Social informatics and CDIO: revolutionizing technological education

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ABSTRACT

Social informatics is an interdisciplinary area that examines how information and communication technologies (ICT), and the complex web of social and cultural contexts interact and change over time. This study not only helps with the design and use of ICT but also shows how these technologies significantly affect society and culture. It encourages new ideas, collaborations between different fields, and policymaking insights, which drives technological innovation and a better knowledge of how ICT affects society. The Conceive, Design, Implement, operate (CDIO) educational system stands out as a new and innovative teaching method. It emphasizes active learning and gives engineering students both technical and social skills. Its use in social informatics ushers in a new era of education that combines innovation and technology to help students become strong and independent. Future study on CDIO programs in social informatics education has the potential to augment the technical proficiency and social consciousness of graduates, thereby rendering them significant contributors to the field.

1. Introduction

Social informatics is an interdisciplinary domain that examines the interplay between Information and Communication Technologies (ICT) and social and cultural environments [1]. Social informatics research contributes to enhancing the design and utilization of ICT by considering the social and cultural environments in which they are employed. The field of social informatics study offers valuable insights into the social and cultural ramifications of ICTs, encompassing their influence on communication patterns [2], privacy concerns [3], and power dynamics [4]. The field of social informatics study has made significant contributions in the form of novel theories and empirical evidence, which enhance our comprehension of the intricate interplay between ICT and their corresponding social and cultural environments [5]. Social informatics is an interdisciplinary topic that facilitates collaboration among scholars from many disciplines, such as information science [6], anthropology [7], computer science [8], sociology [9], and political science [10], to conduct research projects [11]. Social informatics research has the potential to contribute valuable insights to policymaking in the realm of ICT [12], which is achieved via examining and analyzing the social and cultural ramifications that arise from implementing and utilizing various technological advancements [13]. Social informatics offers a theoretical framework that facilitates comprehension of the intricate interplay between ICT and their corresponding social and cultural environments [14]. This interdisciplinary field of study has the potential to enhance the design and utilization of technology,

facilitate more effective policy formulation, and foster a more profound comprehension of the social and cultural ramifications of ICT, encompassing pedagogical and instructional approaches.

Numerous learning methodologies of social informatics have been put out in scholarly literature. Case studies are a valuable method for elucidating the social and cultural ramifications of ICT within particular contexts [15]. The utilization of cases can facilitate students in comprehending the intricate interplay between technology and society, hence fostering the cultivation of critical thinking abilities [16]. Active learning methodologies, such as problem-based learning and group projects, have the potential to effectively engage students in the learning process and facilitate the application of social informatics principles to real-world problems [17]. Scaffolding is an instructional approach that offers pupils assistance and direction while acquiring novel concepts [18]. Within social informatics, scaffolding can be a valuable tool in facilitating students' comprehension of the intricate interplay between technology and society. The Socio-technical Interaction Network (STIN) is a research approach highlighting the significance of examining ICT social and technical dimensions [19]. The STIN approach is a valuable tool for students to gain insight into the intricate interplay between technology and society, fostering a comprehensive comprehension of social informatics. Developing communication and collaboration skills is crucial for social informatics students [20]. Various strategies, such as online discussion forums and collaborative projects, can be employed to facilitate the development of these skills among students [21]. Social informatics learning methodologies generally emphasize active learning, critical thinking, and a comprehensive comprehension of the intricate interplay between technology and society. There is a pressing need for further research into an alternative method to facilitate acquiring essential skills and knowledge required for success in social informatics.

The suggested approach for instructing social informatics is the Conceive, Design, Implement, Operate (CDIO) innovation strategy, which is an educational framework that emphasizes the core principles of engineering in the conceptualization, design, implementation, and operation of tangible systems and products [22]. The CDIO approach employs pedagogical strategies such as group projects and problem-based learning to enhance the proficiency of engineering students in technical knowledge, communication, and professional competencies. CDIO has been widely embraced by collaborators of the CDIO Initiative worldwide, serving as the foundation for their curriculum planning and implementing outcome-based assessment strategies. The CDIO network extends its invitation to members from various institutions, including internationally renowned research-led universities and smaller colleges. The CDIO Initiative offers a range of materials to support instructors at member universities in enhancing their pedagogical skills. Implementing the CDIO framework in social informatics has the potential to incorporate educational transformation technology, which has been identified as a fresh area of study.

