathway success.
Keywords: Social mobility, Engineering education, Workforce pathways, Equity, Virtual design and construction

32

Embed Novice Programming and Web Source Code with Self Direct Learning Design: An Imperative Education

Dr. Alireza Ebrahimi[1]

[1]SUNY Old Westbury , Old Westbury, United States

It is important to embed novice programming concepts and web source code with self-directed learning design as an imperative education. AI (Artificial Intelligence) and the web will dominate technology and will change every aspect of teaching and learning. A plan with visualization is used with self-directed learning design to achieve this goal of learning. The visualization is used in the highest level in human mindset toward the lowest (deep) level of machine with bit code. The visualization of the levels is shown in 5 layers.

Human interaction deals with a memory at a time. A software application installed and operated visualized the familiarity of starting the process. In level 3 a programming language is used to declare a variable and store a value as weather digits (number), or name, although every entry is simply an integer agreement that represents a character and from there the conversion will take place. In assembly code a register is a common location to hold a value and wait until it is changed. machine code will take a direct one to one translation and present it into addresses with opcodes and operands. Finally in the lowest level in the control unit things are automated as supposed to be and interpret the incoming code with a bus and direct it to the action and storage. A sequence with begin and end shows the control flow. A decision-making act on its Boolean condition of true or false to take a truth sequence with its own begin and end or an alternative else with its own begin and end as it is visualized as two-dimensional pathways. A repetition or loop returns a cycle to a point of desire with its specified number of durations. repeat could be fixed, n ways, until a condition has been met or an exhaustive end of file marker or infinite forever.

In self-directed learning design, every concept is shown by a plan that can be visualized and a visual object is used to present the plan and integrate the plans to form a program and solve a problem. An educator can justify the programming materials in an attractive way to create interest and motivation. There is no doubt that programming is ubiquitous learning. Course design should focus on important aspects of programming such as memory and user interaction, decision making, and repetition. A self-learner can focus on concepts and break them down further.

33

SUNY Community College Presidents Plenary

Allison Newman

The community colleges of the State University of New York (SUNY) are national leaders in providing foundational education for prospective engineers – and lifelong learning for those seeking to add new skills and/or competencies throughout their careers.

To meet the needs of the microelectronics industry, SUNY's community colleges integrate agility and flexibility into workforce development coursework and programming. Staff constantly monitor emerging trends, invest resources, and adapt programs and delivery to ensure students receive instruction that prepares them for entry into, or progression through, their careers. Campuses prioritize faculty development, support and research to ensure sustainable, scalable workforce training across the System.

For this plenary panel, SUNY representatives will discuss best practices in meeting the needs of both engineers and the microelectronics industry. The panel will be moderated by Johanna Duncan-Poitier, SUNY's Senior Vice Chancellor for Community Colleges and the Education Pipeline, and participants will include Dr. DeAnna Burt-Nanna*, President of Monroe Community College; Dr. Roger Ramsammy*, President of Hudson Valley Community College; and Dr. Randall VanWagoner*, President of Mohawk Valley Community College.

34

Developing the enterprise educators' mindset to change the teaching methodology: the case of Creating Entrepreneurial Outcomes (CEO) Program

Zhang Jing, **Alison Price**
[1]Enterprise Evolution, ,

The ‘Creating Entrepreneurial Outcomes’ (CEO) Program is the very first UK–China co-created educator training program designed to address China’s enterprise education needs by drawing upon the recent traditions of European and UK enterprise education practice. The paper outlines the range of foundational educational and entrepreneurial concepts that have influenced the design of the CEO program. The objective of the CEO program is to develop the educators’ mindset and teaching methodology, which for many in China is a significant paradigm shift from traditional content-centered teaching to student-centered learning. It seeks to combine good practice from a wide range of subject disciplines to support the needs of enterprise educators as they seek to deliver on the complex challenge of transferring knowledge, building skills and developing learner confidence in their practice. This co-created approach resulted in the development of the ‘CEO Canvas’ as the user-focused approach underpinning approach for the enterprise education curriculum design which has proved valid with over 3000 educators, despite the differences in the policy focus and profiles of the delegates.

36

Seeding Sustainability in Education and Beyond - Plenary

John Atkinson

Seeding Sustainability in Education and Beyond unites a panel of experts who pragmatically engage students and the broader population in adoption of sustainability practices.

Following brief contextual introductions and comments, each panel member will use a storytelling framework to focus upon and describe a key question emanating from their teaching, research and practice.

For example: how might we break the “image” problem of sustainability still being connected to "granola and Birkenstocks"? How is empathy key to adopting long-haul sustainable practices? How might communities inequitably impacted by environmental injustice be empowered? What are the practices that will help institutions, communities and ultimately countries and the globe reach stated carbon reduction goals?

37

A Critical Skill for a Dynamic World - Plenary

Mr. Paul Marca

Innovation has become both a critical mindset and tool for leaders and organizations around the globe. It has also become so ubiquitous as to have lost its meaning. This panel brings together innovation experts, all of whom are in the education space from around the globe who are using innovative practices to energize their companies. Panelists will share their insights on how innovation is happening in their businesses and why innovation remains a valuable tool to reinvent and reinvigorate.

38

Cultivating a culture of entrepreneurship and innovation in engineering education - an opportunity to engage alumni and industry partners

Ms. Hadar Borden

This panel will introduce two initiatives – design challenges and innovation sprints that support the cultivation of entrepreneurship and innovation in engineering education. It will discuss opportunities to engage internal and external organizations to enhance programming and increase opportunities for students, as well as industry partnerships. In this panel, the audience will walk away with a better understanding of two different programs to implement, how to leverage external resources, how to afford students to learn beyond the classroom with ecosystem partners, and how to incorporate Library resources.

Key Takeaways:
• Focus on internal and external resources: understanding how to leverage initiatives in support of programs and intended outcomes
• How to engage alumni and industry experts
• How to align the program in support of sponsorship goals
• Virtual program execution

PAPERS

PENN STATE'S FIRST METAVERSE NODE: A DESIGN4JUSTICE CROSS-FIELD COLLABORATION

Allain, Sandra[1], Sibilia, Lisa[2]

[1]Pennsylvania State University (UNITED STATES)
[2]YOUTOPIAN (UNITED STATES)

Abstract

How might the rise of the 3D web be a historical opportunity? A virtual reality space where users can interact with a computer-generated environment and other users. What if virtual reality was a pathway to greater accessibility? In this paper we will discuss how virtual reality can be used to enhance in-person and online education and foster collaboration. Sandra Allain, Professor of Practice in the School of Engineering Design, Technology and Professional Programs at Pennsylvania State University and Lisa Sibilia, Co-CEO of YOUTOPIAN, an innovation leader in custom AI XR digital transformation and Penn State alumna, will share their collaboration and journey in the project based ENGR 497 Design4Justice course offered Fall 2021 as part of the Law, Policy, and Engineering initiative. In this course students were tasked to explore the use of virtual reality to close the access to civil justice gap. Integrating virtual reality to the classroom brings forth both opportunities and challenges for students, instructors, and diverse stakeholders. In this best practice paper, the authors will share the journey of an industry-academic partnership that enabled engineering students and law students to explore the use of human centered design principles to pioneer a virtual reality scene for Penn State Law's Family Law Clinic and Veterans and Servicemembers Legal Clinic. You will learn how virtual reality can provide opportunities to innovate and change lives across the academic and enterprise ecosystem.

SDG 16: Peace, Justice, and Strong Institutions to promote the rule of law at the national and international levels, ensure equal access to justice for all, and achieve just, peaceful, and inclusive societies.

Keywords: Innovation, technology, virtual reality, experiential learning, engineering education, legal education, access to civil justice.

1 DEVELOPMENT OF THE DESIGN4JUSTICE COURSE

1.1 Background

The course Design4Justice was developed as an elective course for the professional Master of Engineering degree in Engineering, Law, and Policy (MELP) at Pennsylvania State University (Penn State). MELP cultivates the next generation of scientists, technologists, and engineers versed and fluent in science and technology policy, public interest technology, and the regulatory and policy frameworks of emerging technologies. This graduate degree is the first curriculum offering of the Law, Policy, and Engineering initiative (LPE), a collaborative effort between the College of Engineering, the School of International Affairs, and Penn State Law at University Park. LPE provides transformative educational experiences for students by actively integrating components of all three disciplines into the curriculum and exposing students to research and outreach projects that address complex societal challenges where an interdisciplinary approach is required [1]. The LPE initiative has over twenty affiliated faculty across five colleges and is administratively housed within the College of Engineering's School of Engineering Design, Technology, and Professional Programs (SEDTAPP).

Design4Justice was taught during Spring and Fall 2021 at Penn State, a time when Covid-19 was still prevalent. Penn State during this time was transitioning from a fully online synchronous teaching format in Spring back to in-person teaching with mandatory use of masks in the classroom that Fall. Covid's forced reality, including restrictions on gatherings and other safety requirements, brought forth many changes to the teaching experience for both students and instructors. A mandatory shift from face-to-face coursework to remote online learning in a matter of weeks demanded rapidly transforming current teaching practices and content, sometimes with no prior online education experience. New challenges surfaced and expanded from overcoming Zoom fatigue and lack of student participation to broadband issues that led students to turn off their camera, resulting in instructors facing a screen with a collection of student's photographs to teach.

An independent study commissioned by The National Survey on the State of Online STEM Education published by Bay View Analytics in 2021 collected data in October 2020 from 896 STEM faculty teaching at the graduate and undergraduate level. The study found that the most serious barrier to successfully implementing online STEM education, as reported by respondents, is a perceived lack of student motivation to engage with online coursework [2]. Certainly, student engagement was a challenge for many instructors thus becoming an opportunity to explore innovative technologies to drive technology-enhanced active student engagement in remote learning.

1.2 Design & Development

The course Design4Justice was developed by Sandra Allain, Professor of Practice in SEDTAPP and Director of LPE inspired by the work developed in the Design, Justice, and Sustainable Development (DJSD) lab she leads. DJSD at Penn State brings forth the human-centered design framework to a legal and policy context to better understand the use and impact of technology and data-driven tools for the common good and public interest. This includes advancing access to justice (especially for those from marginalized and underrepresented communities), democracy and sustainable development, and supporting legal clinics, non-profits, and civil society organizations.

The course was developed as a temporary engineering online 3 credit project-based course that would expose students to real-world problems across technology, law, and policy. There was interest in exploring an online experiential learning model where engineering students could collaborate with law students and be exposed to access to justice topics leveraging the LPE initiative and existing collaboration between College of Engineering and Penn State Law.

The result was the ENGR 897 Design4Justice spring semester course where interdisciplinary teams of engineering students used human-centered design principles and legal design to work in a virtual lab environment. Students developed innovative digital tools and data-driven solutions at the intersection of technology and public interest to help improve legal services delivery, access to the civil justice system, and enhance stakeholder participation through open innovation practices in public policy and visual law. In this course a group of graduate students from Electrical Engineering, Computer Science, and Engineering Leadership and Innovation Management worked as a team using the Miro board as a collaborative online tool to design and develop a digital prototype addressing the access to justice gap that veterans and military service members face. The course provided the framework for students to use design thinking process to empathize, define, ideate, prototype, and test their prototype solution in collaboration with the Veterans and Servicemembers Legal Clinic at Penn State Law. This enabled further development into the immersive experience discussed later in this paper.

During summer 2021 Prof. Allain met Penn State alumna Lisa Sibilia Co-CEO of YOUTOPIAN, an innovation leader in custom Artificial Intelligence (AI) and Extended Reality (XR) digital transformation. After initial conversations both rapidly realized they could join efforts and push the boundaries of online engineering and legal education by exposing students to the capabilities of virtual reality (VR) and augmented reality (AR) both inside and outside the classroom. The goal would be twofold. First, the course Design4Justice provided the perfect platform to explore the use of virtual reality as a collaborative tool to enhance student online engagement and experiential learning. Second, access to VR technology and YOUTOPIAN's technical expertise provided an opportunity for both engineering and law students to work together, be creative, and envision the role of virtual reality in access to justice and legal services delivery. In addition, Prof. Allain received a 2021 Faculty Engagement Award from Penn State's Office of Teaching and Learning with Technology supporting the use of AR in the classroom. It was time to innovate and dream big.

1.2.1 Learning Outcomes

The course numbering and syllabus was adjusted to include the use of VR and AR technologies and to target advanced undergraduate students and graduate students during the Fall. It was anticipated that students would be unfamiliar with these technologies and there would be a learning curve. The course was offered under a hybrid 75% online instructional mode with most classes happening remote synchronous, and a few in-person sessions along the way.

Upon completion of the ENGR 497 Design4Justice course, students would:

1. Be exposed to fundamental principles of design thinking, UN Sustainable Development Goal 16, Access to Civil Justice, Legal Design, Visual Law, and Open Policymaking.

2. Reflect on the role of technology and human centered design in providing greater empathy, access and efficiency to legal processes and the legal system, transparency of policy and actions, legal service delivery, and an understanding of the vulnerable populations affected.

3. Engage in analysis, reasoning, and problem solving while working in interdisciplinary teams at the intersection of law, policy, and engineering.

4. Become familiar with technologies impacting the field of legal-tech, civic tech, gov-tech and public interest technology.

5. Explore the design, development, and use of virtual reality technology to: a) increase the effectiveness of a person's access and actions when navigating the legal and judicial system, or b) engineer streamlined processes with VR technology, or c) acquire greater understanding of the vulnerable communities affected by the access to justice gap through data collection and data analytics to inform policymakers.

In addition, the Design4Justice learning outcomes support several ABET Criterion 3 student outcomes [3]. This is important to highlight as the skills, knowledge, and behaviors acquired by students through their participation in elective courses of this innovative and interdisciplinary nature help develop well-rounded engineers ready to compete in the global workforce and solve complex engineering problems.

1.2.2 Model

The collaboration with Penn State Law's Legal Clinics was expanded in Fall to include two projects, one with the Veterans and Servicemembers Legal Clinic and the second with the Family Law Clinic. The timeline for course completion was 15 weeks driven by the academic calendar at Penn State, an ambitious timeline to complete two VR projects. Each student from the Design4Justice course received a VR Oculus headset on loan to be returned at the end of the course, these headsets were donated by YOUTOPIAN. Each legal clinic received one VR headset to share among its law students to explore VR technology as well, which were returned at the end of the course.

To meet the learning objectives and allow enough time for engineering and law students to work together, learn about the legal clinics and the communities they serve, brainstorm VR scene applications, and design, iterate and test the prototype, a flipped classroom method combined with a collaborative co-creation model was implemented with the legal clinics and YOUTOPIAN.

The model comprised:

a) In-person session at the beginning of the semester with the legal clinics to explain course objectives, VR technology capabilities, the ENGAGE virtual learning platform, and use of VR in the legal field.

b) Four workshops in the semester that brought together the engineering student teams and the law students from each legal clinic together to design and iterate – the second workshop (brainstorming session) was done in-person at the legal clinics led by the engineering teams.

c) Technical expertise and support from YOUTOPIAN team and Lisa Sibilia throughout the semester and in the classroom for VR technology use and adoption, including access and use of the ENGAGE platform for course delivery on VR platform and custom design of the DJSD VR Dome for Design4Justice course VR activities and meetings.

d) Each engineering student team designed a VR scene, one for the Veterans and Servicemembers Legal Clinic and one for the Family Law Clinic in collaboration with the law students from the legal clinics. YOUTOPIAN supported the development of the 3D VR assets on the ENGAGE platform and bringing to life the prototype design of the VR scene developed by student teams.

Student teams received from YOUTOPIAN parameters for each VR project design: One VR scene; Limit 10 (2D) assets; Limit 3 (3D) assets; One original YouTube video link (optional); Integrate 360-degree video AR component (optional); Combine VR scene and 360 video (optional); Experiential presentation in VR for final assessment (7-minute project video deliverable).

1.3 Implementation

The course Design4Justice pushes students outside their comfort zone. For many engineers it's the first time they engage in any legal topic or interact with law students or legal professionals. Many are not aware of the challenges in the access to civil justice space, or the role legal clinics play in providing legal aid especially in civil justice cases where no attorney is appointed by the court. The reality is that unless

you have the resources and means to pay for an attorney, many facing legal issues such as eviction, debt collection, foreclosure, bankruptcy, health claims, domestic abuse, child custody or divorce among others, are forced to become self-represented litigants and face court on their own. According to the Pew Charitable Trusts, each year more than 30 million Americans encounter civil legal problems without the help of a lawyer. This reality hits those from marginalized communities and low-income households the hardest.

For the law students, many had not interacted with engineering students before nor were familiar with virtual reality technology or contemplated the use and development of technology to provide greater access and educational resources to civil legal services. Many recognize and agree the legal system should be made more open, efficient, and equitable [4]. Exploring how technology can provide the legal clinics and legal system better outcomes for civil litigants facing life-changing consequences, was a challenge embraced by all students participating in the course.

Both groups of students shared at the beginning of the course skepticism regarding the use of VR. This technology was only associated with gaming for those that knew about it. It was largely unknown as a collaborative and educational training platform. During the third week of the course the engineering students were introduced to VR using the ENGAGE platform with the support of YOUTOPIAN. Students had not met in-person at this point, however with the use of VR they were suddenly an avatar interacting side by side with their classmates for 40 minutes, giving each other high fives and feeling this interaction through the vibration of the control. It was an immersive experience that they did not expect and became excited about immediately. Some students felt slightly nauseous and felt the headset a bit heavy after 30 minutes, all normal effects when you begin using VR for the first time. We discussed how to overcommunicate in VR to understand the personal needs of each student.

The course began meeting regularly via VR, where student teams interacted and collaborated, as if they were in-person, discussing their prototype ideas and becoming more familiar with the virtual reality environment. They used handheld controls that enabled them to move through a scene, use the tools available to move objects, write on whiteboards, draw, and place and remove items from the VR asset library available on ENGAGE. See Fig 1 in-person workshop at legal clinic. The VR sessions were followed by a discussion and reflection on the experience in a VR meeting space, see Fig. 2.

Fig. 1.

Fig. 2.

The Fall student cohort of the ENGR 497 Design4Justice course comprised advanced undergraduate students in computer science, students in the master's in Engineering Design, Engineering Leadership and Innovation Management, and PhD students. There were two student teams formed and they each chose one legal clinic to work with to design and develop the VR scene for their project.

2 RESULTS

The development of two VR scenes for Penn State Law's legal clinics are the foundation for Penn State's first metaverse node in legal services. The metaverse, also considered Web 3.0 - the hyperconnected global internet [5] where VR, AR, XR and MR (mixed reality) converge, is an evolving term. Jooyoung Kim highlights the common attributes of the metaverse "continuity (or persistence) of identity and objects, a shared environment, the use of avatars (or embodied self), synchronization, being three-dimensional (or virtual), interoperability, and a user experience that is interactive, immersive, and social", in addition, "the connection should also be considered between the real world and virtual worlds, where virtual experiences can have direct consequences in the real world" [6].

The rise of the 3D web is akin to the advent of the internet. It is an open landscape where there is no single definition. There are failed assumptions that it will replace our sense of reality, yet, as Jane Stanford articulated on July 6, 1904, in her last address to the Board of Trustees, “Let us not be afraid to outgrow old thoughts and ways and dare to think on new lines as to the future of the work under our care” [7]. Higher education is innovating. In Summer 2021 Stanford launched COMM 166/266 “Virtual People” as the first course set entirely in VR led by Prof. Bailenson on the ENGAGE platform where 263 students, all with their own VR headsets, across 20 weeks and two courses, experienced VR [8].

2.1 Project Empowerment

The first student team designed a VR scene prototype in collaboration with Penn State Law’s Family Law Clinic. A 3-stage approach included designing a waiting room, a 360 video of the Centre County courthouse, and a virtual courtroom space. For the first space, the need was a virtual setting that explains the intake process to the client, which prepares them for what is called the “intake meeting” where the Family Law Clinic determines if it can take them on as clients and provide legal aid. The setting is a VR scene designed to be calming and allow the prospective client of the Family Law Clinic to be briefed on the information about the intake appointment by using VR. This space includes comfortable seating and a fish tank complete with the sound of bubbling water to set the calming tone. This space also included plants, mountains, and other nature imagery to promote a sense of peace. For the second approach, students obtained permission to go to the Centre County courthouse and take a 360-walkthrough video where spaces in the courtroom are explained with the purpose of providing self-represented litigants an immersive experience that will help them become familiar with the courthouse and prepare for court [9]. This video includes both verbal and visual callouts of the various spaces of the courtroom, their purpose, and use with 360-degree views. The final element was the VR courtroom which includes all the elements of a live courtroom and allows multiple people to join and interact at the same time; this allows clients and certified legal interns to meet for training or practice before going to court. This approach also enables a self-represented litigant to feel more comfortable and less intimidated by the physical setting of a courtroom. See Fig. 3.

2.2 Project Veterans Legal Assistance

The second student team designed a VR scene prototype in collaboration with the Veterans and Servicemembers Legal Clinic. The main purpose of the scene was to teach veterans how to file an initial disability compensation claim and increase their chances of getting their benefits approved from the US Veterans Affairs Department (VA). Submitting the required applications and appropriate medical information is necessary to speed up the approval process or file a successful appeal. The scene takes place in the nighttime, the sky is clear full of stars with a full moon. A lighted pathway directs the veteran to an outdoor tent where an educational video explaining the initial disability claim process is found along with a fireplace where the legal clinic can talk to its client in a more inviting space compared to the traditional office [9].

Students wanted to empower the veterans by providing them with a disarming space where they feel comfortable. The outdoor scene helps the veteran feel safe to share their personal stories with the legal clinic. Veterans have different needs based on their unique stories and conditions. Students heard the story from one of the oldest veterans who attended the feedback session with the legal clinic. He said it took him around 30 years to apply for the benefits. He mentioned that many of his friends from the same generation, those who served in Vietnam, do not know about the process or if they are eligible for the benefits provided by the VA compared to the younger generation. Students hope their solution provides an alternative space for the legal clinic to meet with their clients and hopefully change lives. See Fig. 4.

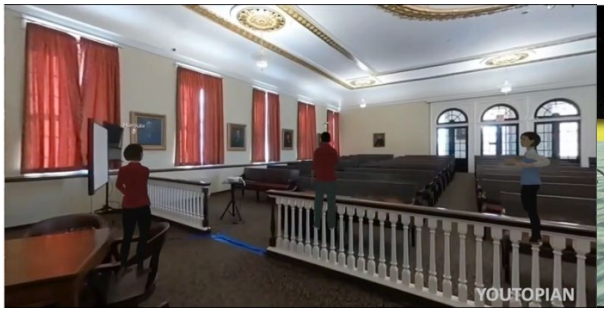


Fig. 3.

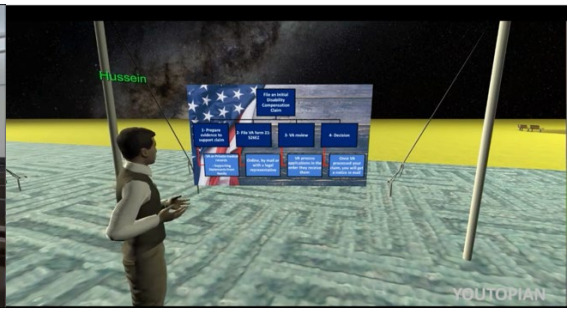


Fig. 4.

3 LESSONS LEARNED

a. Integrating virtual reality to the classroom brings forth both opportunities and challenges for students, instructors, and project partners. It is important when introducing VR to integrate training sessions with both 1:1 and small groups offerings to create familiarity. Forgetting passwords, connectivity issues, or forgetting VR equipment happen frequently at the initial stages, which may disrupt the lesson planned.

b. Students will demonstrate responsibility through a heightened level of collaboration in mixed reality. For example, in the course the added accountability required defining roles/responsibilities without knowledge of the outcome, placing students outside their comfort zone. The intentional integration of interdisciplinary human centered design and right mix of structure and open-ended decision-making was new for the engineers seeking linear pathways.

c. Students found the VR immersive learning experience to be engaging and interactive. They highlighted they were less distracted in VR when compared to Zoom given the use of the headset, all their attention was on the VR experience with no outside distractions. Faculty initially VR skeptical were surprised at the student impact and opportunity to build creative-analytical learning pathways.

d. VR provides an opportunity to enhance legal and engineering education. As a digital collaborative platform, it brings down physical and geographical barriers. Remote learning doesn't feel remote due to the immersive experience and use of self-identifying avatars. You have the best of both worlds, a highly interactive experience with no physical space constraints. We need to leverage digital technologies, digital twins, not to replicate the classroom as we know it but to reimagine the learning experience.

e. Change is constant, yet adults and organizations often get too comfortable with traditional methodology as the *tried and true* method until a paradigm shift happens. What has been a fascinating outcome of the pandemic has been the speed of small organizations demonstrating greater innovation potential and speed than world-renowned large companies. The pandemic drove business strategy pivots and accelerated digital transformation and adoption, providing an opportunity for the field of continuing engineering education to innovate.

f. The amount of time, resources and expertise required to design and develop custom immersive settings (VR scenes) from scratch can be challenging. This "metaverse skill gap" may hinder adoption of this key technology by faculty that don't have the resources, expertise, or industry partnerships necessary to make VR use scalable, sustainable, and attractive to their research, teaching and outreach portfolios. Institutional support is needed to facilitate access to collaborative VR platforms, hardware, and development of VR experiential learning opportunities as described in this paper.

Authors would like to acknowledge seed grant support from Penn State's Leonhard Center for Enhancement of Engineering Education and Faculty Engagement Award from Penn State's Office of Teaching and Learning with Technology.

REFERENCES

[1] LPE (www.lpe.psu.edu)

[2] Seiman, J.; Allen, E.; Ralph, N. (2021). Teaching Online: STEM Education in the Time of Covid. Bay View Analytics. (www.bayviewanalytics.com)

[3] ABET Criteria for Accrediting Engineering Programs 2021 – 2022. (https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2021-2022/)

[4] The PEW Charitable Trusts' civil legal system modernization project (https://www.pewtrusts.org/en/projects/civil-legal-system-modernization)

[5] Jobanputra, Jalak, (2011) Web 3.0+: The Hyperconnected Global Internet, Medium

[6] Jooyoung, Kim (2021) Advertising in the Metaverse: Research Agenda, Journal of Interactive Advertising, 21:3, 141-144

[7] Meyer, H-D. Rowan, B., (2006) The New Institutionalism in Education. State University of New York Press

[8] Virtual Human Interaction Lab, Comms 166, Stanford Univ.(https://stanfordvr.com/comm166/)

[9] DJSD Lab, ENGR Design4Justice Project Videos Fall 2021, (https://sites.psu.edu/djsd/projects/)

The Impact of the Climate Crisis on the Mental Health of Higher Education Students: A Case Study

Celeste Ceballos[1], Carlos Aldama-Castro[1], Mary Cervera-Diaz[1], Fernando Lambarria-Gomez[1], Mariana Paez-Frias[1], Patricia Caratozzolo[2]

[1] Tecnologico de Monterrey (MEXICO)

[2] Institute for the Future of Education, Tecnologico de Monterrey (MEXICO)

Abstract

Historically, the climate crisis has been viewed as a solely environmental and economic issue, with no regard for its effect on mental health. Only the last decade has shown an increase in the analysis of the impact said crisis has on the emotional wellbeing of people. Nevertheless, much research remains to be done in this field.

Most of the available literature analyzing society's perception of climate change utilizes qualitative tools such as interviews and polls. In general, these studies have also focused on establishing a vocabulary adequate for the exploration of this subject; terms like anxiety, climate anxiety, ecoanxiety and solastalgia have been used and discussed. For the purpose of this study, the term ecoanxiety has been chosen, signifying a psychological uneasiness caused by worrying about climate change and the deterioration of the natural environment.

The present work outlines the comprehension of this subject via a qualitative poll-based study, with the sample being composed of individuals of the student community of a Higher Education Institution (HEI). The preliminary results allow the researchers to analyze the presence, as well as the effects, of ecoanxiety in the aforementioned population.

Keywords: ecoanxiety, climate change, psychological impact, anxiety, higher education.

1 INTRODUCTION

With climate change ever present in the media and the 2021 IPCC Report confirming that the climate change crisis we experience as of today is unequivocally caused by human action [1], it is evident that the environmental crisis is one of the most relevant issues of the 21st century. However, it seems that individuals perceive themselves (and as such, their actions) as too insignificant in the big scope of the problem [2], leading to inaction or denial [3] in the face of the climate crisis. Even with conclusive evidence of climate change impacting their immediate surroundings, people refuse to take meaningful measures against it [2]. With this global lack of action toward such a pressing matter, it is perhaps expected that there should be psychological effects related to this issue. So far, climate change and its related disasters, which involve floods or prolonged droughts, have been linked to elevated levels of anxiety, depression and post-traumatic stress disorders [4].

In fact, some studies have focused on establishing a vocabulary adequate for the description of the emotional responses to the climate crisis; terms like climate anxiety [5], climate change anxiety [4] ecoanxiety [6] and solastalgia [7] have been used and discussed. Ecoanxiety is identified as closely linked to fear and worry [8]; and can range from mild stress to clinical disorders [5]. For the purpose of this paper, the term ecoanxiety has been chosen to signify a psychological uneasiness caused by worrying about climate change and the deterioration of the natural environment. This word was chosen because it includes a broader range of emotions than climate anxiety [6].

The effects that environmental issues have on people's mental health have also been studied. It has been found that many factors can influence an individual's relationship to the natural environment, such as gender, age, socio-economic position, among others [9], [10]. For instance, women tend to feel more stressed than men when thinking about the environment [10]. Gen-z, whose date of birth is between 1997 and 2012, is one of the generations most concerned with international issues [11], and according to the 12th annual Stress in America survey conducted by the American Psychological Association (APA), nearly 58% of young adults become stressed when they identify global warming and climate change [11]. This increase in stress levels can be a result of suffering a previous experience related to an extreme weather event or the fear of the possibility of experiencing one [12].

Moreover, people with a pro-environmental perspective tend to worry more about the environment and, as a result, are more likely to get involved in pro-environmental behaviour (PEB) [13]. Also, it has been identified that people with a higher socio-economic standing show more concern for the environment; which seems to indicate that environmental concern tends to happen only after an individual satisfies their basic needs [13]. Additionally, first responders in climate-change-related natural disasters, as well as climate activists and scientists, are much more prone to report feeling climate anxiety [5], [14].

Nevertheless, it is worth noting that it has been found that ecoanxiety is not as effective as other emotions (namely eco-anger and eco-depression) in causing engagement in adaptive responses to the climate crisis [15].

1.1 Research questions

After considering the information previously displayed and placing it in a Higher Education Institution (HEI) setting, the following questions arise:

RQ1. *Do ecoanxiety levels vary across young adult university students of different fields of study?*

RQ2. *Do certain fields of study have a higher involvement in actions to mitigate the climate crisis?*

RQ3. *Does ecoanxiety motivate involvement in actions to mitigate the climate crisis?*

1.2 Hypothesis

As such, the present research paper will attempt to analyze the presence, as well as the effects of ecoanxiety in a sample of individuals in the student community of a HEI. Our hypotheses are as follow:

H1. *Artistic, social studies and science-related majors will report higher levels of ecoanxiety than business majors.*

H2. *Artistic, social studies and science-related majors will report a higher involvement in actions to mitigate the climate crisis than business majors.*

H3. *Higher levels of ecoanxiety will not result in higher involvement in actions to mitigate the climate crisis.*

2 METHODOLOGY

Due to the nature of the study, a qualitative survey was chosen for data collection. The survey was created and applied via Google Forms and authors requested answers by sharing the link to the survey via group chats or messages, as well as by asking in person for people to answer with their phones by scanning a QR code that led to the survey page.

The survey consisted of 19 questions and was designed to keep the anonymity of the respondent in order to avoid any social pressure they may feel that might bias their answers. The first section of the survey consisted of seven questions that were aimed to determine the respondent's profile, such as their age, gender, field of studies, major, and their socio-economic status.

The second section (**Table 1**) of the survey consisted of 12 questions chosen with the objective of understanding the respondent 's relationship with the environmental crisis in regards to five spheres: Environmental Health Perception (EHP), Knowledge About the Environmental Crisis (KAEC), Emotional Responses to the Environmental Crisis (EREC), Actions Taken (AT) to combat the environmental crisis and Motivation to Action (MA).

Table 1. List of questions asked in the survey, not pertaining to the respondent's background.

No.	Question	Sphere	Type of answer
1	*How do you perceive the health of the planet?*	EHP	Likert Scale (1-5)
2	*Have you ever taken a class, course or certification course about the environmental crisis?*	KAEC	Yes/No
3	*What do you feel when you think about climate change?*	EREC	List of emotions

4	*Do you agree with the actions that have been taken to deal with climate change?*	EHP	Likert scale
5	*Have you taken any action toward solving this problem? (Including during quarantine due to the pandemic.)*	AT	Yes/No
6	*What actions have you taken?*	AT	Open-ended
7	*Did the pandemic motivate you or limit you from taking climatic actions?*	AT	Motivate, limit, neither
8	*Where have you implemented these measures?*	AT	List of places
9	*What motivated you to take actions against climate change?*	MA	Egoistic, social-altruistic and biospheric
10	*In case of not having taken action, why didn't you?*	MA	List of options
11	*Do you identify climate change as something stressful in your life?*	EREC	Yes/No
12	*Do you think climate change is a serious issue for society?*	EHP	Likert scale

Questions involving EHP were asked in order to understand the mindset of the respondent and their experiences regarding the environment. The rating scale used to measure these answers was the Likert scale, as it is the most broadly used with this type of research and helps to identify how much the respondent agrees or disagrees with the statement. It has the advantage that it does not expect simple answers, but rather allows the individual to choose between degrees of opinion or to choose a neutral stance [16].

The KAEC question was asked to determine whether having more knowledge about the environmental crisis changed the respondent's perception of the subject. EREC questions aimed to detect if there was a relationship between the emotions felt by the respondent and their actions to mitigate climate change. AT questions seek to know where, how and how much the respondent contributed to putting an end to the environmental crisis. It was also deemed important to identify whether or not the pandemic affected the respondent's inclination or ways of taking action. Lastly, MA questions were made to classify the respondent's motivation to take action. This last sphere was based on Stern and Dietz's Value-Belief-Norm Theory, which classified motivation for pro-environmental behaviour into egoistic, social-altruistic and biospheric reasoning [17].

3 RESULTS AND DISCUSSION

We received a total of 117 answers to our survey. Respondent ages ranged from 18 to 26 years of age, with 34.5% of respondents being 21 and 27.6% 20 years old. 53% of respondents identified as woman, 45% as man and 2% as non-binary. As for field of studies, 54% of respondents belonged to Engineering, 22% to Health, 15% to Business, 6% to Creative Studies and 3% to Social Studies. Since the respondents from Social Studies consisted of only 2 people, we decided not to consider this field of study in the analysis, as to not generalize from a statistically insignificant population sample. 67.5% of respondents reported having a scholarship or tuition financing, while 32.5% did not. Finally, 49.6% of respondents reported having some sort of sustainability or ecology education, while the rest (50.4%) did not receive any kind of education on the subject.

EHP among participants averaged 2, 1 being really bad and 5 being really good. This result indicates that all of the people surveyed are aware of the negative impacts of the climate crisis. However, it is worth noting that the EHP of students who reported not having KAEC averaged 2, slightly higher than those who did have this kind of education (1.88). Nevertheless, this difference wasn't considered as statistically significant either. Another point worth mentioning is that the average grade of EHP in respondents from Business and Creative Studies fields ranges from 1.85 to 1.89 respectively, which is a lower grade than the one shown by engineering students (2). Students from Health showed an EHP worse than any other field.

In regards to EREC (**Figure 1**), the most frequently reported emotion when asked about climate change was frustration (73%), followed by impotence (70%) and sadness (68%). The first two emotions indicate a helplessness likely to lead to inaction [15]. These emotions might be a result of the negative EHP reported, and they can result from stressful situations, especially if they have experienced any natural disasters caused by climate change [12]. In general, 72.6% of respondents identified climate change as something stressful in their lives. No correlation between EREC and field of study was found (**Figure 2**).

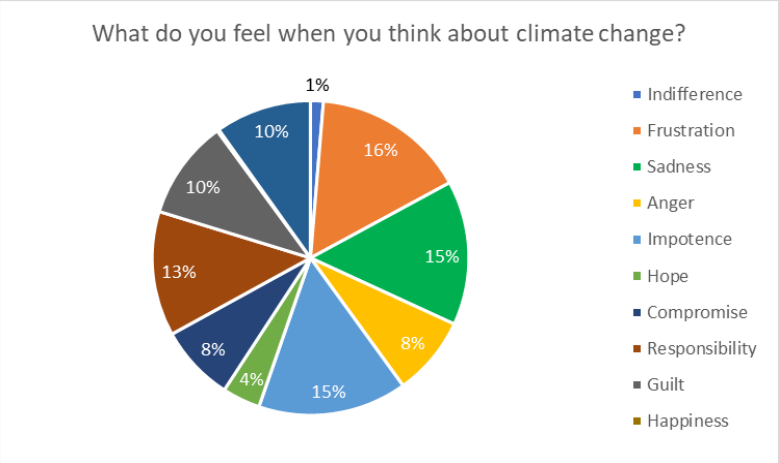


Figure 1. Emotional Response to the Environmental Crisis (EREC) among respondents.

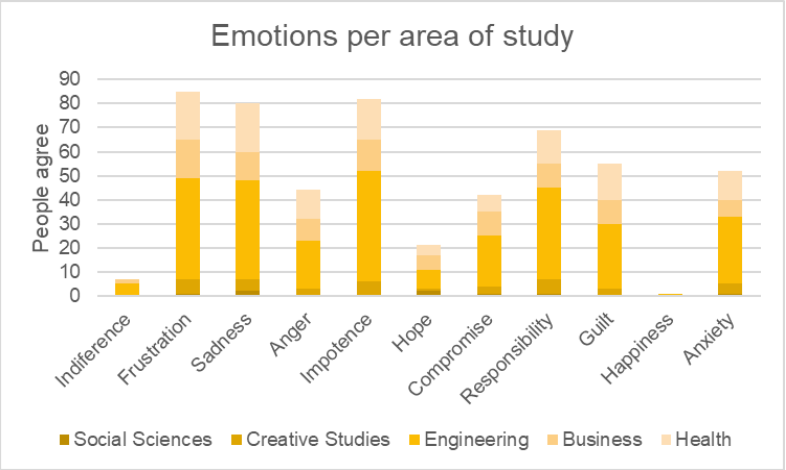


Figure 2. Average EREC by field of study.

When asked **Question 12** (*Do you think climate change is a serious issue for society?*), an overwhelming 82% answered: *Yes, now it is left to our generation to deal with the consequences*. We would have thought this answer implied an anger toward older generations for not taking the actions needed to combat climate change, yet only about a third (39 people) of respondents who selected this option reported feeling anger when thinking about climate change. However, the majority did report feeling impotence.

As for AT, 73.5% of interviewees reported PEB taken to mitigate climate change; of those who answered yes, 44% claimed egoistic, 37% biospheric and, lastly, 17% social-altruistic reasons. The remaining 2% identified all three reasons as equally important. Yet, it is important to mention that only 12 people out of the 117 interviewed reported engagement in PEB requiring a significant lifestyle change; such as diet change to vegetarian or vegan, cultivation of urban horticulture gardens, usage of menstrual cups or reusable sanitary pads, living a zero or low-waste lifestyle, composting and carpooling. Interestingly, these same individuals also reported (from most to least frequent) compromise, responsibility and/or guilt when thinking about climate change in their answers to **Question 3** (*What do you feel when you think about climate change?*). On the other hand, lack of AT was attributed to ignorance (56%) and lack of time (53%).

4 CONCLUSION

The present work endeavoured to analyze ecoanxiety levels in students of a HEI via a qualitative survey. The results indicate that respondents are aware of the climate crisis and acknowledge it as a serious issue for society. As a result, they present symptoms such as frustration, impotence and sadness, which the literature has identified as symptoms of ecoanxiety [18]. However, in analyzing ecoanxiety levels across fields of study, **H1**. *"Artistic, social studies and science-related majors will report higher levels of ecoanxiety than business majors"* was refuted, as no correlation was found between field of study and variation of ecoanxiety levels. Furthermore, **H2.** "*Artistic, social studies and science-related majors will report a higher involvement in actions to mitigate the climate crisis than business majors"* was also found to be false, given that there was no correlation between field of study and level of involvement in actions to mitigate the climate crisis. Finally, **H3**. *"Higher levels of ecoanxiety will not result in higher involvement in actions to mitigate the climate crisis"* was found to be true given that, in most cases, ecoanxiety did not lead to significant PEB.

4.1 Future Research

We advise that future research is conducted to delve deeper into: (1) the connection between nature exposure and pro-environmental behaviours (PEB) in young adult university students living in urban locations; (2) the habits and characteristics of young adult university students who report proactive emotions which encourage effective actions to fight the climate crisis; and (3) the link between formal sustainability education and significant PEB.

5 ACKNOWLEDGEMENTS

We would like to thank Dr. Patricia Caratozzolo Martelliti for her valuable mentorship in this research and for her neverending support to the team. We would also like to thank Dr. Carlos Antonio Caballero Valdés for his aid in finding the necessary information to design and apply our survey.

6 APPENDIX

In case readers wish to look at survey results in more detail, we have attached the answers to our survey in an additional document.

Answers and Results of the Ecoanxiety Survey

REFERENCES

[1] IPCC, "Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for PolicyMakers", *Clim. Change 2021 Phys. Sci. Basis*, 2021.

[2] K. M. Norgaard, "'People Want to Protect Themselves a Little Bit': Emotions, Denial, and Social Movement Nonparticipation*", *Social. Inq.*, vol. 76, núm. 3, pp. 372–396, ago. 2006, doi: 10.1111/j.1475-682X.2006.00160.x.

[3] M. C. Wullenkord, J. Tröger, K. R. S. Hamann, L. S. Loy, y G. Reese, "Anxiety and climate change: a validation of the Climate Anxiety Scale in a German-speaking quota sample and an investigation of psychological correlates", *Clim. Change*, vol. 168, núm. 3–4, p. 20, oct. 2021, doi: 10.1007/s10584-021-03234-6.

[4] S. Clayton y B. T. Karazsia, "Development and validation of a measure of climate change anxiety", *J. Environ. Psychol.*, vol. 69, p. 101434, jun. 2020, doi: 10.1016/j.jenvp.2020.101434.

[5] J. Dodds, "The psychology of climate anxiety", *BJPsych Bull.*, vol. 45, núm. 4, pp. 222–226, ago. 2021, doi: 10.1192/bjb.2021.18.

[6] P. Pihkala, "Climate Anxiety". MIELI Mental Health Finland, 2019. [Online]. Available through: https://mieli.fi/wp-content/uploads/2021/12/mieli_climate_anxiety_30_10_2019.pdf

[7] G. Albrecht, "'Solastalgia' : a new concept in health and identity", p. 238594 Bytes, 2016, doi: 10.4225/03/584F410704696.

[8] P. Panu, "Anxiety and the Ecological Crisis: An Analysis of Eco-Anxiety and Climate Anxiety", *Sustainability*, vol. 12, núm. 19, p. 7836, sep. 2020, doi: 10.3390/su12197836.

[9] K. M. Jylhä, C. Cantal, N. Akrami, y T. L. Milfont, "Denial of anthropogenic climate change: Social dominance orientation helps explain the conservative male effect in Brazil and Sweden", *Personal. Individ. Differ.*, vol. 98, pp. 184–187, ago. 2016, doi: 10.1016/j.paid.2016.04.020.

[10] J. Roe *et al.*, "Green Space and Stress: Evidence from Cortisol Measures in Deprived Urban

Communities", *Int. J. Environ. Res. Public. Health*, vol. 10, núm. 9, pp. 4086–4103, sep. 2013, doi: 10.3390/ijerph10094086.
[11] American Psychological Association, "Stress in America", *American Psychological Association*, 2018.
[12] S. E. L. Burke, A. V. Sanson, y J. Van Hoorn, "The Psychological Effects of Climate Change on Children", *Curr. Psychiatry Rep.*, vol. 20, núm. 5, p. 35, may 2018, doi: 10.1007/s11920-018-0896-9.
[13] A. M. McCright, S. T. Marquart-Pyatt, R. L. Shwom, S. R. Brechin, y S. Allen, "Ideology, capitalism, and climate: Explaining public views about climate change in the United States", *Energy Res. Soc. Sci.*, vol. 21, pp. 180–189, nov. 2016, doi: 10.1016/j.erss.2016.08.003.
[14] D. A. Alexander y S. Klein, "First Responders after Disasters: A Review of Stress Reactions, At-Risk, Vulnerability, and Resilience Factors", *Prehospital Disaster Med.*, vol. 24, núm. 2, pp. 87–94, abr. 2009, doi: 10.1017/S1049023X00006610.
[15] S. K. Stanley, T. L. Hogg, Z. Leviston, y I. Walker, "From anger to action: Differential impacts of eco-anxiety, eco-depression, and eco-anger on climate action and wellbeing", *J. Clim. Change Health*, vol. 1, p. 100003, mar. 2021, doi: 10.1016/j.joclim.2021.100003.
[16] "Likert Scale Definition, Examples and Analysis | Simply Psychology". https://www.simplypsychology.org/likert-scale.html (consultado el 24 de abril de 2022).
[17] P. C. Stern y T. Dietz, "The Value Basis of Environmental Concern", *J. Soc. Issues*, vol. 50, no. 3, pp. 65–84, oct. 1994, doi: 10.1111/j.1540-4560.1994.tb02420.x.
[18] S. Clayton, C. Manning, M. Speiser, y A. Nicole, "MENTAL HEALTH AND OUR CHANGING CLIMATE", American Psychological Association and ecoAmerica, Washington, D.C., 2021. [Online]. Available through: https://www.apa.org/news/press/releases/mental-health-climate-change.pdf

Embed Novice Programming and Web Source Code with Self Direct Learning Design: An Imperative Education

Alireza Ebrahimi, SUNY Old Westbury

What drives technology as a tool is its programming and the code that carries it on. The pedagogical benefit would be to earn confidence and competence by educating the concepts and finding what's going on. Therefore, it is important to embed novice programming concepts and web source code with self-directed learning design as an imperative education. Artificial Intelligence (AI) and Web Systems are becoming a dominant force of technology with an impact on every aspect of teaching and learning. It is essential for self-educators to know the breadth knowledge of the programming and when it is necessary go to the depth knowledge of programming. It is exciting to see self-learners be able to manipulate existing code and observe the results. An example of this would be to change the repetition of the loop from 5 to 5000 or forever. Another motivating example would be to give about 20 lines of code for a tic tac toe program that never loses. Many of studies show that self-learning can be an additional vehicle to excel in career and self-satisfaction. A Visual Plan Oriented Paradigm is proposed to achieve the goal to incorporate Programming concepts as ubiquitous and imperative learning. A plan Visualization with self-directed learning design is introduced from the highest level as in the human mindset toward the lowest (deep) level of a machine with bit code and has been illustrated in five layers scenario.

The first layer known as human interactions deals with a web system for the desired task to be performed. The second layer is known as a software application layer in which a software has been installed prior to and operated in sequences of processes. Down to layer three, is a programming language layer where the program shows the prompt and/or takes the responses by

storing the values for the interaction and the possible computation or comparison. A value can be a digit (number), or name, although every entry is simply an integer agreement that represents a character and from there the conversion will take place.

In the assembly code layer, a register is a common location to hold a value and waits until it is changed. The machine code will take a direct one-to-one translation and present it into addresses with opcodes and operands. At the final layer of microcoding, in the lowest level of the control unit, things are automated as supposed to be and interpret the incoming code with a bus and direct it to the action and storage. A sequence with begin and end shows the control flow. A decision-making act on its Boolean condition of true or false to take a truth sequence with its begin and end or an alternative else with its own begin and end as it is visualized in two-dimensional pathways. A repetition or loop returns a cycle to a point of desire with its specified number of durations, repeat could be fixed, n ways until a condition has been met or an exhaustive end of file marker or infinite forever.

In self-directed learning design, every concept is shown by a plan that can be visualized and a visual object is used to present the plan and integrate the plans to form a program and solve a problem. An educator can attractively utilize the programming materials to create interest and motivation. There is no doubt that programming is ubiquitous learning. To incorporate the above concepts a Visual Plan Construct Language (VPCL) design is used to navigate and create the processes. VPCL is an environment that comes with a library of preexisting problems and plans with the three modes of Plan Rehearsal (observation), Plan Integration(composition/decomposition), and Plan Creation (innovation). A user can work with VPCL to do any programming manipulation.

A successful example of self-learning is a group of students at SUNY Old Westbury were directed to create their network system collaboratively for a case of Covid-19 health throughout a case study in a Web System and E-Commerce course. The self-design framework is plan-oriented and based on the concept of the plan and plans integrations and spatial relationships. The self-learners are directed to break the system into plans and sub plans. The design purpose is to self-guide the learners to build a system to comprehend, combat, coexist, cope, and traces COVID-19. The self-learners given four layers of diagnostics, simulation, and pattern matching database. The self-learner can communicate with the system collaborating with others. The implication of the study was for the learner to initiate their own participant's system and to find a pattern and formulate an algorithm for the pandemic. The idea of self-design and self-directed learning to be transferred to another topic like learning programming or giving other health services.

Another example of motivating self-learning was to give a skeleton for the simulation program as a game, depicting interaction with the covid virus trying to enter the body's cells and the impact by winning or defeating using recursive algorithms. Self-learners were engaged to play with a combination of HTML color red, green, and blue (RGB) using more than 16 million color code for participants health.

Programming Scenario

Here is the scenario that can be used as a self-learning design. A program using plan-oriented programming approach for a generic problem of finding the average of a series of numbers. The program will be extended to find min, max, sorting, and searching. At a later time, a program can perform some statistical data analytics tasks such as finding trends or-manipulating data for desired outcomes. The purpose of programming is to solve problems and

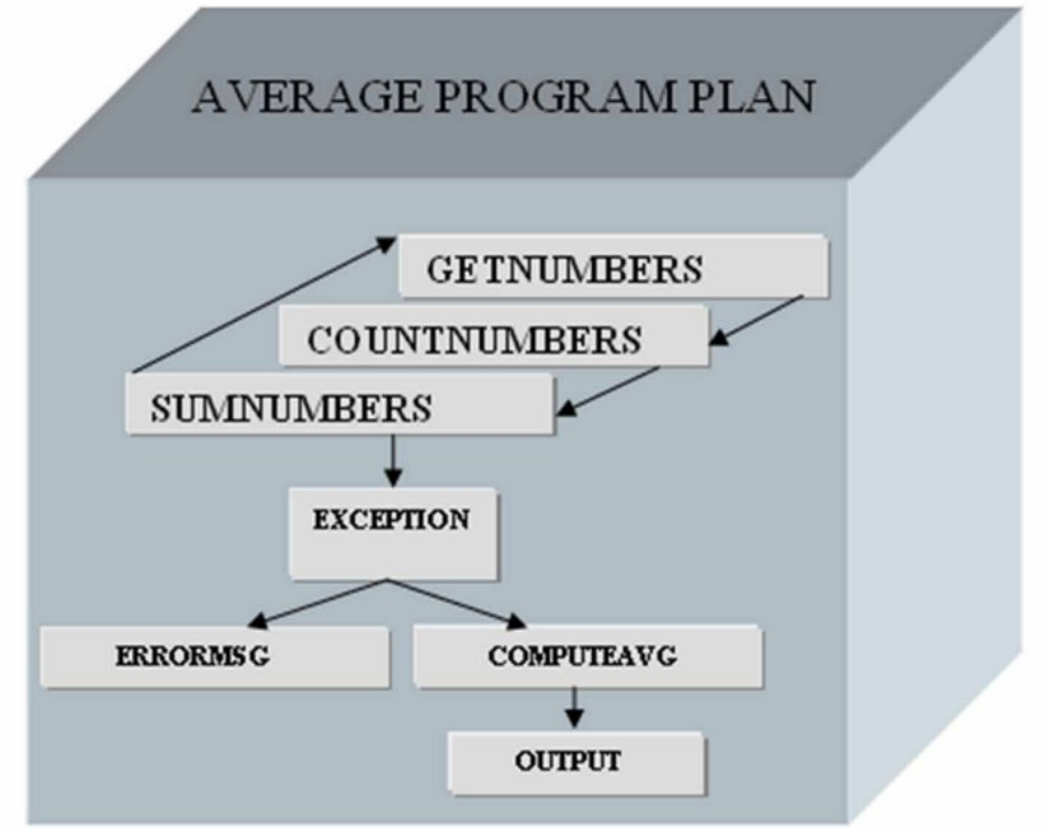
map our minds. So where does the plan come from? The plan is an activity that has a purpose with its own space and relationship, timing, and step sequences.

Now the question is how to find the average ourselves? The basic first step is the have a plan for getting the data. The next plan would be to sum the data. The next plan is to count. These plans are embedded into the loop plan. Now the learner hasn't done any OOP and functions, but they are learning how to visually problem solve such as the average plan. These plans are one after another known as interleaved plans. This is for self-learners and before introducing the concept of arrays and these three plans into the loop plan. Another issue with programming self-learning difficulty would be the order of execution. That's why the loop plan is introduced to teach self-learners how these plans are interleaved. Outside of the loop plan, there is a branch plan that contains two other plans. One is the error display plan and average display plan. A novice programmer should be able to successfully visualize this plan and be able to tell a story. 90 percent of novice programmer self-learners misplace the average plan in the loop plan and do not consider the error plan at all for example divide by zero. Any meaningful activity or code can be considered a plan. The plan can go up or down it can go left or right. It can go as deep as assembly code or even microcode. Eventually, a novice or expert programmer can visualize this plan as an assembly task or even microcode task. Later on, they will be introduced to the concept of plan misplacement, or if the plan is missing what will happen. They will learn about what happens if the plan doesn't work or doesn't validate properly. They will also be exposed to debugging. At this point, a novice programmer will learn the importance of the existence of a plan, placement of a plan, the accuracy of a plan, and manipulation/misconception of the plan. This can be visually illustrated and taught. The plan can

be taught visually such as flow charts or hooked to a compiler for any language or by itself be a compiler.

To reiterate what a plan is, any meaningful steps taken to problem-solving can be considered a plan at a different stage. We have four different standards of integration/decomposition, assurance/error detection. An object can be a plan as well as a function or could be a coroutine for multitasking. This process will illustrate to self-learner programmers the importance of having a plan. the plan can be taught individually and to be executed. Another scenario of plan-oriented programming is sorting. For example, by combining an exchange sort plan with a selection sort plan a new optimized plan can be induced. The figure shows how average computation illustrated by visualization of the plans and how VPCL will take the charge of clicking on each of the plans to see the code layer to layer. Entire programming can be viewed, and output can be visually produced.

The question now is, how self-education of programming can be done in such a way that can improve the quality and effectiveness of taught material and becoming a norm and a model for the rest to follow? There would be difficulties and challenges that can be learned during the course of execution of the plans using experience and experiments for the years to come.



References

Ebrahimi, A. (1992). VPCL: A visual language for teaching and learning programming. (A picture is worth a thousand words). Journal of Visual Languages & Computing, 3(3), 299–317. https://doi.org/10.1016/1045-926x(92)90021-d

Ebrahimi, A. (2020). In search of a pattern and algorithmic code for COVID-19: A participant self-customized awareness systems for diagnostics, simulation, tracing and pattern matching. 2020 IEEE International Symposium on Technology and Society (ISTAS). https://doi.org/10.1109/istas50296.2020.9462189

Ebrahimi, A. (2021). A User Self-Design Collaborative Web System for Self-directed Health Learning: A Covid-19 Awareness Project. 2021 IEEE CSCI 2021. ISBN # 1-60132-515-0; American Council on Science & Education

Tough, A (1967). Learning without a teacher: A study of task and assistance during adult self-teaching. Toronto: Ontario Institute for Studies in Education.

BUILDING A TRAINING SYSTEM FOR FUTURE LEADERS IN SCIENCE, TECHNOLOGY AND BUSINESS

JIA Fan

Sinopec Human Resource Department (China)

Abstract

Sinopec is the largest oil and petrochemical products supplier and the second largest oil and gas producer in China, the largest refining company and the second largest chemical company in the world. It has ranked the top five on Fortune's Global 500 List for ten consecutive years. Sinopec is committed to leading the development of the energy and chemical industry with innovation, taking young talents as a new force to build a world leading clean energy and chemical company, and creating conditions for the all-round development of young talents. Sinopec vigorously implements the "Zhaoyang (Morning Suns) Program" for 150,000 young talents. The program takes serving the enterprise development strategy as the goal, strengthening the career planning of new college graduates as the starting point, and continuously improving the growth potential of young talents as the core. The training program has been organized as an organic project building a university-company cooperative training system of early-stage training, following-up training and whole-process training. It has carried out beneficial exploration and practice in talent training mode innovation, production, knowledge and research coordination, and training operation management optimization. This has played an important role in cultivating a pool of future leaders in scientific, technological and business innovation, catalyzing a number of strategic and forward-looking key core technologies, and forming a number of new models of talent training.

Keywords: Future leaders, talent training, innovation, university-company cooperation.

1 BACKGROUND AND STRATEGIES

In recent years, COVID-19 has been raging across the globe, and the world is evolving faster with a new round of scientific & technological and industrial revolutions advancing by leaps and bounds.[1] In the meantime, China has entered the stage of high-quality development[2] and is more eager for talents than at any other time in history[3]. The urgency of independent innovation is unprecedented.[4] Sinopec takes becoming the world leading clean energy chemical company as its vision and goal, speeds up to build an industrial pattern of "One Foundation of energy and resources, Two Wings of clean fuels and advanced chemical material and Three New Growth Drivers of new energy, new materials and new economy". We strengthen our corporate development with talents and lead the company future with technologies. The Group Chairman personally deploys, promotes and supports talent development, and attaches great importance to the training of innovative talents, especially those young talents leading the future development. Group Executives participate in education and training activities more than 40 times a year. We have established a leading team to further strengthen the top-level design and overall management of education and training, and put forward a systematic plan for the education and training of all employees in the past five years. We implement the Zhaoyang Program for 150,000 young talents within the whole group, integrate recruitment, training, employment and incentives, and accelerate the all-round growth of young outstanding talents.

The Zhaoyang Program focuses on serving the development strategy of the enterprise. Starting from new college graduates, it carries out progressive training for eight years in three stages of "Daybreak Suns", "Emerging Suns" and "Rising Suns". The program step by step establishes and improves a systematic training, management and incentive mechanism for young talents, helps to form a good ecosystem of university-company cooperation, promotes the growth of enough young talents with competence and vitality, and cultivates a group of future scientific, technological and business innovation leaders for building a world-leading enterprise.

2 EXPLORING PATHS AND PRACTICE

Sinopec Zhaoyang Program relies on strategic guidance, focuses on the future, adheres to systematic planning, explores potential, sticks to innovative mechanism and forms joint force. It has carried out beneficial exploration and practice in talent training mode innovation, production, knowledge and research coordination, and training operation management optimization, through which we have accumulated a lot of valuable experience for training and education.

2.1 Systematic planning of the training path

We focus on cultivating future leading talents in science, technology and business innovation, follow the law of talent growth, and strengthen the combination of career planning and progressive training. Starting with new college graduates, we carry out step-by-step and systematic training for eight years in three stages (the implementation path is shown in Fig. 1). **Firstly, we implement the "Daybreak Suns" plan.** For new college graduates, it will take one to two years to consolidate their growth foundation through moral guidance, strengthening induction training, career planning, and implementing the measures of "masters leading apprentices". **Secondly, we implement the "Emerging Suns" plan.** It will take two to three years for budding young backbones to accumulate growth potential through professional training, grass-roots training, job rotation exchange and other measures. **Thirdly, we implement the plan of "Rising Suns".** It will take two to three years for the outstanding young elites to accelerate their growth through measures such as improving their realm, centralized training and on-the-job training. Nearly 10 thousand new graduates in the whole group are trained though the Zhaoyang Program each year. The headquarters organizes demonstration and field-trip training, with more than 2000 people intensively involved every year.

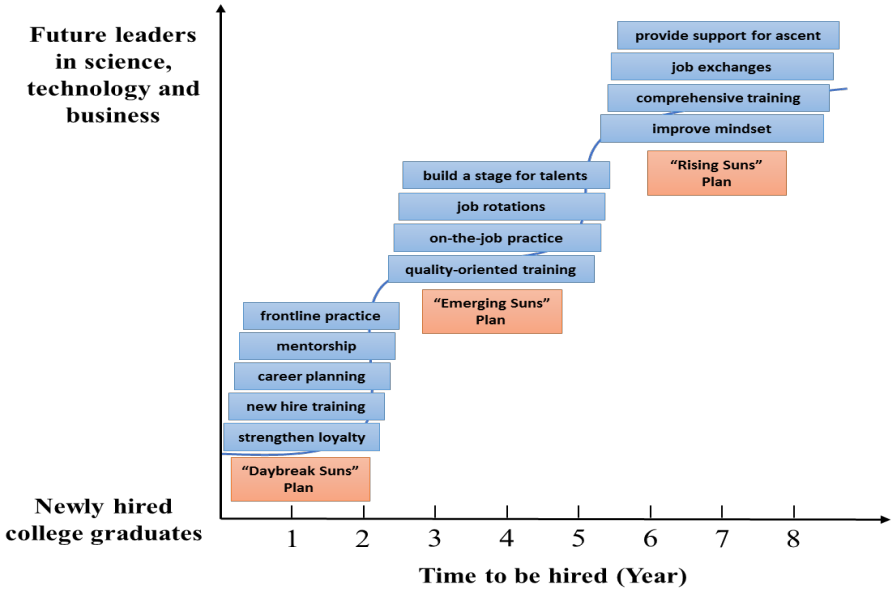


Fig. 1 Training Path for the Zhaoyang Program

2.2 Integrated and innovative talent cultivation model

We put the cultivation of young talents as a major strategic task, strengthen the introduction of college graduates, continuously select and train the talents, arrange outstanding young talents to experience major technological challenges and important positions, improve the appropriate incentive mechanism compatible to their positions, capabilities, and contributions, **explore the formation of a new talent training model that effectively dovetails introduction, training, utilization, and incentives, focus on the training and cultivation of future scientists, management elites, and outstanding engineers, and build more innovative stages for young talents.** Sinopec pays special attention to the combination of education, cultivation, and training. For example, a "specific policy for specific person" will be formulated based on career planning for newly recruited high-quality research talents, who will

be arranged to engage in important reform management activities, key technological research projects, and emerging business fields in a planned way. Through organizing scientific competitions among the young elites, we will select innovative talents and projects, strengthen compound training, mature employee instruction, and follow-up training for more than 200 young talents who stand out, and provide special incentives such as direct appointment as experts and research funding support to stimulate the dynamism of innovation and cultivate “future scientists” for the development of Sinopec.

2.3 University-company collaboration approach in talent cultivation

We adhere to the concept of talent cultivation cooperation among universities and the company, face the needs of future technological development and business innovation, follow the guidance of cutting-edge technological theories, center on solving practical problems, integrate various resources such as research institutions, universities, and companies in our industry, and establish an open and inclusive youth talent collaborative training system open for wide participation to achieve win-win cooperation. **Before enrollment,** Sinopec actively leverages the practical advantages as an industry leader and cooperates with more than 60 universities to build a platform for teacher-student practice and the application of technological R&D transformation for the students, so as to cultivate future technology leaders ahead of schedule from existing pioneers. For example, we established the Imperial College London-Sinopec Resources Geophysics Research Institute and the Tsinghua University-Sinopec Green Chemical Research Institute. **After the college graduates join the company,** Sinopec, Tsinghua University, Zhejiang University, and other universities have arranged more than 100 young talents to participate in the training as new energy and new materials strategic reserve team, setting up the platform of integration and innovation based on the academic advantages of the universities and the transforming capability of our industrial peers, cultivating innovation teams that integrate manufacturing, research, and application, catalyzing the basic and forward-looking technological achievements, and at the same time building new momentum for the strategic development of Sinopec’s new businesses. As a founding member of the International Association for Continuing Engineering Education and a council member of the China Association for Continuing Engineering Education, Sinopec closely works with professional organizations like the Chinese Chemical Society and the China Petroleum Education Association to actively participate in and drive forward continuing engineering education.

2.4 Improving the organization and operation of training

One of the key issues in cultivating leading talents in technology and business innovation in the future is to effectively stimulate the endogenous motivation of young talents to learn and develop independently. The organization and operation of Sinopec’s training programs accordingly pay more attention to learning for the future, teaching for the unknown, highlighting the combination of training and practical use, and integrating learning and application. For example, **in the training program for young management elites, as for the arrangement of contents,** the design of learning content is highly consistent with the actual application, and the typical frontier management scenarios and actual cases are well chosen, and teaching activities are organized according to the real working environment to help graduates grasp the transition from technology to management, and the solution and working methods of the business problems upon first entry into the field. **In terms of training and teaching methods,** a separate training model of “online self-study, centralized training, project practice, and oral defense assessment” is adopted. After centralized training, action learning is carried out in the following 3 to 6 months through project practice, and such training is closely related to the strategic focus and challenges of Sinopec, delivering management cases and solutions. **Regarding the form of training organization,** the empowerment training, job rotation, and practical training will be arranged in a holistic way. More than 3000 outstanding young talents have been selected to different units, business sectors, overseas projects, and front-line positions in various and remote areas to sharpen their ability in solving real problems.

2.5 Continuous improvement of the training quality

Sinopec has continued to strengthen the training quality management, training evaluation and training review to improve the training quality and results. **For training projects,** Sinopec used comprehensive evaluation tools such as 360-degree evaluation feedback and Kirkpatrick Model for various training projects, courses and teachers to carry out evaluations at the reaction, learning, behavior, and result levels, analyze the gaps between the training results and expected goals, reflect on problems, accumulate valuable experience, and promote iterative upgrading of training programs. **For the trainees,** Sinopec has strengthened the follow-up evaluation. For the key training projects of more than

one month, the follow-up evaluation of the trainees have been carried out in 6 months or 1 year after the training, on the behavior changes and performance improvement of the trainees to better training through evaluation. **For the training work,** Sinopec, on the basis of standardizing the operation and management of training projects, has strengthened the guidance for youth training throughout the company by formulating 9 measures and setting up 2 guidance groups who lived and studied together with the trainees and conducted a comprehensive follow-up evaluation and supervision of the training of young talents. In this way, training programs and models have been further refined and continuously improved.

2.6 Gathering all advantageous resources

Advantageous resources, both domestic and foreign, online and offline have been gathered through platform integration, international exchanges and talent co-creation, providing strong support for the training of future leaders in technology and business innovation. Sinopec has established multi-level, multi-field and multi-dimensional international exchanges and cooperation with world-renowned universities, scientific research institutions, leading enterprises and pioneering scientists. Outstanding young talents have been selected for academic visits and exchanges, hence creating a first-class international training environment. For example, more than 300 young talents have been selected through the international operation and management talent training program to take training in world-renowned university organizations such as Hult-Ashridge Business School in the past five years thanks to the strategies of "bringing in" and "going out". Moreover, they have been sent to Sinopec overseas subsidiaries to broaden international vision and participate in multinational operation. Sinopec advocates "lifelong learning". In 10 years' time, an industry-leading digital learning management platform - Sinopec i-Academy has been built, gathering more than 2,000 full-time training teachers and opening over 20,000 high-quality courses. Learning zones in different professional fields help young talents access learning resources anytime, anywhere, making learning more convenient, efficient and targeted. Sinopec has established a mechanism for continuous investment of funds and resources to provide a solid guarantee for the training of young talents and the formation of a sustainable development model.

3 OUTCOME AND OUTLOOK

In the past five years, Sinopec has incorporated the "Zhaoyang (Morning Sun) Program" for young talents into the overall planning of the group's talent work, used various measures to stimulate the growth potential and creative vitality of young talents, and established a normalized training mechanism for young talents connecting different management levels and requiring long-term attention. Sinopec has built a working mechanism of normalized discovery, dynamic management, systematic training, diversified use, and collaborative service, making contributions to cultivating a group of future leaders in technology and business innovation, developing a group of strategic and forward-looking key technologies, and forming a number of new models of talent training. As a result, Sinopec formed a benign ecosystem in which everyone can become a talent and make the best use of their talents. The proportion of middle-level managers under the age of 40 has reached 18.4%, and the number of experts under the age of 40 has reached 260. In the past 5 years, 85 young talents have won the national technologies and talents awards. 398 young talents have won the Sinopec Young Scientific and Technological Talent Award. 390 young talents have won the Sinopec Gold Award of the Vocational Skills Competition. More than 1000 young talents have won the Sinopec Outstanding Young Talents Award. Sinopec has cooperated with universities such as China University of petroleum, Beijing University of Chemical Technology, and has made innovative breakthroughs in the field of original technologies such as ultra-deep oil and gas exploration and development, functional film. 28 cooperative projects have won national and international awards such as the National Science and Technology Progress Award. The training model for young engineers in the refining process won the Excellent Practice Award of the International Talent Development Association.

Facing the future, Sinopec will continue to promote the strategy of strengthening the enterprise with talents, implement the "Zhaoyang Program" for young talents, accelerate the comprehensive and sound growth of young talents, gather the continuous innovation force to build a world-leading enterprise, and make Sinopec's own contributions to accelerating the construction of a global talent center in China and promoting innovation.

REFERENCES

[1] WANG Yiming. (2021). Changes Unseen in a Century, High-Quality Development, and the Construction of a New Development Pattern. Journal of Management World (12), pp. 1-12.

[2] ZHANG Yang, XIE Ningyu, HAN Qingyan. (2022). Research on the Measurement and Spatial Difference of China's High-Quality Economic Development Level. Statistics and Decision (1), pp. 103-107.

[3] HOU Jianguo. (2022). Building a Contingent of High-Level Scientific and Technological Talents. Defence Industry Conversion in China (2), pp. 54-56.

[4] CHEN Jin, YANG Zhen, YIN Ximing. (2021). China's Science and Technology Innovation Strategy under the New Development Pattern of "Dual Circulation". Modern Economic Science 43(1), pp. 1-9.

LOOKING BEYOND FIDDLERS GREEN COLLEGE: SOCIAL JUSTICE IN WORKFORCE ENGINEERING EDUCATION PATHWAYS

Ryan Lundell[1], Jonathan Montoya[2], Forest Peterson[3], Anthony Kinslow II[3], Renate Fruchter[4], Martin Fischer[3], Andres Sebastian Bustamante[5], Pedro Nava[1]

[1] School of Education, Santa Clara University (United States)
[2] Digital Learning Lab, University of California Irvine (United States)
[3] Center for Integrated Facility Engineering, Stanford University (United States)
[4] Project Based Learning Laboratory, Stanford University (United States)
[5] STEM Learning Lab, University of California Irvine (United States)

Abstract

Too often, research into postsecondary workforce and engineering education focuses solely on curricula and ignores student matriculation to high-skill high-wage careers. The purpose of this study is to investigate this subject through dual ethnographies in Project-Based Learning (PBL) Career and Technical Education (CTE) workforce pathways in Silicon Valley. This study looks to better explain functioning pathways. The authors take inspiration from three publications: past research found that seven PBL essentials form good learning outcomes [1]; a measurable outcome of PBL is higher attendance [2]; to which Applied STEM CTE (AS-CTE) [3] framed attendance as a predictor metric of the efficacy of a workforce pathway. We ask which metrics help explain successful workforce CTE pathways. Our ethnography uncovers two distinct postsecondary PBL pathways and explores a new predictive metric of social mobility, which helps to reveal the pathways' struggle to support marginalized students' mobility into the high-skill high-wage building workforce. Despite these challenges, a Labor-Union-administered apprenticeship pathway showed promise in aiding social mobility. The authors uncovered early evidence that social mobility may be added as a metric to a predictive ontology framework of pathway success.

Keywords: Social mobility, Engineering education, Workforce pathways, Equity, Virtual design and construction

1 INTRODUCTION

Despite the fact that Silicon Valley is one of the most technologically advanced regions in the world, entire groups of people are prevented from partaking in this prosperity. Just as the technology industry attracts the best talent globally, technical trades taught in the workforce postsecondary Career Technical Education (CTE) industry also draw talent. Highly skilled workers are in ever-increasing demand to construct the massive mixed-use development projects in the San José region. For many, the high-skill CTE pathway is the pathway to high-wage prosperity.

Employing ethnographic methods as postsecondary Applied Science Technology Engineering and Mathematics (STEM) CTE (AS-CTE) instructors, the investigators observed that many students did not achieve their goal of social mobility to high-skill, high-wage jobs. These observations necessitate further inquiry to address that lack of student matriculation into that high-wage high-skill workforce. Practitioners and theorists must first acknowledge large systemic barriers to success in order to ensure program efficacy and to also include historically marginalized groups in these successful pathways.

Historically, high-skill trades were learned through trade Union–mentored apprentice programs. Versions of workforce training have taken many forms, and the investigators are attuned to the past exploitation of non-union vocational programs that largely targeted Black, Indigenous, and People of Color (BIPOC). These programs did not provide social mobility. We must be clear that the investigators are not promoting this toxic form of workforce education, nor are we advocating for a 'cheap' labor force.

2 PROBLEM STATEMENT

The investigators predict the observed lack of social mobility is due to leaks in the education system. The purpose of this study is to investigate the postsecondary AS-CTE workforce pathways in the San José region to uncover additional metrics that help explain successful workforce pathways.

3 REVIEW OF POSTSECONDARY SUCCESS METRICS

Research on Applied STEM Career and Technical Education (AS-CTE) typically frames vocational education success through input metrics like motivation [2], and administrative qualities like leadership [3]. Plasman and Gottfried [1], employing a case of AS-CTE, used attendance as an input metric predictor of a successful workforce pathway. The investigators draw from underpinning concepts in AS-CTE to guide their formalization of a metric framework that shows an improvement in predictive efficacy for academic success, building on Plasman and Gottfried's contribution of an attendance metric.

3.1 Critique of workforce education

There is currently a movement to rebrand the CTE or vocational education pathways for high-skill labor to attract more diverse students. The unfortunate reality is that despite this attempt, these pathways cannot escape their toxic past. For many years, vocational institutions have exploited people locally and abroad. Domestically, this victimization and exploitation included Indigenous youth and other BIPOC groups [6]. In order to truly address these issues in workforce pathways, we must first accept and acknowledge injustices such as historical tracking and exploitation of marginalized groups in vocational institutions. Many training centers or vocational schools were created for proletarization. In workforce vocational education, the personification of proletarization can be seen in high-tech manufacturing industries where exploited workers help produce commodities that they cannot afford. The necessary rebranding of high-tech CTE is evident in fields such as cybersecurity, and coding, where these fields are being rebranded to attract and retain a more diverse workforce [34]. This attempt at rebranding and attraction may be the birth of a new era of vocational education, which continues to exploit a new version of high-skill workers.

3.2 Historical views of CTE certifications

The workforce education system aims to develop human capital. Domestically, this is completed through the community college system, which educates 40 percent of American undergraduate students [9]. Community colleges focus on credentials that categorize workers, assigning them different values from a historical lens. Groeger [10, 11]—in extending Human Capital Theory—posits that craft employers see this education as a metric of human capital. The investigators are aware of these origins and the role of credentials and certifications. Although the investigators are well aware of this framing, we do not wish to view this study through a lens of Human Capital Theory. The investigators are inspired by Groeger's [11] problematizing of human capital theory and their critique of credentialism. Following the lead of Groeger [11], the investigators question an actualization of human capital for the marginalized.

Viewing CTE history through a critical lens, the investigators entered their ethnographies of the Silicon Valley postsecondary AS-CTE workforce education centers to develop and teach an AS-CTE course.

4 STUDY METHODOLOGY

4.1 Experiment setting

The investigators studied the role of predictive ontology metrics such as social mobility through ethnography [12] and examples gained through a community-based participatory research approach (CBPR) [13]. This CBPR is part of a larger project [15, 17, 18] that includes community participants such as Union leadership, policymakers, and industry practitioners. The CBPR is collectively known as the Santa Clara County Construction Careers Association (S4CA). The investigators' methodological approach does not attempt to interject a fictional perfect reality into our observations [11, 13]. Rather, we look to understand a pragmatic reality, and then explain that reality and apply the explanation in a useful way [16]. The ethnography was operated through investigator roles as classroom instructors in postsecondary Problem-, Project-, Product-, Process-, People-based Learning (5-PBL) [19] educational settings in community college, apprenticeship, and adult education: note that in a quick census this is the only PBL program the investigators found in Silicon Valley public education. PBL industry mentor role provided the investigators an additional observatory perspective along with the CBPR participants which contributed as industry mentors.

The investigators are informed by their larger lived experiences. Before their roles as investigators in university settings, they were laborers [36, 37]. During these years-long experiences, they took on leadership roles where they were recognized by their fellow workers as 'lead' laborers—carpenter

material handler and concrete laborer respectively—taking on responsibilities including mentoring new laborers. That lived role allowed for insight and brought a legacy of unique relationships, which facilitated access to this academic setting.

4.2 Research-practice partnership

The RPP includes educators from four high schools, three community colleges, eight apprenticeship programs, an adult education program, and two universities. This paper, and hence these partnerships, focus primarily on the postsecondary education institutions.

4.3 Participants

This study relies on data from participating students, instructors, and mentors. The participants were recruited from two community colleges which we have combined and assigned the pseudonym Fiddlers Green College. Participants also come from an apprenticeship education center which we call the Pipe Trades Education Center.

The community is located in the San José region of Silicon Valley. Regional demographics are approximately evenly divided between Latinx, Asian, and white. As one of the most linguistically diverse regions in the country [20], more than half of households primarily speak languages other than English.

Our participants primarily live in a lower-income working-class community where feeder school demographics are 50 percent low socioeconomic status, which qualifies these students for free and reduced-price meals in K-12 schools. Although distinctly working-class and racialized, the students are high-performing with their public schools ranked among the best in the state and country.

5 ETHNOGRAPHY-INFORMED STUDY

In order to address barriers and inequities in workforce pathways, the investigators explored the social mobility of these pathways through taking on roles as associate faculty members at two local community colleges collectively called Fiddlers Green [22]. We define social mobility as the students' perceptions that their education can award them a living wage career ($ 60.29 – $ 117.60 per hour [36]) and a viable pathway to a higher education [17]. The Applied STEM CTE (AS-CTE) courses taught implemented a social and environmental justice–focused virtual design and construction curriculum [12, 25, 26, 27, 28, 29, 17, 30, 31, 32, 18, 33]. The course is a stepping stone from a 2-year associate degree to a 4-year bachelor's degree: course content includes engineering tools such as ALICE Technologies BIM (Building Information Model) tools for preconstruction (5D BIM) and management (6D BIM) [33].

5.1 Interaction with a college student

The following narrative explores the experiences of one student who represents the many shared experiences of students in these pathways.

The quote below is an account of an instructor/investigator's first encounter with a postsecondary student outside a classroom at Fiddlers Green College. The student shares their reasoning for attending the postsecondary CTE course.

> *Although they did well in high school (secondary) and had completed a CTE education program, they could not find a job. In their opinion, the college's residential construction framing course would give them an opportunity to secure a 'good job.' I asked if they ever considered an apprenticeship. They said no. The student preferred community college because they could work during the day.*

This was a high-performing student in their late twenties. The student had perfect attendance in their secondary and postsecondary courses. This student is a product of the secondary school which acts as a feeder CTE program for the pipeline from secondary to postsecondary workforce education in the region. Despite filling all the requirements to transition to a career-centered postsecondary education pathway and subsequent career, this student was still taking courses at community college well into their late twenties. They were also working an unrelated low-wage job to supplement their career education. This lack of matriculation can be the result of many factors, but we must acknowledge the lack of articulation which works to hinder the social mobility of this student and others like them. Their pathway thus far has not led to the promised high-skill, high-wage workforce identified as the end goal of college CTE programs.

Below, an instructor/investigator describes arriving at a Fiddlers Green classroom early and waiting outside, which allowed them to have conversations with several students. Their individual and collective stories were very similar to this student and representative of many others. The instructor discusses the issue of limited enrolment capacity, and the instructor/investigator ethnographer describes their concern for the students who showed up for the course only to be turned away.

> *With enthusiasm, students asked if they would be able to add the class. The senior instructor replied that they were not sure how many could add and to show up next week. They then released the group and proceeded to explain to me that we needed to cap the class at 18 students. I thought it was important to let them know there would be no additions and not to waste their time. The senior instructor's response: just tell them next week.*

It is not uncommon for community college CTE programs to be heavily impacted, but this interaction highlighted a potential roadblock for students. Programs' lack of transparency about the reality of their policies provides more barriers for students. Unfortunately, many students returned to the following course and were turned away. This instructor did not see their time as valuable. A complete disregard for students' time seemed to permeate much of the postsecondary CTE program at Fiddlers Green. There were many instances where the instructors made it clear that they were not invested in accommodating students' schedules. Student needs in scheduling were not adequately considered. More importantly, the instructors were not transparent about the program's expectations and policies. The attitudes and subsequent policies created inequitable programs where many of these students were left in limbo, consistently a few courses away from certificates and degree completion. The completion of these programs would theoretically give them the credentials to gain access to the high-skill, high-wage job market. These experiences revealed that the labyrinthine pathway to work and career still has many forks and blocks, and that its outcomes are often unfair.

5.2 Interaction with a college administrator

Fiddlers Green's response when asked how many students have petitioned for an associates degree in construction technology this past year.

> *There are typically nine per year of Associate of Science and Art combined.*

Despite this information, the investigators could not actually find a case where a student had completed their college workforce program. The investigators had themselves automatically received an Associate in Art when they petitioned for an Associate in Science—it was not clear if the nine degrees issued were to nine distinct students or to only five students.

5.3 Interaction with a pipe trades administrator

At the Pipe Trades Education Center, the investigator's role is that of a guest to observe an often-unseen reality in CTE education. The Center is administered by a trade Union, and without a specific reason to be on that site, you would not know it exists. A complex of clean, low-rise education buildings is tucked away adjacent to a commercial zone, with a solidly constructed iron fence protecting the site.

The investigators interacted with students and administrators, revealing that an apprenticed pipe trades journeyperson makes over 130 percent of the regional mean income. In addition, they have pension-protected benefits, hiring hall, Union-negotiated labor standards and job protections, as well as continued skills development.

The following quotes are from discussions with an administrator about student matriculation.

The administrator describes how current pathways make it difficult for students to transfer to higher education.

> *There should be a new pathway for journeypersons graduating from the building trades to earn a bachelor of science degree—the current pathways don't fit their needs as first-generation students navigating through transfer requirements to various university systems.*

The structure of postsecondary pathways hurts the ability of first-generation students to obtain advanced degrees. One of the main purposes of education institutions should be to promote social mobility for marginalized groups. In such a vital sector of the Silicon Valley economy, we should have a clear and

sustainable pathway that meets the needs of all community members; without this pathway, we limit access to jobs that pay a living wage and strengthen the middle class.

The administrator describes the success of the Pipe Trades Education Center in their formal partnership with a Local Educational Agency (LEA) and adds a vision for the future.

> *Right now, the Pipe Trades Education Center graduates each year a handful of apprentices (less than a dozen) that have successfully petitioned for an associate of science; however, in each of the next years, there will be increasingly more graduates as the students that started the first year of the new associate pathway complete the last year.*

Although more data must be gathered, the Pipe Trades Education Center has initially created a successful pathway for students to enter postsecondary education. Using the Pipe Trades Education Center as a model, the building trades industry in Silicon Valley can create successful pathways that promote social mobility for marginalized groups.

6 DISCUSSION

This study reveals a lack of both social mobility and perceived social mobility for students meeting all other success metrics.

The collective narrative of these students reveals a contradiction between how the workforce is displayed and the objective realities of historically marginalized students: social mobility is symbolic and not actual. The failure of the community colleges to create a functioning pathway contributes to the predatory lending of for-profit education institutions: since the community college is a bureaucratic labyrinth that is difficult to escape, students become easily swindled by the provocative marketing of these for-profit institutions and their empty promises of social mobility. The result has been student debt with no promise or hope for a job after graduation. In the end, students may be able to gain cultural capital through certifications, but they are unable to convert that cultural capital to economic capital [38]. The Pipe Trades Education Center has begun to offer a counter-narrative, where social mobility is seen as a defining metric of success along with attendance. For an equitable workforce, we must reflect upon the historical roots of workforce pathways and avoid superficial improvements of past wrongs. To change systemic problems, we need changes to the system. Let us first discard traditional instructions and take only what is useful to avoid perpetuating historical injustices. The Pipe Trades counter-narrative reveals that intentional pathways can lead to a socially mobile workforce.

Classes articulated to postsecondary institutions, a living wage, and protections of health and safety might seem like a pipe dream; however, this reality exists in trade education at the authors' regional Pipe Trades Education Center.

This study sheds light on how postsecondary Career Technical Education (CTE) institutions fall short of their mission to increase employment and social mobility for students from marginalized communities. Historically, access to education is not enough [10]. Unequal access to education credentials sustains a privileged ruling class [11]. The demographic breakdown of these inequalities is seen in neighborhoods throughout Silicon Valley [17]. This study examines possible correlations and connections between inequities in the built environment and postsecondary CTE facilities.

If we understand the inequities present in society and how postsecondary institutions generate social mobility, then we can begin to discover the best practices to change these inequities. Motivated by a solidarity to their community, the authors aim to inform and involve community stakeholders so institutions facilitate their workforce's mobility. Too often, underrepresented minorities and/or low-income individuals are burdened by social and environmental injustices that impact livelihood and lack of mobility. In high-tech regions like Silicon Valley, residents are exposed to environmental stresses and contaminants that negatively impact the health of the community [17]. Furthermore, many live with neurotoxins like lead paint, carcinogens like asbestos, or in close proximity to brownfields and manufacturing facilities of unknown and mixed pollutants [21].

The authors explored pathways from the apprenticeship to regional university undergraduate programs. In discussion with the apprentice education center's local educational agency administrator, the investigators discovered a newly-formed pathway which has potential to become a successful pathway for marginalized students to enter higher education: academic credit is given for knowledge gained through high-skill apprenticeship education. However, despite the initial success of this pipe trades pathway, more work must be done. For example, academic hegemony demands that students meet the

needs of the institutions that serve them instead of the institutions considering the needs of the students. This approach results in a complex pathway that limits the opportunity for the most marginalized community members to enter a highly skilled and socially mobile workforce. These pathways could adopt more horizontal power structures and let communities lead to meet their diverse needs. One way to work towards this is to schedule courses around student need rather than faculty convenience, with an occupationally aligned trade union administering the education center. Lastly, with no meaningful data and no alignment between apprentice programs and community colleges, Silicon Valley building and trades pathways have not maximized their ability to integrate marginalized community members into middle-class jobs.

Union apprenticeship programs—such as the Pipe Trades Education Center—are an apparent pathway to a higher education degree. When students understand concepts such as social justice, they begin to believe deeply in social mobility. The skilled apprentice described in this paper would never be allowed to teach even a CTE community college course; in contrast, even though the investigators knew nothing specifically of the topic they were teaching, their advanced degrees allowed them to teach community college classes.

7 LIMITATIONS

Due to their positionality and particular lens, the investigators understand that these ethnographies have limitations in generality and blindness; thus, this study should not be generalized beyond its unique setting. The investigators go in-depth with specific students and experiences in their unique pathway; thus, while every effort is made to accurately describe their students' experiences in the pathway, blind spots and misinterpretations will inevitably occur. Lastly, the investigators provided extensive pre-experiment education in VDC and PBL to the regional CTE construction instructors so that they could collaborate with the RPP by administering a 5-PBL VDC program; however, once the investigators exited the ethnography, the pathway program was not sustainable.

8 ACKNOWLEDGEMENTS

This work was supported by the ECMC Bridging the Gaps to Postsecondary Career and Technical Education fellowship. Thank you to Professor James Bartlett and Professor Michelle Bartlett from North Carolina State University. This paper is a substantial revision with updated and new content of versions of this paper titled "It's Just a Pipe Dream: Equitable Workforce Pathways For Silicon Valley," which was published as a research gate preprint, and a journal article titled "Fiddlers Green College: Looking for Equitable Workforce Pathways in Silicon Valley," which was published in the Journal of Problem Based Learning in Higher Education.

REFERENCES

[1] Amaral, A., Gonçalves, P., & Hess, A. (2015). Creating a project-based learning environment to improve project management skills of graduate students, *Journal of Problem-based Learning in Higher Education*, 3(2), 120–130.

[2] Creghan, C., & Adair-Creghan, K. (2015). The positive impact of project-based learning on attendance of an economically disadvantaged student population: A multiyear study. *Interdisciplinary Journal of Problem-based Learning*, 9(2). https://doi.org/10.7771/1541-5015.1496

[3] Plasman, J. S., & Gottfried, M. A. (2020). School absence in the United States: Understanding the role of STEM-related vocational education and training in encouraging attendance. *Journal of Vocational Education & Training*, 1–23. https://doi.org/10.1080/13636820.2020.1765841

[4] Lee, J., & Stankov, L. (2018). Non-cognitive predictors of academic achievement: Evidence from TIMSS and PISA. *Learning and Individual Differences*, (65), 50–64.

[5] Bartlett, J. E., Bartlett, M. E., Dolfi, J. J., Jaeger, A. J., & Chapman, D. D. (2018). Redesigning the education doctorate for community college leaders: Generation, transformation, and use of professional knowledge and practice. *Impacting Education: Journal on Transforming Professional Practice*, 3(2). https://doi.org/10.5195/ie.2018.80

[6] Lomawaima, K. T. (1996). Estelle Reel, superintendent of Indian schools, 19891910: Politics, curriculum, and land. *Journal of American Indian Education*, 35(3), 5–31.

[7] Hardt, M. (1999). Affective labor. *Duke University Press, boundary 2*, 26(2), 89–100.

[8] Vora, K. (2015). Call center agents, *Life support: Biocapital and the new history of outsourced labor.* University of Minnesota Press. https://doi.org/10.5749/minnesota/9780816693948.003.0003

[9] Budd, D. (2018, March 17). Explaining the role of community colleges. *School's In Podcast*, Stanford University Graduate School of Education.

[10] Groeger, C. V. (2017). Paths to work: The political economy of education and social inequality in the United States, 1870–1940. Doctoral dissertation, *Harvard University, Graduate School of Arts and Sciences*.

[11] Groeger, C. V. (2021). *The education trap: Schools and the remaking of inequality in Boston*. Harvard University Press.

[12] Hartmann, T., Fischer, M., & Haymaker, J. (2009). Implementing information systems with project teams using ethnographic-action research. *Advanced Engineering Informatics*, 23(1), 57–67. https://doi.org/10.1016/j.aei.2008.06.006

[13] Minkler, M., & Wallerstein, N. (Eds.). (2011). Community-based participatory research for health: From process to outcomes. *John Wiley & Sons*.

[14] Kliewer, C., Fitzgerald, L. M., Meyer-Mork, J., Hartman, P., English-Sand, P., & Raschke, D. (2004). Citizenship for all in the literate community: An ethnography of young children with significant disabilities in inclusive early childhood settings. *Harvard Educational Review*, *74*(4), 373–403. https://doi.org/10.17763/haer.74.4.p46171013714642x

[15] Montoya, J., Peterson, F., & Bonilla, S. (2020). Opportunity gap and women in the energy infrastructure workforce: Educate for the future, *PBL, Sustainability and Digitalisation 2020*. (1. ed.) Aalborg University. International Research Symposium on PBL.

[16] Bernstein, R. (2013). The pragmatic turn. *Hoboken, NJ: Polity*.

[17] Montoya, J., Lundell, R., Peterson, F., Tarantino, S., Ramsey, M., Katz, G., Fruchter, R., Fischer, M., & Baldini, R. (2018). Building sustainable communities: A project-based learning approach to modify student perceptions of the building industry. *ACEEE Summer Study on Energy Efficiency in Buildings*, Asilomar conference center, Pacific Grove, CA.

[18] Tarantino, S., Peterson, F., Cooperman, A., Struthers, N., & Fischer, M. (2016). Community scale research-based integrated education experience, *Proceedings of the ACEEE summer study on energy efficiency in buildings*, Asilomar conference center, Pacific Grove, CA.

[19] Fruchter, R. (1998). Internet-based web-mediated collaborative design and learning environment. In: Smith, I. (eds) *Artificial Intelligence in Structural Engineering. Lecture Notes in Computer Science*, vol 1454. Springer, Berlin, Heidelberg. https://doi-org.stanford.idm.oclc.org/10.1007/BFb0030448

[20] McCann, A. (2021, February 17). *Most & least ethnically diverse cities in the U.S - wallethub*. Wallet Hub. Retrieved March 25, 2022, from https://wallethub.com/edu/cities-with-the-most-and-least-ethno-racial-and-linguistic-diversity/10264

[21] Hall, D. M., Čustović, I., Sriram, R., & Chen, Q. (2022). Teaching generative construction scheduling: Proposed curriculum design and analysis of student learning for the Tri-Constraint Method. *Advanced Engineering Informatics*, 51, 101455. https://doi.org/10.1016/j.aei.2021.101455

[22] Pimentel, B. (2004). The valley's toxic history / IBM trial is latest round in long-running dispute over the tech industry's environmental record, SFGATE.

[23] Schlanger, Z. (2017). Silicon Valley is home to more toxic Superfund sites than anywhere else in the country, Quartz.

[24] Stewart, I. T., Bacon, C. M., & Burke, W. D. (2014). The uneven distribution of environmental burdens and benefits in Silicon Valley's backyard. *Applied Geography*, 55, 266–277. https://doi.org/10.1016/j.apgeog.2014.09.016

[25] Willis, P. E. (1977). Learning to labour: How working class kids get working class jobs. *Farnborough, Eng: Saxon House*.

[26] Barg, S., Flager, F., & Fischer, M. (2020). A design-focused, cost-ranked, structural-frame sizing optimization, *Journal of Building Engineering*, 30.

[27] Bick, I. A., Santiago Tate, A. F., Serafin, K. A., Miltenberger, A., Anyansi, I., Evans, M., Ortolano, L., Ouyang, D., & Suckale, J. (2021). Rising seas, rising inequity? Communities at risk in the San Francisco Bay Area and implications for adaptation policy. *Earth's Future*, 9(7).

[28] Brosque, C., Skeie, G., & Fischer, M. (2021). Comparative analysis of manual and robotic concrete drilling for installation hangers, *Journal of Construction Engineering and Management*, 147(3).

[29] Fischer, M. (2006). Formalizing construction knowledge for concurrent performance-based design. *Lecture Notes in Computer Science*, Springer Berlin Heidelberg, 186–205. https://doi.org/10.1007/11888598_20

[30] Garcia-Lopez, N. P., & Fischer, M. (2014). A system to track work progress at construction jobsites. In *IIE Annual Conference. Proceedings* (p. 3403). Institute of Industrial and Systems Engineers (IISE).

[31] Peng, B., Flager, F., Barg, S., & Fischer, M. (2021). Cost-based optimization of steel frame member sizing and connection type using dimension increasing search. *Optimization and Engineering*, 1–34.

[32] Peterson, F., Hartmann, T., Fruchter, R., & Fischer, M. (2011). Teaching construction project management with BIM support: Experience and lessons learned. *Automation in Construction*, 20(2), 115–125. https://doi.org/10.1016/j.autcon.2010.09.009

[33] Song, M. H., & Fischer, M. (2020). Daily plan-do-check-act (PDCA) cycles with level of development (LoD) 400 objects for foremen. *Advanced Engineering Informatics*, 44.

[34] Tayag, M., Silver Taube, R., Mondina, F., Nasol, K., Kinslow, A., II, & Peterson, F. (2021). Wage theft in low-wage industries: mixed methods research in Silicon Valley, *Center for Integrated Facility Engineering*, Working Paper #147, Stanford University.

[35] Sax, L. J., Newhouse, K. N., Goode, J., Nakajima, T. M., Skorodinsky, M., & Sendowski, M. (2022). Can computing be diversified on “Principles” alone? exploring the role of AP Computer Science courses in students’ major and career intentions. *ACM Transactions on Computing Education*, *22*(2), 1–26. https://doi.org/10.1145/3479431

[36] California Department of Industrial Relations. (2022) General prevailing wage determination: Index 2022-1 Northern California basic trade journeyman rates.

[37] California Department of Industrial Relations. (2021) Current residential prevailing wage determinations.

[38] Cottom, M. M. T. (2016). *Lower ed: How for-profit colleges deepen inequality in America*. The New Press.

Paper World Conference 2022 Buffalo

A PANORAMIC VIEW OF THE STATE OF CONTINUING ENGINEERING EDUCATION IN EUROPA

The development and future insight

Bente Nørgaard[1], Katriina Schrey-Niemenmaa[2], Ellen Sjoer[3], Ragna Ann Berge[4], Aniko Kalman[5], Kirsti Miettinen[6],

[1]Aalborg University, DENMARK
[2]Academic Engineers and Architects, FINLAND
[3]The Hague University of Applied Sciences, THE NETHERLAND
[4]Norwegian University of Technology and Sciences, NORWAY
[5]Budapest University of Technology and Economics, HUNGARY
[6]Rastor-instituutti, FINLAND

The European countries have national education strategies and policies. Although, those who are members of the European Union, have some mutual policies and shared funding opportunities e.g., the Erasmus+ Program for Education which to some extent affects and guides research and development within CEE. But how CEE activities are organized and practiced is unique for the individual European countries, just as there may be national variances among education institutions. This paper will point at the current state for CEE in five European countries and elicit trends in organization, activities, and practices, drivers and barriers for development of CEE.

Keywords: Europe, CEE policies, CEE strategies, CEE practices, CEE organization

1. Introduction

This paper takes a panoramic view of the state of the Continuing Engineering Education (CEE) in Europe. In the countries, Finland, the Netherlands, Hungary, Norway, and Denmark many of the challenges are similar. Who should take care of the professional development? How to reach the professionals needing more education? Who should cover the costs, who should organize the education? What is the responsibility of the universities in relation to their alumnae - does it end with the graduation, or does it continue throughout life? What is the knowledge transfer responsibility of the universities? These are some of the questions that need to be answered to meet the needs of CEE. As various global organizations like professional bodies, industrial and educational organizations, World Economic Forum, United Nations etc. have recently highlighted the rapidly growing need of continuing professional development. This covers competences of working in multi-professional teams, solving complex challenges for a sustainable global digital world – where global trade works in peace despite diversity of values, religions and cultures. The data for the study has been collected from reviewing diverse and numerous resources such as surveys, interviews, documents, case studies, etc., all with the common denominator that they relate to CEE in a broad European perspective or with a specific elaboration of CEE in Finland, Hungary, the Netherlands, Norway, and Denmark. In the following chapters, some thoughts from each of the above countries are shared. What is happening now and how has CEE developed in recent years? Where are we headed in our efforts to facilitate CEE?

2. The Netherlands

National strategy on Lifelong development

The national strategy aims to achieve a breakthrough in the field of lifelong development resulting in vital people who can be deployed flexibly and sustainably on the labor market. The core of the lifelong development approach is to encourage and facilitate people to manage their own career. Measures have been proposed around the following four interrelated pillars: 1. Further strengthening the self-management of individuals; 2. Stimulating employers and social partners in learning and development (esp. in SMEs); 3. Flexibility of the offerings for learning and development; 4. Stimulating a learning culture (Kamerbrief 13-10-2020). Continuing engineering education at all educational levels is at the focus of the agenda since there is a shortage in many professions and sectors and this is being exacerbated by the climate and energy transition. Other, flexible, informal, and 'non-school' ways of development are stimulated (also financially), to accelerate innovations, for example with learning communities, and to target groups that are difficult to reach, using f.i. skills passports. One of the recommendations of the OECD Skills strategy report of 2017 was to ensure fostering more equitable skills outcomes. Although the Netherlands performs relatively well, certain groups have more limited opportunities to develop and fully use their skills and they struggle to find work and participate fully in society (OECD 2017, p. 2).

Institutional strategy on lifelong development
However, whether adults actually participate in learning and development activities depends on the *interaction* between aspects at the micro level (such as individual motivation, interest, previous learning experiences), meso level (such as educational offerings and learning culture) and macro level (such as national policy). The difference with a few years ago is that universities take more responsibility for lifelong development f.i. by making massive open online courses (MOOCS) to "open education and allow learners from all around the world, students as well as lifelong learners, to gain access to the universities' knowledge and expertise" (mission of TU Delft). Furthermore, flexible education is stimulated by modular contract education, and 'learning outcomes pilots' instead of fixed educational programs. Nevertheless, not all intended groups are easily reached. At The Hague University of Applied Sciences (THUAS), a program for lifelong learning was launched in 2019. The aim was to make existing part-time courses more flexible: in time and place, and more learning path independent, as well as detecting new opportunities for lifelong development. For example, 60 ECTS in separate modules have been developed in the Applied Data Science theme.

Challenges/opportunities in lifelong development
At THUAS, one of the biggest gains was that much more collaboration took place across faculties. Moreover, a new educational framework for lifelong development was created and pilots f.i. in micro-credentials have been carried out. Challenges in this transformation process towards flexible education for lifelong development are 1. Thinking in complete standalone modules requires a different way of designing and implementing education. The costs precede the benefits. 2. The organization's support systems are not tailored to delivering flexible education to professionals; 3. marketing and communication are not targeting employers (B2B) and employees yet. Finally, 4. current teachers are not used to facilitate learning to professionals or in some domains, such as IT, are hard to get anyway. "A lot of sacred houses will have to be helped over." Nevertheless, the future in education is flexible. A major operation is making all full-time education programs flexible in the Netherlands and allowing the interaction across the world, alongside accurate (tax) incentive measures, since all levels (micro, meso and macro) must be aligned to stimulate lifelong development.

3. Hungary

In Hungary, legislation on educational systems has undergone a change in the last 10 years in order that it should facilitate the development of work-based society. This is also demonstrated by the fact that Vocational Education 4.0 has been synchronized with Industry 4.0, and it has become the responsibility of the Ministry of Innovation and Technology together with higher education. The traditional approach to education has been renewed along two dimensions: with the definition of dual vocational training and the demands of the labor market: e.g., the school-leaving age of 16 years has also served this purpose. On the other hand, the rigid interpretation of age limits has also become more flexible: adult learning has become a realistic opportunity in the framework of both adult and vocational education. Registration is mandatory for everyone, but the accreditation requirement has been eased. Anybody can launch a training course except for the courses of reduced number advertised in the National Training Register, which can only be launched by the state.

A model change has been carried out in higher education: the effects are unknown yet, but several universities have joined the internationalization of education: teacher exchange, student exchange, hosting an increasing number of foreign students.

In this process, Budapest University of Technology and Economics (BME) has had initiatives in internal innovation (it is one of the universities not involved in the model change). Internal training has started: training of trainers, hosting large forums to discuss engineering education: organization of the 2019 SEFI conference, the university has signed several agreements for strategic cooperation with partner companies in the field of training. At the university, the focus has been shifted to elitist excellence, and classical adult education is less important. The university has joined common international engineering education, a good example of which is the EELISA project, launched in 2020.

BME has joined the EELISA project: The mission of the consortium is to create a new European education model through which to define the “European engineer.” EELISA aims to encourage knowledge and technology transfer, to apply a comprehensive approach to engineering education through interdisciplinary engineering learning. EELISA offers a variety of benefits for BME to strengthen its ties in education and research with prestigious European institutions by building an international community. The EELISA consortium is led by the Polytechnic University of Madrid and includes universities from Hungary, Germany, French, Italy, Romania and Turkey as members. The European Network for Accreditation of Engineering Education (ENAEE) is involved as an associated partner. EELISA mid-term objective is to ensure that 100% of students are engaged in the program at least at recognition level. The consortium already has its governing bodies in place and there are working groups carrying out operational duties where BME is also working on important tasks. BME set up an EELISA coordination body including representatives from all relevant key organizational units. The operational tasks of project implementation, similarly to the details of a shared syllabus, are developed by the working groups set up based on various themes and tasks. These working groups will address the issues of accreditation, communities, industrial traineeships, research, development and innovation, student life, mobility and education. The period of the pandemic promoted the development of online infrastructure, helping the operation, serving and maintenance of new forums later, as well.

In the Andragogy Subcommittee of the Hungarian Academy of Sciences, adult education has become a more focused on content element, and the profession has accepted the operation of MELLearn network (Higher education network for lifelong learning).

4. Norway

National and regional strategies on Lifelong Learning

The Skills reform whitepaper came in 2019 and was the start of a new, national focus on lifelong learning and the need of a workforce with needs of upskilling/ reskilling and states that *"Objectives of the Government's Skills Reform are that no one's skills become obsolete, and that the labor market has access to the skills it needs*". The year after was followed by the strategy for flexible and decentralized education at vocational colleges, university colleges and universities. The purpose of this strategy from the ministry of education and research was to increase access to flexible and decentralized high-quality education programs that are adapted to the various needs of the workforce as a whole and of individuals.

The new Government "Hurdal" platform stated *"We will focus on knowledge and practical learning throughout life…. Vocational subjects and practical education and skills will receive increased recognition. Efforts will be made on workers' skills throughout working life and a good, decentralized educational offer close to the regional and local labor market."*

There are many ongoing national processes, like the Finance Committee, the Competence Needs committee, the Admissions Committee, The Digitization Board and National Action Plan for digitization, to name some.

The regions have become more important in the role of education of the workforce, backed by the Competency Strategy for Norway. *Trondelag* is a partnership at county level with members from the county, public and private sector and vocational and higher education. The forum will ensure comprehensive and coordinated follow-up of the regions competence strategy (in Norwegian).

"*Trondelag is facing major changes in society and working life. In the years ahead, technology development, climate challenges, internationalization, changes in business structure, immigration and aging of the population will affect the skills needs in all areas of working life. The rapid changes in technology and working life indicate an increased need for lifelong learning*."

Institutional strategies/ plans at NTNU

NTNUs Strategy 2018-2025 Knowledge says: «*A development goal in the field of education is that NTNU will develop continuing and further education offers in interaction with working life… In collaboration with academic environments nationally and internationally, we have a relevant study portfolio for lifelong learning…. The close dialogue with working life is crucial for developing quality* "

In addition, NTNU has had two major projects for developing the education programs at NTNU: The Technology Studies of the Future and the future of the studies in humanities and social science. The Technology Studies of the Future was a two-year project finished December 2021 and is in these days "handed over" to the organization to follow up. The technology studies of the future should facilitate that NTNU's study portfolio in technology is in line with technology development, societal challenges and the needs of business and industry in the period from 2025 onwards. The project developed a recommended framework for NTNU's future study portfolio within technology at bachelor, master's and PhD level including lifelong learning. It includes the classical technology studies, mainly civil

engineering, and engineering subjects, as well as science and architecture, design, and planning subjects. The project is owned by the vice rector of education which also includes the project The Future's HUMSAM studies.

Lifelong learning competence is about developing good learning strategies, independent judgment ('evaluative judgment'), and the ability to both give, receive, and utilize feedback in a constructive and effective way ('feedback literacy'): [Competency profile 8 from the report] *It is about being able to assess the quality of one's own and others' work, reflect on strengths and weaknesses in one's own competence profile, be aware of one's own competence needs, take responsibility for one's own learning needs, and actively seek competence replenishment when the situation indicates it is needed.*

NTNU also has international collaboration which includes LLL through the Nordic Five Tech initiative with four other technological universities. Focus area 2: Developing our Educational Infrastructure: … "*Lifelong learning is an arena of increasing importance that is both in high demand from industry and prioritized by all of the alliance Universities*". …. "*N5T will greatly emphasis benchmarking and sharing of best practices within these areas*".

5. Denmark

National strategy on CEE

Since the beginning of 2000, Denmark has had various policies and initiatives to foster interaction between universities and its surrounding society. Activities that primarily support transfer of research to society and provide incitement to increase initiatives such as continuing education and lifelong learning activities. In 2003 the Minister of Science introduced a new proposal - '*New paths between research and business - from thought to invoice'* which became well known as the slogan *'from research to invoice'*. The basic idea was to increase Danish companies' opportunities to make money and grow by creating a strong flow of ideas from university research to private companies. Also, initiatives to increase spin-out business for universities were in focus.

With The Lisbon Strategy aiming for - '*the European Union in 2010 to become the most competitive and dynamic knowledge-based economy in the world - with more and better jobs'*. The member states were called on to develop coherent national strategies for lifelong learning by 2006 as an important contribution to achieving the ambitious goal. In the spring of 2006 a strategy, the Global Economy, was published with strategic goals for a six- and twelve-years period. The overall goal of the globalization strategy was to make Denmark a leading knowledge society with a strong competitive force and a strong cohesive force. Education, lifelong learning, research and innovation at the very highest international level was crucial to achieving this goal. The strategy included among other the following two objectives:

· *There must be relevant, high-quality adult and continuing education offers for everyone in the labor market that match the needs and that also have a special focus on the needs of the shortest educated for lifelong retraining.*

· *Systematic competence development in the workplace must be strengthened in both public and private companies.*

Above mentioned are more general national strategies aiming at the broad workforce. There is no national strategy for specific continuing engineering education, but the Danish Society of Engineers (IDA) has always been a major player in the field of CEE and has continuously had an interest in the continuing education of their members (https://ida.dk). IDA has a strategy that meets the fulfillment of the UN's 17 sustainable development goals. To achieve this, IDA contributes by recommending solutions in different areas, one of which is 'Strengthening competencies - Lifelong learning and new learning technology. IDA is a strong society among engineers in Denmark and they offer a wide range of tool-oriented continuing education that qualifies their members.

Institutional strategy on CEE

In Denmark, the universities enter a strategic framework contract with the government. With the current contract (2018-2021) the universities have set goals for their core tasks based on their institution-specific challenges and strengths (https://ufm.dk).

However, one must read between the lines to find strategies or goals related to CEE. Aalborg University (AAU) will further develop its commercialization efforts with a focus on supporting and motivating more commercialized inventions and technologies, more entrepreneurial activities for students and employees, and better opportunities for students to take project-oriented courses (internships) in a private company or in the public. The Technical University of Denmark (DTU) will expand the collaboration with companies and the surrounding community within all the university's core activities throughout Denmark. DTU must be a driving force for welfare and sustainable value creation in close interaction with large and small companies and the surrounding community - both nationally and internationally, among other things. through extensive research collaborations, co-publishing as well as education, innovation and continuing education activities, etc.

Challenges/opportunities in lifelong development

The political debate about developing the lifelong learning opportunities of the academic educated workforce takes up very little space. This is, even though, good opportunities for competence development throughout working life create great opportunities for both strengthening productivity, solving complex problems in society and for creating a better working life which has been the aim since 2006 with the strategy the Global Economy. Even though Danes with a higher education make up a larger and larger part of the workforce they are often completely overlooked in the question of competence development (Ejlertsen, 2021). It is an ongoing debate that universities must show action and take on that task, but they must have the finances and the capacity. What is needed is a strategy for learning for all groups in the labor market. Perhaps with the new report from the Kompetencerådet (2021), which has recently presented recommendations to the Danish government, how to ensure a better and more strategic effort for further training of the entire workforce. With this document, the Kompetencerådet (2021), proposes a new national strategy for lifelong learning for all in the workforce - an agreement on adult, continuing and further education valid from 2022.

6. Finland

During the last University reform in 2010 Finnish Universities along with other European Universities were defining strategies for their three missions: research, education and third mission, which was called service to society. At a strategic level, for example at Aalto

University, Lifelong Learning (LLL) was seen inside a holistic “Knowledge Triangle” -activity. This meant “being based on collaboration with experts from various disciplines, these services enable the integration of research, under- and postgraduate education, LLL including continuing engineering education (CEE) and development projects' '. That strategy was implemented by considering CEE as a part of the third mission, not as a part of education. While research and degree education were at the core of universities annual negotiations with the Ministry of Education, CEE was in many cases considered a service that could even be organized as a separate business owned by the University. That kept CEE at a distance from the core mission of the university. Especially in engineering and business, CEE was considered more a source of money-generation rather than a service to society. So, the continuum of University’s LLL (and also Life-Wide Learning) was already broken by separating CEE from other forms of learning opportunities. ´This all led to graduated working professionals being “cut out” from the wider source of knowledge sharing than universities could offer.

Now after a decade, knowledge creation and transfer from research and development was found not to be as effective as it should be. The majority of professionals, especially with an academic background, are struggling to keep up with the speed of the need to renew and expand their knowledge. This is also strengthened by the fact that today 70-80 % of Finnish companies are complaining that they cannot find enough competent workforce with the latest knowledge and skills. Additionally aging professionals should be kept updated and enabled to continue in working life instead of becoming retired. This notion has moved the universities to rethink LLL.

At its start in late 2019 the new government of Finland took continuous learning into a central role in its strategy. The vision is *that everyone possesses the knowledge, skills and competencies needed in a meaningful life, everyone will develop their competencies during their working life. Thus, competence will renew working life and working life will renew competencies*. New strategies and initiatives were designed at all educational levels. For Universities this meant bringing lifelong learning back closer to the core of their activities. The Ministry of Education more than doubled the incentives for continuous learning. Doing this has already resulted to concrete actions.

Before this undergraduate or postgraduate degree education courses and other learning opportunities were not very visible or accessible to graduates at workplaces. Furthermore, the Open University was targeted to audiences that were not graduate professionals. (The OU was used as an alternative route to university access or by other University undergraduates to widen their studies.) CEE courses with price tags were actively offered mainly to technology professionals and accessible to those who had a sponsor to support them. All this was even less achievable for people having no sponsor for their studies, such as those returning from maternity leave, unemployment or on sabbatical leave. Very recently all the Universities have opened their extensive offering to wider audiences. Former separate CE -centers are turning to be part of extension activities, where courses totally free of charge up to expensive management courses are offered and coordinated from the same one stop shop.

One very concrete example of opening up the University knowledge to all is done by FITech (https://fitech.io/en/) - The Finnish Institute of Technology, a network of eight Finnish Universities of technology, Technology Industries in Finland and Academic Engineers and Architects in Finland TEK. FITech offers a wide variety of technology education free of charge to working professionals through a joint service platform.

Finland is a country, where all degree education is offered free of charge, paid by the government. Currently the tendency of increasing the national financing is targeted to raising

the total level of education i.e., the money is allocated to those having less education. However, there is also concern for the need for the government to support the continuous and ever-increasing competence update of people with higher education.

7. Summary

Engineers with updated knowledge, skills and competences, throughout working life career, is undoubtedly needed. Universities' role in creating, collecting and transferring knowledge to the use of industry and the society becomes even more important. And, no less seen in the light of industry complaining that they cannot find enough competent workforce with the latest knowledge and skills. In some Europe countries degree education is offered free of charge, meaning is paid by government fundings. However, it is most prevalent among the Scandinavian countries, but it influences the discussion on CEE and how it should be organized and practiced in these countries. However, there is a general need for governments to support the ongoing and ever-increasing skills update of people with higher education in all European countries. This is seen in various national and cross-European initiatives within the CEE area, such as micro-credentials; learning communities; a new European education “European engineer;” the Nordic Five Tech initiative; FITech and many more but all with either national or European fundings. But furthermore, local initiatives such as internal training of academic staff, - the training of trainers, and hosting large forums to discuss engineering education. Such activities have also initiated more collaboration across faculties which is often a hurdle that universities operate in silos and have great difficulty in working interdisciplinary and interfaculty.

The challenges, however, in the change process towards flexible education for lifelong learning shows that universities are not yet at the finish-line, and some have longer to go end others. Especially lifelong learning for higher educated is underprioritized and that even though people
with a higher education, in general, make up a larger and larger part of the workforce. They are often completely overlooked and the government fundings is mainly allocated to those having less education. At institutional level universities also experience challenges such as CEE modules requires new and different designs; calculation the costs of CEE; the administration and organization are not tailored to delivering CEE, finally academic staff is not trained to organize and facilitate CEE learning activities, furthermore the university incentive systems most often does not either supports these activities.

Even though, certain European countries have renewed their national strategies to advance the possibilities for engineers to keep up with the needed development of competences however, it is an ongoing debate that universities must show action and take on that task, but they must have the finances and the capacity

REFERENCES

[1] Act LXXX of 2019 on vocational education

[2] CEDEFOP (2018): Skills forecast trend and challenges to 2030. http://www.cedefop.europa.eu/files/3077_en.pdf https://skillspanorama.cedefop.europa.eu/en/analytical_highlights/skills-forecast-key-eu-trends-2030#_skills_forecast__key_eu_trends_to_2030

[3] Einstein, A. (1916). General Theory of Relativity. Annalen der Physik 49(7), pp. 769-822.

[4] Ejlertsen, M. 2021, Akademikerbladet

[5] FITech.io

[6] Fremtidens teknologistudier, NTNU (in Norwegian) https://www.ntnu.no/fremtidensteknologistudier

[7] Government decree No. 12/2020. (II. 7.) on the implementation of the Act on vocational education

[8] https://aaudk.sharepoint.com/sites/aau-strategi

[9] https://ida.dk

[10] https://okm.fi/en/project?tunnus=OKM033:00/2019 (Reform of Continuous Learning)

[11] https://regi.tankonyvtar.hu/hu/tartalom/tamop412b2/2013-0002_az_europai_es_hazai_szakkepzesi_rendszer_fejlodesenek_tendenciai/ES/sesjbx2g.htm ('Tendencies in the development of the European and Hungarian systems of vocational education')

[12] https://ufm.dk/uddannelse/videregaende-uddannelse/efter-og-videreuddannelse

[13] https://www.regjeringen.no/no/dokumenter/hurdalsplattformen/id2877252/?ch=1

[14] ISBN nr:978-87-603-3145-9 (www version)

[15] Kálmán, Anikó : Az oktatástól az önálló tanulásig ('From education to independent learning'). (2009) Budapest. Tanulástámogató.

[16] Kompetencerådet, 2021, Livelang læring – fra slagord til realitet.

[17] Nordic Five Tech, http://www.nordicfivetech.org/

[18] NTNUs strategy Knowledge for a better world, https://www.ntnu.edu/strategy

[19] Nye kompetencer hele livet, 2017, Ekspertgruppen for voksen-, efter- og videreuddannelse

[20] On adult vocational training and the economy: Benedek, András: http://opuseteducatio.hu/index.php/opusHU/article/view/277/477

[21] Rambøll, 2019, Analyse af udbud af videregående VEU barrierer, drivkræfter og potentialer

[22] Report No 14 to the Storting (2019-2020): White paper, https://www.regjeringen.no/en/dokumenter/report-no-14-to-the-storting-20192020/id2698284/

[23] Strategy for flexible and decentralised education at vocational colleges, university colleges and universities, Ministry of Education and Research https://www.regjeringen.no/en/dokumenter/flexible-and-decentralised-education-at-vocational-colleges-university-colleges-and-universities/id2861368/

[24] Szakképzés 4.0 Stratégia ('Vocational training 4.0 strategy') : https://www.nive.hu/Downloads/Hirek/DL.php?f=szakkepzes-4.0.pdf

[25] The Competence strategy for Trondelag County (in Norwegian) https://www.trondelagfylke.no/contentassets/5a346d082e204b25b482fa10011cede9/kompetansestrategi-for-trondelag-revidert-07.05.pdf

[26] The Hurdal platform: The new Government's platform after the 2021 election (in Norwegian),

[27] The universities' strategic framework contracts 2018; https://ufm.dk

[28] Tom Lindholm, Head of Lifewide Learning of Aalto University and CEO of Aalto Executive Education interview 13.3.2022

[29] University strategy development for Lifelong learning and innovation, van Petegem, Wim et.al., 39th EUCEN 27-29.10.2010 Conference paper

SERinA Sustainable Engineering Education Research Project

La Grange E[1], Smith A.E[2] and Soeiro A[3]

[1]la Grange E, Co-Founder and Chair Cahoot Learning (Melbourne, Victoria, Australia) Past VP IACEE, Global Sustainability Initiatives
[2]Smith A.E. M.Ed. (Research), B.Ed. Adult Workplace Education Hons, IACEE committee member (Tasmania)
[3]Soeiro A, Ph.D., University of Porto (Porto, Portugal)

Abstract

1. Research Aim

To qualitatively research and investigate the extent to which and how Engineering Learning Curricula (ELC) incorporate and embed sustainability as central to the work of all engineers, be it in planning, practice or policy, within both the private and public sectors.

2. Outcomes

Buffalo Conference paper with case study report findings which will be of use to and assist **IACEE** institutions and members. In the longer term this is to be of use to other institutions, corporate and government policy development, together with ongoing **IACEE** members and CEE providers, utilising ***SERinA*** [1] as a database of best practices.

IACEE's engineering academic member organisations, its member's institutions and other engineering institutions outside of the **IACEE** will be incorporated into this project. Initially information will be obtained via each institution's external website for the purpose of this research paper. After the Conference the research aim will both broaden and continue in more detail, with results shared on an ongoing basis in ***SERinA***'s web sites [1] and future academic papers.

Keywords: Engineering Learning Curricula, Sustainability, UN Sustainability Goals, Research Project, Fundamental Human Need satisfaction, Knowledge creation

1. Introduction

Sustainability for the planet is not a sideshow. Engineers and engineering will play crucial and pivotal roles in assisting the global community to meet fast changing planetary needs, and the UN Sustainable Development Goals by 2030, in the process [3]. To have the best chance of success, sustainability in all of its emerging facets, must form an integral part of mind and tool sets of engineers in all aspects of engineering education, research and practice. Sustainability needs to become ingrained into the DNA of engineers' daily practice as a fundamental core value, just as safety has become a universal central tenant of best engineering practice. For this to take place, this paper proposes that sustainability must become an essential and integral component of the education and training of engineers across all engineering curricula. This research references sustainability by way of the UN 17 Sustainable Development Goals [3] and Fundamental Human Needs [4] as a basis against which

to scrutinise active present-day teaching and learning context, content and practice. Investigating where and if sustainability is core to engineering educational initiatives as described within a particular institution's engineering core curricula.

This research paper and future research endeavours concerning embeddedness of sustainably thinking and doing, needs to have its origins within all aspects of STEM/ STEAM education, research and practice. Not as an addon but rather being integral to the journey of becoming and being a practicing Engineer. Sustainable education should be an educative process embedded from initial schooling through to tertiary and daily practice, and within ongoing engineering education particularly for the older and most experienced of engineering practitioners.

Over a number of decades now, there have been world-wide calls for the embeddedness of sustainably thinking and practice to be part of all engineering curricula and not just an add-on [5] This is a call for **Sustainability Thinking** to become ingrained in the DNA of engineering practice as a fundamental core value, just as **safety** has become a universal central tenant of engineering practice.

This all links in with the ***IACEE*** Porto Declaration challenging engineers, especially the ***IACEE's*** members to take this on board and embedded in everyday practice and learning opportunities.

> *"In the IACEE (International Association for Continuing Engineering Education – www.iacee.org) world conference held in May 2016 and under the theme "Innovation in Continuing Professional Development: A vision of the Future" a declaration was signed by participants."* [5]

The Porto Declaration then led to the creation of a database of best practice called ***SERinA*** (**S**ustainable **E**ducation **R**esearch in **A**ction). The intention is to post the findings of this paper and further research for access within the ***SERinA*** website databases [1].

1.1. Research Hypothesis

There is an urgent need for sustainability to be embedded in engineering curriculum, as deeply as safety is embedded, as a means of supporting post education engineers' thinking and practice to meet the needs of sustainable development and our world's future.

1.2. Research Aim

To qualitatively research and investigate the extent to which and how **Engineering Learning Curricula** (**ELC**) incorporate and embed sustainability as central to the work of all engineers, be it in planning, practice or policy, within both the private and public sectors.

1.3. Research Focus

For the purpose of this project sustainability can be defined as “meeting the needs of the present without compromising the ability of future generations to meet their own needs.” [6]

The Royal Academy of Engineering’s guiding principles for sustainable engineering explains the concept in clearer detail:

> *“Sustainable development is the process of moving human activities to a pattern that can be sustained in perpetuity. It is an approach to environmental and development issues that seeks to reconcile human needs with the capacity of the planet to cope with the consequences of human activities.”* [7]

It can therefore be postulated that sustainable development is the *“…process for reshaping human activities to a form that can be sustained both in the present and in the future. It is an approach to environmental and development issues that seeks to reconcile human needs with the capacity of the planet to cope with the consequences of human activities.”* [8]

This research paper references sustainability by way of the UN 17 Goals [3] and Fundamental Human Need [4] as a basis for this research so as to scrutinise sustainability in active teaching and learning content and practice, and as being core to engineering educational initiatives as described and initiated within a particular institution’s engineering core curriculum and outlook.

The ***International Association for Continuing Engineering Education (IACEE***’s) engineering academic member organisations, its member’s institutions and other engineering institutions outside of the ***IACEE*** will be incorporated into this as part of a longer-term research project. Initially this endeavourer will be limited to three institution’s external websites for the purpose of this research paper. The research will then continue in more detail, post the ***IACEE*** Buffalo conference, as an ongoing **SERinA** project seeking to discover best practice in this regard across the world and reported on via the ***IACEE***’s ***SERinA*** (***S****ustainable* ***E****ducation* ***R****esearch* ***in A****ction*) website, Facebook page [1] [2]

1.1. The overall objectives of this research will be to:

1.1.1. Identify curricula that are delivered to/undertaken by engineering students.

1.1.2. Identify possible gaps within engineering curricula activity concerning sustainability.

1.1.3. In the long term to examine for any factors that enhance or inhibit the use of sustainable structured curricula and learning, so as to meet the needs of engineers’ post degree/diploma active practice.

1.1.4. Prepare three case studies of curricula practice, for the purpose of this paper, which fully or partially utilises structured sustainable engineering curricula to meet the needs of learners.

1.1.5. In the long term to investigate the roles of regional industry, government and engineering learning providers and how they can best assist in meeting teaching/training needs of future and practicing engineers.

1.1.6. Utilise **SERinA** as a data base of examples of sound practice, both within degree/diploma courses and on-going engineering education.

1.2 Outcomes

A Buffalo Conference paper, with a case study report of findings that can be of use to and assist ***IACEE*** institutions and members. In the longer term this research is to be of use to other institutions, corporate and government policy development, together with ongoing ***IACEE*** members and Civil and Environmental Engineering (CEE) providers, utilising ***SERinA*** as a database of best practices. More detail on the longer-term research project will be provided down the track with a view to possible funding opportunities.

2. Case Studies

Below can be found three case studies of sustainability engineering curriculum design and practice according to each of the relevant university's websites [10] [18] [19] :

2.1. The University of Victoria (UVic), B.C. Canada has set in motion what they call a Green Civil Engineering learning space named "Green Civil Engineering". They are doing so to grow and develop their sustainability active engineering education degree.

The UVic's *Civil Engineering Vision Statement* and sustainability goals are to work at:

> *"…addressing the most pressing global environmental and sustainability challenges through engineering design, science and practical solutions. Our research and graduate programs focus on green civil engineering solutions for Canada and beyond. Our undergraduate program teaches fundamental competencies supplemented with cutting-edge ideas from environmental science, building science and industrial ecology."*

So as to:

> ***"****… improve the green engineering and active learning of the civil engineering program at the University of Victoria, Canada, we are developing a design spine: a series of courses running throughout the program with major design activities based on a sustainability-centred design approach."* [11]

The UVic's curriculum framework organizes both the subjects of design and of sustainability into four high-level categories:

- *foundations,*
- *frameworks,*
- *tools and techniques, and*
- *application capabilities*

The University puts forward that embedded green civil engineering is made up of managing, designing, constructing and maintaining the built and natural environment, using technologies and techniques that provide services to society, while working within the carrying capacity of local ecosystems and the planet.

UVic states that their Civil Engineering [12] *"…department is working towards a green future where:*

- *we are carbon neutral or net positive*
- *we use only renewable water and do not pollute it*
- *we renew infrastructure and only construct sustainable infrastructure*
- *engineers understand how natural ecosystems function and are skilled and motivated to protect biodiversity*

Towards these goals, students in our undergraduate program take core courses in:

- *Sustainable development in civil engineering*
- *Building science fundamentals*
- *Environmental engineering*
- *Environmental policy*
- *Sustainable transportation systems*

Many other undergraduate courses address sustainability concerns. There are also several fourth-year technical electives aligned with the emphasis on green civil engineering, such as:

- *Solid waste, air and water pollution*
- *Resilient smart cities*
- *Green building design*
- *Infrastructure for indigenous and rural communities*
- *Building and district energy simulation*
- *Water & sanitation for developing countries:*
- *Energy systems decarbonization*
- *Groundwater hydrology*
- *Drinking water contaminants - chemistry, toxicology and greener interventions*

Teaching and research at the graduate level follows four broad themes [12]:

- *Green structures & materials* [13]
- *Smart structures & materials* [14]
- *Industrial ecology* [15]
- *Sustainable water* [16]

2.2. Massachusetts Institute of Technology (MIT)

"Study new ideas, push the boundaries of what's possible.

An ambitious vision for campus sustainability at MIT is underway and achieving it will be a process. We want you to think of your own journey to sustainability as a process, too :- ***start, study, solve****."* [17]

The reference link [18] points to a minor in Environment and Sustainability and is open to:

"…all MIT undergraduates in any major, the Environment and Sustainability Minor (E&S Minor) offers students the opportunity to apply their STEM and major-course knowledge to some of the most critical and challenging problems facing humanity. The minor equips students with interdisciplinary knowledge and real-world experience needed to understand, diagnose, and develop solutions to complex problems faced by society as it strives for social and environmental sustainability. Students tailor their MIT education to their professional goals, preparing to apply the principles of sustainability in diverse workplace contexts, including business/industry, government, civil society, and academia."

Searching the link *catalog.mit.edu/schools/engineering/* [19] shows no reference to sustainability, although the word environment is mentioned once. The phrases "poverty alleviation" and "Environmental Engineering" each are mentioned once.

catalog.mit.edu/schools/engineering/#degreesandprogramstext
Using the above search, the word "environment" is mentioned once and "sustainability" not at all.
http://catalog.mit.edu/subjects/ Here the word "environmental" is mentioned once, as part of Civil and Environmental Engineering (Course 1) This course link opens to a page that lists 79 environmentally linked optional courses.

2.3. Oxford University [19]

"Oxford University aims to offer all students the opportunity to study environmental sustainability, either within or outside the examined curriculum.

Oxford provides an exciting and challenging learning environment, training future generations of researchers, innovators and leaders in sustainability.

We give our students the opportunity to develop their knowledge, understanding and skills to become the sustainability leaders of the future. The University curriculum reflects its wide expertise in the fields of climate change, biodiversity and sustainability. Sustainability-related opportunities for internships and training courses are offered to students, and student societies are pioneering extra-curricular courses…

…Our commitments

1. *Ensure courses with core and optional sustainability content are easily identifiable.*
2. *The Education Committee will encourage and monitor existing degree programmes' development of further environmental sustainability streams in the core curriculum.*
3. *Consider and support new courses related to interdisciplinary environmental and social sustainability questions.*
4. *Extend existing opportunities for extra-curricular study of environmental sustainability, internship programmes and short courses to all students."*

"The MEng degree in Engineering Science is accredited by the Professional Engineering Institutions, making it your first step towards full membership of one of the institutions and Engineering Chartership.

The course has been designed to achieve thresholds of learning that satisfy those institutions' criteria, including acquiring the knowledge and ability to handle broader implications of work as a professional engineer. It is especially important that the principles of sustainability (environmental, social and economic) are embedded in the teaching and learning throughout the course." [20]

"Accreditation: Principles of sustainability

The MEng degree in Engineering Science is accredited by the Professional Engineering Institutions; the first step towards full membership of one of the institutions and Engineering Chartership. The course has been designed to achieve certain thresholds of knowledge and standards of learning across key areas that satisfy the criteria set out by the accrediting institutions; including acquiring the knowledge and ability to handle broader implications of work as a professional engineer. It is especially important that the principles of sustainability (environmental, social and economic) are embedded in the teaching and learning throughout the course in lectures, tutorials, laboratories and project work. [21]

"The MEng in Engineering Science lasts for four years."

Second year picks up sustainability:

"You will gain an understanding of how your technical knowledge relates to engineering in the wider world. This includes: Technical

Writing and Communication Skills; Engineering Ethics; Safety and Risk; Engineering, Sustainability and the Environment." [22]

3. Discussion

The United Nations (UN) has been instrumental in developing the concepts of Sustainable Development Education when UNESCO (UNESCO, 2005) named the decade 2005-2014 the 'UN *Decade of Education for Sustainable Development'* (DESD). The UN defines *Education for Sustainable Development* (ESD) as education that encourages *'changes in behaviour that will create a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations'* (UN, 2002) [23] [24]

This initiative gave support to a much broader view of learning content for engineers besides that of protecting the environment:

> *"A purely environmental approach is insufficient, and increasingly engineers are required to take a wider perspective including goals such as poverty alleviation, social justice and local and global connections. The leadership and influencing role of engineers in achieving sustainability should not be under-estimated. Increasingly this will be as part of multi-disciplinary teams that include non-engineers, and through work that crosses national boundaries."* [25]

Human, as well as environmental need should be entrenched as part of the learning and practice environment of students and post university engineering practitioners. Necessity for the satisfaction of human needs, values and norms can be seen as embedded in the UN Goals. Fundamental Human Needs can be said to underpin the UN Goals as recognised within a particular cultural space and time. Each of these have a role to play in planning and delivering engineering projects underpinned by the 17 UN Goals.

Max-Neef Matrix of Fundamental Human Needs

The Max-Neef taxonomy of human needs and satisfiers provides a useful framework. Using this taxonomy we can identify impediments to meeting fundamental human needs but also high light synergies which help achieve higher states of well-being and happiness.

Fundamental Human Needs	Being (qualities)	Having (things)	Doing (actions)	Interacting (settings)
subsistence	physical and mental health	food, shelter, work	feed, clothe, rest, work	living environment, social setting
protection	care, adaptability, autonomy	social security, health systems, work	co-operate, plan, take care of, help	social environment, dwelling
affection	respect, sense of humour, generosity, sensuality	friendships, family, relationships with nature	share, take care of, make love, express	privacy, intimate spaces of togetherness
understanding	critical capacity, curiosity, intuition	literature, teachers, educational policies	analyze, study, meditate, investigate	schools, families, universities, communities
participation	receptiveness, dedication, sense of humour	responsibilities, duties, work, rights	cooperate, dissent, express opinions	associations, parties, churches, neighborhoods
leisure	imagination, tranquility, spontaneity	games, parties, peace of mind	day-dream, remember, relax, have fun	landscapes, intimate spaces, places to be alone
creation	imagination, boldness, inventiveness, curiosity	abilities, skills, work, techniques	invent, build, design, work, compose, interpret	spaces for expression, workshops, audiences
identity	sense of belonging, self-esteem, consistency	language, religions, work, customs, values, norms	get to know oneself, grow, commit oneself	places one belongs to, everyday settings
freedom	autonomy, passion, self-esteem, open-mindedness	equal rights	dissent, choose, run risks, develop awareness	anywhere

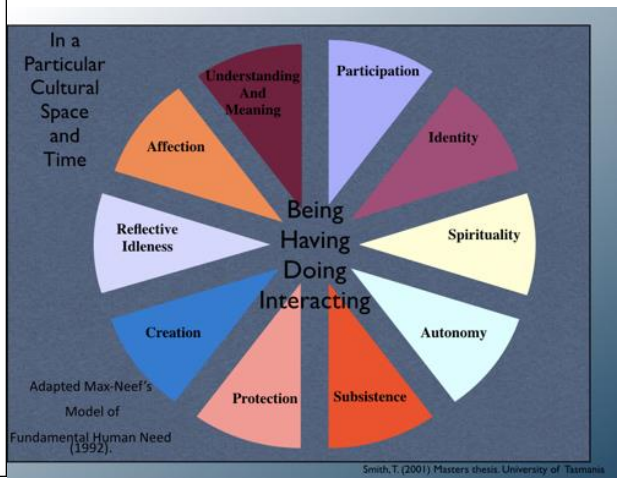


Fig 1 [26] and Fig 2 [27]

"The Canadian Council of Professional Engineers published a 'National Guideline on Environment and Sustainability' in 2006 (CCPE, 2006) [28] *which outlined nine tenets that professional engineers should adhere to. It states that engineers:*

1. *Should develop and maintain a reasonable level of understanding, awareness, and a system of monitoring environmental and sustainability issues related to their field of expertise.*
2. *Should use appropriate expertise of specialists in areas where the professional engineer's knowledge alone is not adequate to address environmental and sustainability issues.*
3. *Should apply professional and responsible judgment in their environmental and sustainability considerations.*
4. *Should ensure that environmental planning and management is integrated into all their activities which are likely to have any adverse effects.*
5. *Should include the costs of environmental protection among the essential factors used for evaluating the economic viability of projects for which they are responsible.*
6. *Should recognize the value of environmental efficiency and sustainability, consider full life-cycle assessment to determine the benefits and costs of additional environmental stewardship, and endeavour to implement efficient, sustainable solutions.*
7. *Should engage and solicit input from stakeholders in an open manner and strive to respond to environmental concerns in a timely fashion.*
8. *Should comply with regulatory requirements and endeavour to exceed or better them by striving toward the application of best available, cost-effective technologies and procedures. Should disclose information necessary to protect public safety to appropriate authorities.*
9. *Should actively work with others to improve environmental understanding and sustainability practices."* [28]

The accreditation process is a powerful instrument in directing the education of engineers and over the longer term, the capacity of the engineering profession. The Royal Academy of Engineering highlight the importance of accreditation as an agent for evolution and change in their report on educating engineers for the 21st Century (RAE, 2007) where they observe that:

> *"…the accreditation process for university engineering courses should be proactive in driving the development and updating of course content, rather than being a passive auditing exercise".* [29]

Whilst all of the above is of seminal importance there is also a need to understand that the nature of curricula design and content is not primarily about the explicit side of knowledge acquisition. There is, particularly where sustainability and safety are taken into account, the need for tacit knowledge acquisition to be part of the equation.

It is recognised that as much as 70% of our knowledge lies within the tacit side of our understandings of and interaction with the world around us. This verses 30% of our knowledge as being explicit. [30]

At “The Knowledge Advantage Conference held November 11-12, 1997, Dr. Ikujiro Nonaka gave a presentation, a summary of which can be found below.

Dr. Ikujiro Nonako, at the Knowledge Advantage Conference, reiterated the premise that there are two types of knowledge. This premise is based on his and a colleague’s, Takeushi, previous research and writings around the concept of knowledge creation in organisations. [31]

Tacit Knowledge, according to Nonako, plays a seminal role via socialisation in establishing shared understandings giving a common sense of achieving a subjective shared purpose, such as shared thoughts and actions within the learning environment. A pivotal role around the achievement of UN sustainability goals and the satisfaction of human needs. This type of knowledge is what causes a person to reach out and act without thinking and is based around unconsciously embedded sets of shared values, norms and actions, such as crafting something or working safely. [32]

This type of knowledge cannot be shared in words or expressed in numbers or formula. This would include beliefs, intuition, and mental models of context linked to specific action, association and location, particularly in association with other human beings and the world around us and so internalised through socialisation.

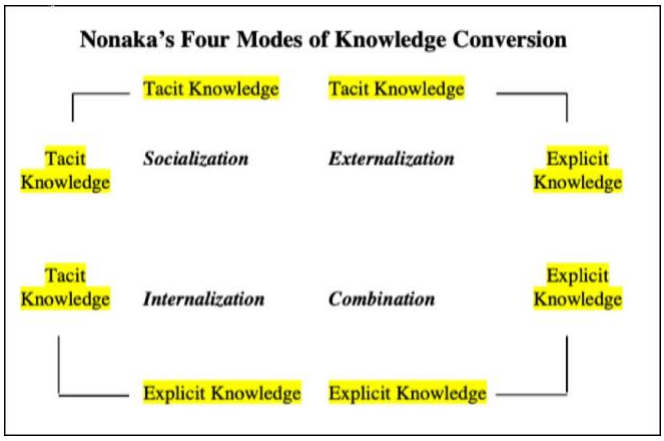


Fig 3

Explicit Knowledge is objective and factual according to *Nonaka.* It can be said to be rational as it can be expressed in words, sentences, numbers and formulas. The classic teacher/student learning environment where theoretical approaches, problem solving, and manuals and textbooks are utilised. The interactive and explicit teaching and learning environment. For examples utilizing safety procedures rule book.

Nonako and Takeushi’s knowledge creation model can be said to be a clockwise spiralling model of dialog, interaction and combination leading to internalisation. A dynamic process of tacit to explicit creation of knowledge and then leading to internalised new meaning and understanding by doing. A process both within a person’s personal

learning world and their shared learning environment with others. Underpinned by shared values, norms and beliefs. This gives the opportunity of creating a cycle of deeper and deeper levels of understanding. Fig.4

This socialisation process transfers tacit knowledge in one person to tacit knowledge in another, experientially, actively and as a lived experience in the learning environment from 1st year to the last. It continues post formal studies then into the world of interactive design, creation and everyday engineering practice dialoguing with those around one.

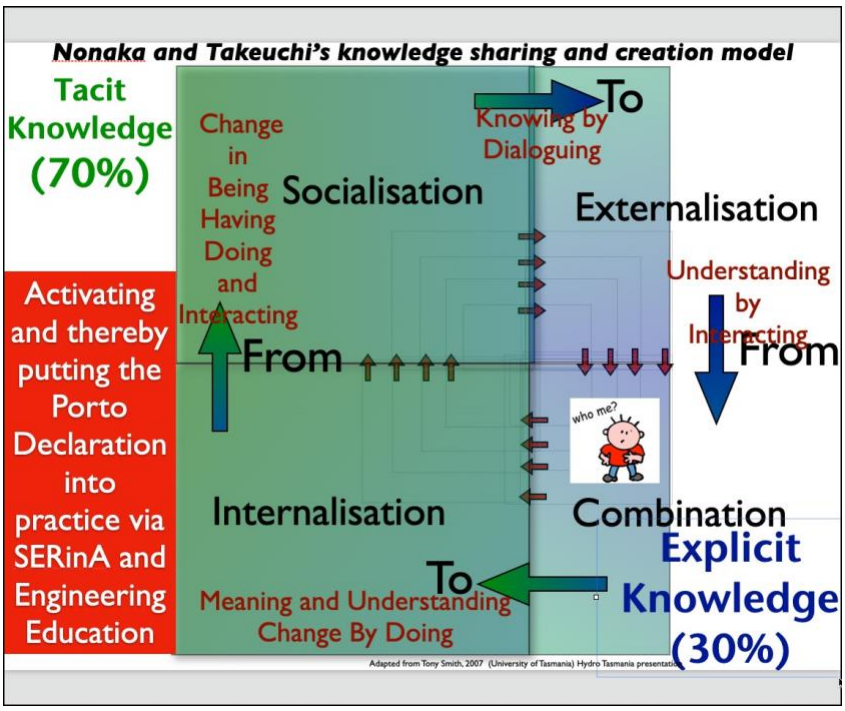


Fig.4

So how does this bring about a greater understanding of the need for sustainable practices in the knowledge gaining environment, both at university and when practicing as an engineer in the wider world? [31]

Some work has already been done in this regard along these lines. Aboagye-Nimo, Raiden, King and Tietze's research is an example of this. [32]

They state that:

> "Tacit knowledge plays an invaluable role in construction and has been labelled as the most strategically important resource in organisations. Microconstruction firms rely heavily on the tacit knowledge acquired by their workers when managing site safety. Unfortunately, the importance of this knowledge is sometimes overlooked due to its inexpressible and informal nature. This paper investigates how microconstruction firms use tacit knowledge to prevent accidents on site, thereby improving overall site safety…" [32]

> "…Findings from the case studies suggest that workers of micro-construction firms use tacit knowledge in areas such as training newcomers and also identifying and managing imminent risks and dangers on site. Additionally, tacit knowledge plays an important role in safety communications among the workers of these micro-firms; it helps establish shared understanding and a common sense of achieving their goals…"

> "… An important assertion that needs to be made is that tacit knowledge cannot be captured and shared as done with explicit knowledge. However, the flow of tacit knowledge can be developed with time and experience through training. More importantly, through practices such as 'mentoring' (usually informally in micro-firms), new and less experienced workers are able to work under the close supervision of experienced and conscientious workers in order to appreciate, understand and share common safety goals. This is an effective way of sharing tacit knowledge as the experienced workers are able to check and ensure that the knowledge passed on to new workers has been assimilated unambiguously. In addition, workers can try and share it by demonstrating good safety practice on site, for example, and in interactions with individuals who are learning by doing/observing them." [32]

The above research underpins the need for social interaction - socialisation, as a seminal part of growing active practice knowledge and an engineer's sustainable engineering practice.

So, what does this mean for engineering curricula design? We begin to explore this in our conclusions below.

4. Conclusions

> *"Civil engineers have a responsibility, as stewards of the built environment specific to civil infrastructure systems on which society relies, to ensure a sustainable future. It is incumbent on engineers to provide a holistic approach to the management of infrastructure throughout its full life cycle participating in multi-disciplinary teams of professionals including ecologists, economists and sociologists that effectively address the issues and challenges of sustainable development."* [33]

The engineering education community is now at a critical juncture as can be seen via this paper. To date, there has been a significant level of "grass-roots" activities but little embedded sustainability structure or organisation within curricula design over the years since the inception of the UN Sustainable education for meeting the goals in 1997.

The next step will be for university engineering schools to continue to think even more critically about what should or should not be included in a curriculum into which sustainable engineering has been incorporated and how this should be achieved.

The path forward will require the evolution of a set of both tacit and explicit knowledge gain standards as stated below.

As put forward above, the 1997 report of the Joint Conference on Engineering Education and Training for Sustainable Development in Paris called for sustainability to be *"integrated into engineering education, at all levels from foundation courses to ongoing projects and research"* and for engineering organisations to "*adopt accreditation policies that require the integration of sustainability in engineering teaching"*

This paper and its research have set out to demonstrate how this responsibility could be ingrained right from the start of learning to become an engineer.

> ***We believe a long-term goal of 21st century engineering education is to enable practicing engineers to incorporate tenets of sustainability into all phases of their practice, so that "sustainable engineering" eventually equates with "good engineering' and subsequently embedded in all design and practice.***

5. Postscript

What this paper does not explore, but must become a key part of subsequent research, are the drivers for change within engineering education (and education more generally) from practitioners and more broadly from governments through policy and procurement practices and prerequisites for tender of government contracts.

McKinsey & Company in a report *"The ESG premium: new perspectives on value and performance (February 12, 2020 Survey)"* looks at the role of Environmental, Social & Governance programs in establishing shareholder value [35] :

- Just as company boards are being pressured (or should be) by shareholders to ensure that their organisations address the UN Goals within their organisations, what pressure, if any, is being asserted by those organisations on the educational systems to address sustainability at the formative outset of student education within curricula?
- Can the same be said of governments proclaiming to set bold sustainability goals for perhaps what can be seen as political expedience?
- At what point do those goals translate into grass roots behavioural initiatives for meaningful change that seeks to tackle the issues of sustainability at the source, by way of ensuring that curricula at all levels of school and higher education across the board have sustainability at the core?

Are these valid questions? Do these questions assist in driving the right conversations? These and further questions will be considered in ongoing research post Conference.

REFERENCES

[1] http://serina.iacee.org/

[2] https://www.facebook.com/serina.iacee

[3] *https://www.un.org/sustainabledevelopment/* - Accessed 18/4/2022

[4] Max-Neef et al, (1991), Human scale development. The Apex Press, New York and London. *(https://en.wikipedia.org/wiki/Manfred_Max-Neef%27s_Fundamental_human_needs)*

[5]

[6] https://peer.asee.org/iacee-porto-declaration-a-global-challenge-for-engineers.pdf

[7] *United Nations Brundtland Commission* Report (1987) (pg16: point 3)

[8] https://www.raeng.org.uk/publications/other/engineering-for-sustainable-development - Accessed 18/4/2022

[9] *https://www.un.org/en/academic-impact/sustainability* - Accessed 18/4/2022

[10] https://www.uvic.ca/ecs/civil/green/index.php - Accessed 18/4/2022

[11] Froese, T. M., Bristow, D. N. and Rankin, K. (2021). Towards a sustainability-centred design curriculum in civil engineering, EESD2021: Proceedings of the 10th Engineering Education for Sustainable Development Conference, 'Building Flourishing Communities', University College Cork, Ireland, 14-16 June.

[12] *https://www.uvic.ca/ecs/civil/green/index.php* - Accessed 18/4/2022

[13] https://www.uvic.ca/ecs/civil/research/home/green-structures-and-materials/index.php --Accessed 18/4/2022

[14] https://www.uvic.ca/ecs/civil/research/home/smart-buildings-infrastructure-cities/index.php - Accessed 18/4/2022

[15] https://www.uvic.ca/ecs/civil/research/home/industrial-ecology/index.php - Accessed 18/04/2022

[16] https://www.uvic.ca/ecs/civil/research/home/sustainable-water/index.php - Accessed 18/04/2022

[17] http://sustainability.mit.edu/study - Accessed 18/04/2022

[18] http://catalog.mit.edu/interdisciplinary/undergraduate-programs/minors/environment-sustainability/ - Accessed 18/04/2022

[19] https://sustainability.admin.ox.ac.uk/curriculum - Accessed 18/04/2022

[20] https://eng.ox.ac.uk/media/7743/fhs-course-handbook-2020.pdf pg 15 - Accessed 18/04/2022

[21] https://eng.ox.ac.uk/study/undergraduate/your-degree/ - Accessed 18/04/2022

[22] https://eng.ox.ac.uk/study/undergraduate/your-degree/course-structure/ - Accessed 18/04/2022

[23] UNESCO, (2005). United Nations Decade of Education for Sustainable Development (2005-2014): International Implementation Scheme. Paris, France: United Nations Educational Social and Cultural Organisation.

[24] http://unesdoc.unesco.org/images/0014/001486/148654e.pdf - Accessed 18/04/2022

[25] ECUK, 2009. *Guidance on sustainability for the engineering profession,* London, England: Engineering Council UK. Pg.2

[26] https://en.wikipedia.org/wiki/Manfred_Max-Neef%27s_Fundamental_human_needs - Accessed 18/04/2022

[27] SMITH, A. E., *The Role of Social Capital in Negotiating Socio-Economic Needs*, Research Master thesis, University of Tasmania, 2001, https://eprints.utas.edu.au/21606/, accessed 18/04/2022

[28] CCPE, 2006. Canadian Engineering Qualifications Board National Guideline on Environment and Sustainability, Ottawa, ON, Canada: Canadian Council of Professional Engineers http://www.engineerscanada.ca/e/files/guideline_enviro_with.pdf - Accessed 18/04/2022

[29] RAE, 2007. Engineering for sustainable development: Guiding principles, London, England: The Royal Academy of Engineering. Pg.2

[30] http://pagebaldwin.com/fa57/docs/KM_Organizational_Knowledge_Creation.pdf

[31] Nonaka I. and Takeuchi H. (1995). The Knowledge Creating Company,. New York: Oxford University Press,

[32] Aboagye-Nimo, Raiden, King and Tietze's (2014) *"Using tacit knowledge in training and accident prevention"* Management, Procurement and Law, Volume 168 Issue MP5. Pgs. 232, 238

[33] *(https://csce.ca/en/sustainable-infrastructure/*CSCE Policy on Sustainable Infrastructure – Policy #2015-01) -pg 2

[34] JCEETSD, (1997). Joint conference report, engineering education and training for sustainable development, *Joint UNEP, WFEO, WBCSD, ENPC Conference,* Paris, France, 24–26

[35] https://www.mckinsey.com/business-functions/sustainability/our-insights/the-esg-premium-new-perspectives-on-value-and-performance

Creating Learning Environments to Expand Access and Student Engagement

Lisa A. Stephens[1], Rebecca V. Frazee[2]

[1]University at Buffalo (USA)

[2]San Diego State University (USA)

Abstract

Campus faculty and staff are frequently called upon to provide context and advice when classroom facilities are designed or renovated. In 2013, SUNY (State University of New York) launched FLEXspace: the Flexible Learning Environments eXchange which has evolved into a respected, well-adopted global community of practice and open educational resource/repository. Recently, EDUCAUSE.edu, a major educational professional association, made an investment in this community-driven portal to integrate the Learning Space Rating System (LSRS), a quantitative measure of active learning potential within learning spaces, including metrics for inclusion.

The combination of these two resources, freely available for educator use, has resulted in the FLEXspace Integrated Planning Pathway (FLIPP) to help senior leadership leverage advisory groups when making investment decisions by engaging faculty, AV/IT technologists, librarians, instructional designers and facilities planner perspectives when offering consensus-based recommendations.

This paper describes the FLIPP process which has proven successful at multiple colleges, universities and K-12 environments. The goal is to empower advisory groups with diverse perspectives and expertise to follow a step-by-step process that creates internal group alignment prior to meeting with external contractors and consultants. This alignment results from adopting and prioritizing core pedagogical values within budgetary constraints, including definition of acceptable alternatives when preferred solutions are potentially limited by resource or environmental limitations.

Keywords: Innovation, technology, research projects, OER, shared decision-making

1 A NEED FOR A SHARED, GLOBAL COMMUNITY OF LEARNING SPACES

The State University of New York (SUNY) is the largest, most comprehensive system of higher education in the United States, with all 64 campuses reporting to a Chancellor and SUNY Board of Trustees. A highly diverse institution, SUNY supports community colleges, comprehensive and statutory colleges as well as research institutions – including two AAU flagship universities. The scale of higher learning across multiple sectors challenges a “one size fits all” approach when seeking economic efficiencies supporting the enterprise.

In the early 2000’s, active learning pedagogy gained popularity; specific instructional strategies for student engagement that heavily relied upon group activities, problem-based learning and “flipped classes.” Students digested material outside of class, then applied those concepts studied in advance to group discussion and problem-solving during live class sessions. Consequently, classroom design began to evolve from a model that focused exclusively on maximizing density of seating within defined square footage to that of flexible, reconfigurable classroom and lab spaces enabling a range of student groupings and activities depending upon the active learning engagement techniques faculty chose to use.

The SUNY Provost suggested in an advisory group meeting that the system could benefit from a new communication model that openly shared learning space plans while being sensitive to the needs of individual campus and sectors [1]. Ideally, the solution would be image-intensive, enabling campuses to seek inspiration and ideate from detailed, shared exemplars.

A task group was charged to explore options that could realize a solution, the only parameters being that the outcome be openly available and non-commercial in nature (thereby eliminating use of early sharing platforms like Facebook™ or Flickr™). A beta test was set up with help from a company called Artstor™ already well known within university library communities for image-rich digital collections of art history and architecture. The beta example was enthusiastically received at early conference presentations, energizing the task group to investigate a production release of the shared beta repository.

2 CAUTIOUS COLLABORATION WITHIN COMMUNITIES

Artstor generously provided resources to develop a production release, as their corporate interest was focused on a pilot program that would enable educators to create and curate user-based collections by leveraging existing Artstor infrastructure. The Consortium of College and University Media Centers (CCUMC), a large professional education technology association, partnered with SUNY by supporting the initial hosting costs. The effort became branded as FLEXspace: the Flexible Learning Environments eXchange, with emphasis on "exchange", a key term that referenced the volunteer community "exchange" of ideas through detailed record uploads.

It was a significant undertaking to determine taxonomy terms that would describe the key attributes of each space and be useful to various stakeholder groups. The SUNY Provost was not only concerned about "getting the right people around the table" to guide built environment investment, he was also seeking better understanding and empathy from the key stakeholders that heavily influence learning space outcomes. Architects and facilities planners face a heavy burden to safely and efficiently create spaces, but don't necessarily have easy access to faculty input that could help make new active learning environments more effective. Audio/Video and IT staff often feel that their efforts were included too late in the planning stages to efficiently integrate academic technologies requiring designed infrastructure prior to construction. As more active learning spaces were created, a pattern of expensive AV retrofits was emerging to accommodate shared annotation displays, complex sound systems, etc. A key purpose of this growing collaboration among institutions was to find ways to increase understanding of each other's roles in designing, building and maintaining these increasingly complex spaces (Fig 1).

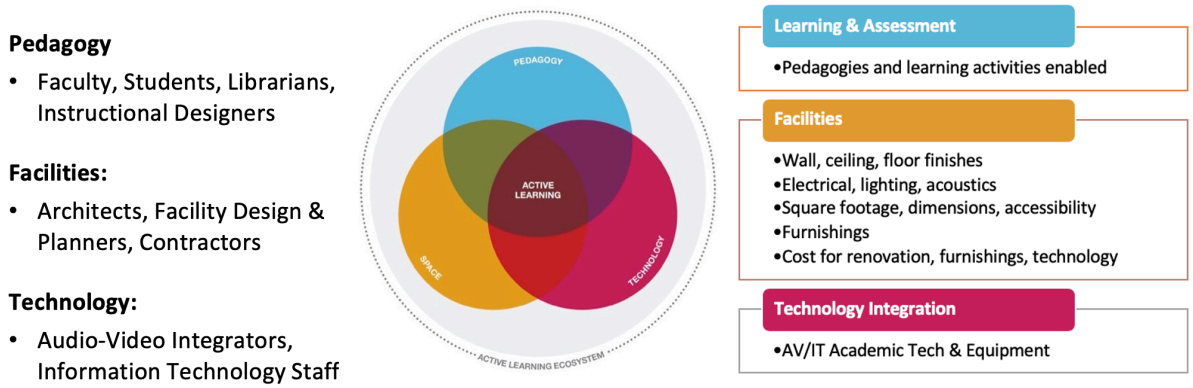


Figure 1: Intersection of key stakeholder roles and responsibilities

As the FLEXspace repository was forming, a group of educators and architects were meanwhile dedicated to developing a rating system, based on the LEED environmental credit system to measure a learning space's potential to support active learning. Unlike FLEXspace that relies heavily on images, design rationale, and details of room attributes to describe spaces, the Learning Space Rating System (LSRS) is a quantitative solution designed to create baseline data across several dimensions that measure institutional support, furnishings, lighting, inclusion, faculty development, and more. Points are awarded when specific conditions are met. There was clear synergy emerging across these two separate efforts, leading to the consideration of how to best combine the efforts for the greater education community.

A tough decision was made among representatives from each initiative. We could have (and perhaps even should have) aligned terminology for consistent use across both systems when the synergy was first identified. But the cost of attribute alignment would have been to delay development of each independent effort. The outcome was a friendly handshake to pursue further integration once FLEXspace and LSRS each arrived at a level of maturity where they could be combined. This could only occur with custom portal development to enable mobile-friendly data intake.

3 ADOPTION SUCCESS DRIVES A NEW PLANNING PATHWAY MODEL: FLIPP

Now several years into implementation, FLEXspace has realized significant adoption success. To date, over 5,000 individuals from 1,200+ unique institutions have established accounts (Fig 2). Data suggests that users' primary purposes are to 1) use the collection to ideate from and benchmark potential renovations or new builds, and 2) to showcase innovative institutional spaces.

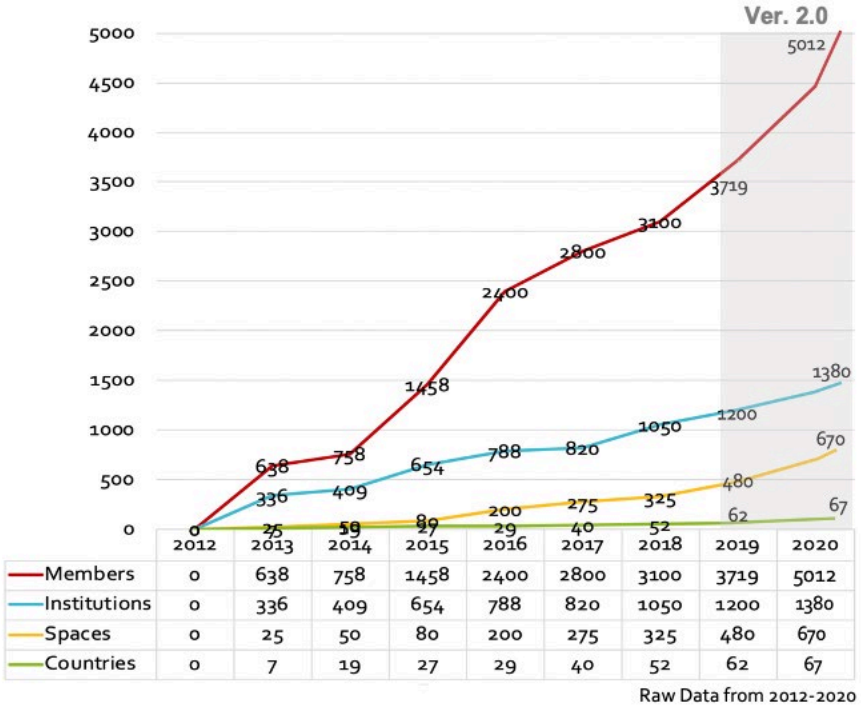


Figure 2: Rate of FLEXspace Adoption

Higher education is unique in the institutional willingness to share information among campuses that would normally be considered in competition with each other. This is a stance that has long perplexed "outsiders" with a more focused business mindset. It was determined early in the rollout process that institutional contributors were willing to participate but expressed a strong preference for limiting access to those who were credentialed as having legitimate business need to the data. The filtering mechanism became the .edu email address (or an international or K-12 equivalent). This ensured that educators were communicating with other educators, the only exception being corporations and vendors that chose to sponsor the collection. The sponsors were to have full access to the collection and members, as well as dedicated webspace in the portal to share content of interest to the community.

The custom portal was released during the summer of 2018, with an LSRS reporting feature later added for both LSRS Versions 2 and 3 (which included measures of multimodal learning and inclusion). The collective "aha!" moment was realized in December 2021, late in the 4th quarter when the informal use of LSRS and FLEXspace together became codified as a new model: the FLEXspace Integrated Planning Pathway, or FLIPP for short.

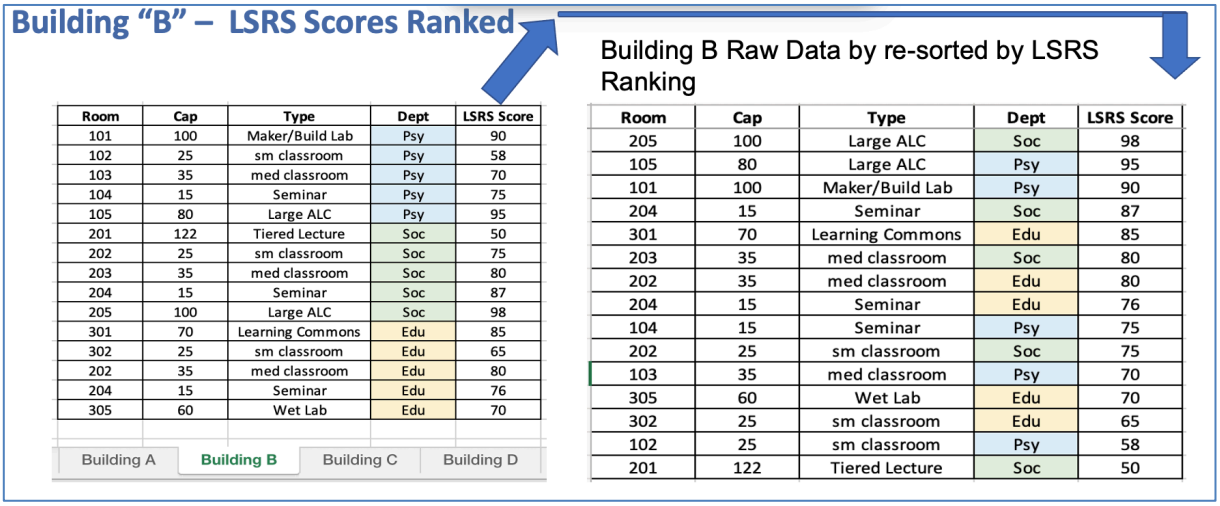
3.1 The FLIPP Process

FLIPP (FLEXspace Integrated Planning Pathway) realizes the founders' original intent of FLEXspace – to bring diverse stakeholders to the table and provide a pathway to foster interaction among those advising new space investment. It is very typical for advisors with different focal points to become competitive with resources. This is understandable, but not always the best use of time when faculty and staff earnestly work to convince colleagues of the importance of investing in learning spaces they value.

The key to time savings in the planning process is to disrupt personal advocacy (regardless of how-well supported) with LSRS benchmarking data. Once a campus project scope is defined (a building, cluster

of buildings or entire campus) the Learning Space Rating System criteria are used to score spaces relevant to the project. It is useful to benchmark an entire campus if possible and time permits, but at minimum it's necessary to gather data for the project scope. It is not necessary to use faculty or professional staff time to conduct this task. Student time/labor to gather data works well as long as they are properly trained to ensure inter-rater reliability. A team need only download the LSRS spreadsheet which is pre-populated with measurement attributes, and the guiding criteria handbook which is openly available through EDUCAUSE or FLEXspace. The spreadsheet attributes are statistically weighted and produce a compiled score for each classroom record.

Following data collection whereby each room receives an LSRS score, a spreadsheet is created to compile the project space scores. In a simulation represented below, "Building B" contains three departments on three different floors. The scoring team visited each room of the building, entered criteria scores on the LSRS spreadsheet, then transferred the compiled scores by room to an internal tracking spreadsheet. Upon completion, the classrooms were re-ranked from high to low according to score. (Fig. 3)

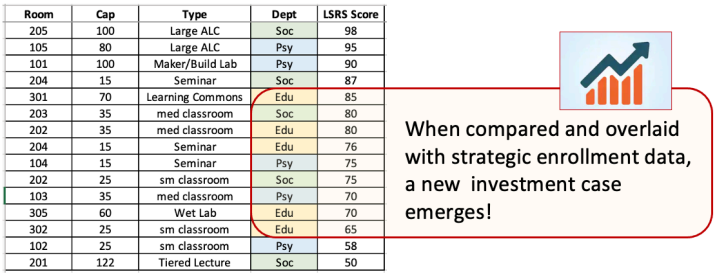


Room	Cap	Type	Dept	LSRS Score
101	100	Maker/Build Lab	Psy	90
102	25	sm classroom	Psy	58
103	35	med classroom	Psy	70
104	15	Seminar	Psy	75
105	80	Large ALC	Psy	95
201	122	Tiered Lecture	Soc	50
202	25	sm classroom	Soc	75
203	35	med classroom	Soc	80
204	15	Seminar	Soc	87
205	100	Large ALC	Soc	98
301	70	Learning Commons	Edu	85
302	25	sm classroom	Edu	65
202	35	med classroom	Edu	80
204	15	Seminar	Edu	76
305	60	Wet Lab	Edu	70

Room	Cap	Type	Dept	LSRS Score
205	100	Large ALC	Soc	98
105	80	Large ALC	Psy	95
101	100	Maker/Build Lab	Psy	90
204	15	Seminar	Soc	87
301	70	Learning Commons	Edu	85
203	35	med classroom	Soc	80
202	35	med classroom	Edu	80
204	15	Seminar	Edu	76
104	15	Seminar	Psy	75
202	25	sm classroom	Soc	75
103	35	med classroom	Psy	70
305	60	Wet Lab	Edu	70
302	25	sm classroom	Edu	65
102	25	sm classroom	Psy	58
201	122	Tiered Lecture	Soc	50

Figure 3: Example of "Building B" scores collected and re-ranked by LSRS value

This information would be useful in isolation, but when ranked LSRS scores are coupled to strategic institutional enrollment data, a more refined investment picture emerges. In this simulation, we learn from the campus registrar that the education department is growing enrollments in a new program that is attracting working teachers to comply with state certification requirements. This drives investment in some classrooms that are already considered "high scoring" in the 80's, but will require additional investment to accommodate high quality course capture to reach remote, adult educators (Fig. 4)



Room	Cap	Type	Dept	LSRS Score
205	100	Large ALC	Soc	98
105	80	Large ALC	Psy	95
101	100	Maker/Build Lab	Psy	90
204	15	Seminar	Soc	87
301	70	Learning Commons	Edu	85
203	35	med classroom	Soc	80
202	35	med classroom	Edu	80
204	15	Seminar	Edu	76
104	15	Seminar	Psy	75
202	25	sm classroom	Soc	75
103	35	med classroom	Psy	70
305	60	Wet Lab	Edu	70
302	25	sm classroom	Edu	65
102	25	sm classroom	Psy	58
201	122	Tiered Lecture	Soc	50

Figure 4: Enrollment data suggests Education Dept. may require priority classroom investment

Recall that to this point in the FLIPP process, the advisory team has not yet necessarily met to discuss the attributes of classrooms they would recommend for investment. Once the LSRS data is collected for the renovation project under consideration and presented to the advisory team, each member should create (or be assigned by the team leader) a FLEXspace account. The first advisory meeting priority

should include reviewing the simple navigation of FLEXspace to enable members to begin searching for spaces that interest them from their particular area of expertise. The taxonomies and details within each record provide critical information to an advisor – whether their primary interest is teaching, design, technology, or faculty support. The filters enable users to search for records by a particular type of space (e.g., STEM labs, Esports, Lecture Halls, etc.), institutional type (public, private, higher edu, K-12), seating capacity, and more. The advisors can then begin tagging "spaces of interest" on a FLEXspace private, "shared idea board" within the portal created by the team leader.

The time saving collaboration is realized when advisors reconvene to discuss the spaces they have added to the shared idea board. FLEXspace staff have received multiple reports from advisory teams that a palpable shift can be detected at this planning stage. The conversation tends to shift from personal or departmental advocacy to a shared commitment to institutional student success (regardless of departmental affiliation). How? Why? A conversation may resemble this: "I'm an industrial engineer and you're using the same active learning exercises in your anatomy class as I am in my supply chain class!… How did you solve the issue of…?"

When these conversations spark curricular interest and highlight shared needs among the faculty and staff advisors, it becomes much easier to select examples from peer institutions that may suit their institutional needs. Further, it enables productive conversations around "good, better and best" solutions within budget constraints – helping to define elements that should consistently be present in rooms across the enterprise, and "right sizing" the population and distribution of "higher tech" rooms to meet certain enrollment-driven and teaching/learning requirements. Engaging in conversation around pedagogy may at first seem like a mission distraction to non-faculty advisors – but it quickly becomes the glue that elevates the conversation around attributes within classrooms that support learning. This process enables a cohesive presentation to executive leadership who make the actual investment decisions. It builds trust within the institution as faculty and staff leading the FLIPP process become powerful advocates within their distributed colleague communities [2].

FEATURES THAT ENHANCE FLEXSPACE PORTAL VALUE

In addition to individual, searchable records within FLEXspace, there are also curated galleries that organize records around specific themes. For instance, the California State University (CSU) system, a FLEXspace partner, uploaded individual makerspaces from across their state, which were curated into a gallery to more easily examine best practices (Fig. 5)

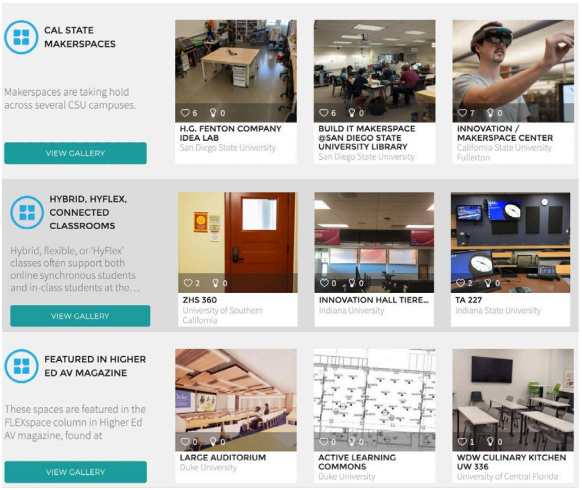


Figure 5: Curated galleries gathered from contributions are good conversation starters

The "Toolkit" is a community feature where members contribute resources they have found useful. For example, Penn State University conducted research early during the pandemic comparing different types of personal protective gear (masks and visors). Using rigorous measurements and objective criteria, the goal was to identify which gear enabled students to clearly understand a professor's lecture whether attending class socially distanced in person, or via remote connections or course captured recording. Other toolkit contributions offer post-occupancy research instruments, faculty support resources, and guidelines for building and implementing specific learning environments such as hybrid or HyFlex environments.

Each FLEXspace account holder can create personal collections by tagging favorite learning space examples and tools, then keeping the selections organized in personal idea boards. Many members use FLEXspace during conference presentations to upload slide presentations and navigating within the portal live to share space records. This creates a nice “all in one” repository to share the story of a campus learning space project.

The goal of this paper is to build a convincing case to use the FLEXspace portal and FLIPP process to increase adoption of these tools and encourage contribution of new records for continuous growth. Specifically, the hope is to motivate more contributions of STEM labs and learning spaces to help improve the learning experience for engineering faculty and students, as well as provide a fresh communication resource where specific questions can be asked probed regarding STEM based spaces.

REFERENCES

[1] Stephens, L, Lavallee, D., Moreau, J., Orzech, M. EDUCAUSE Quarterly Magazine – *Advisory Groups to Encourage Collaboration – A Case Study* Tuesday, September 27, 2011. https://er.educause.edu/articles/2011/9/advisory-groups-to-encourage-collaboration-a-case-study

[2] Grush, M. Campus Technology C-Level View Feature - *FLEXspace: Building the Resource, Fostering the Community* 01/10/22. https://campustechnology.com/articles/2022/01/10/flexspace-building-the-resource-fostering-the-community.aspx

This page is intentionally left blank


IACEE