2. Method

The research utilized a robust quasi-experimental methodology, integrating pre-test and post-test evaluations to thoroughly examine and evaluate the educational achievements of two separate groups. In this methodological framework, we diligently collect data from the participants before and after the intervention to identify any significant differences between the initial pre-test scores and the subsequent post-test outcomes. In order to further explore the complexities of a quasi-experimental design (Fig. 1), a set of methodological procedures is involved. The first and crucial step entails the identification of a clearly defined research subject that necessitates thorough inquiry. Once the research problem has been clearly defined, we choose the most appropriate research methodology to address the identified issue effectively. Within the quasi-experimental design framework, we face the intricate challenge of altering the independent variable without the advantage of randomly assigning participants to different circumstances or sequences of conditions.

It is essential to highlight that selecting study participants in a quasi-experimental design follows a non-random trajectory. In this study, the allocation of participants to groups does not follow a random process; instead, it is based on specified criteria that are precise and pre-established. The alignment of these criteria frequently corresponds to the study aims and the characteristics of the investigated intervention. During the study, we diligently gathered data from the participants before the intervention's commencement and afterward to its conclusion. The utilization of dual data collection is an essential element within the quasi-experimental design, as it forms the foundation for assessing the efficacy of the intervention. After collecting the necessary data, we conducted a thorough

study, utilizing statistical tools and procedures to determine if a substantial disparity exists between the pre-test and post-test results.

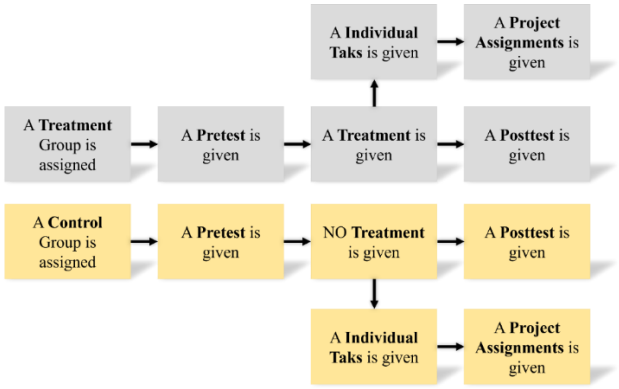


Fig. 1. Quasi experimental design

The analytical phase plays a crucial role in deriving significant conclusions about the intervention's impact and effectiveness. After the posttest, we deliver another two tasks and project assignments. Both individual task and project assignments relate to the concept of Society 5.0. The concept is related to integrating cyberspace and physical space to balance economic advancement with resolving social problems by providing goods and services that granularly address manifold latent needs regardless of locale, age, sex, or language [23]. The Society 5.0 initiative aims to create a human-centered society that leverages advanced technologies such as big data, Artificial Intelligence (AI), and the Internet of Things (IoT) [24] as present in Fig. 2. Therefore, teaching materials for Society 5.0 may include topics related to these advanced technologies, their applications, and their impact on society. Additionally, teaching materials may include case studies, research papers, and reports on the implementation of Society 5.0 in Japan and other countries.

Fig. 2. Society 5.0

The personally assigned objective involves the creation of a video campaign centered around the concept of Society 5.0. Students employ a methodical and purpose-driven methodology in the production of multimedia content. This framework places significant emphasis on the creative and production components and the comprehensive lifespan of their campaign, encompassing the stages of inception through to assessment. CDIO platform [25] (Table 1) facilitates developing a video campaign that educates, motivates, and engages viewers in substantial dialogues concerning Society 5.0 and its broader societal consequences. This comprehensive strategy goes beyond the mere sharing of knowledge. It enables students to develop a video campaign that surpasses superficial levels of involvement. The multimedia creation is strategically crafted to provide information, evoke inspiration, and stimulate substantive dialogues. Society 5.0 elicits introspection, encourages exploration, and fosters dialogue regarding the significant societal ramifications arising from the convergence of technology and humans. This convergence presents an exhilarating and revolutionary future on the horizon.

Table 1. CDIO process of a personal video campaign

CDIO step	Activity	Details
Conceive (C)	Define the Purpose and Message	Start by making sure the goal and message of the video promotion are clear: What do you want to say about Society 5.0 to your audience? What are your most important goals? Figure out who you write for and consider their hobbies, needs, and preferences. Make sure the message speaks to them.
Design (D)	Plan the Video Campaign	Make a detailed plan for the video campaign, outlining the main idea, the material, and how it will be put together. Make a storyboard or outline for the videos, listing the most important scenes, images, and how the story goes. Think about the tone, style, and looks that go best with the message and the group you want to reach.
Implement (I)	Create the Video Content	Shoot or collect relevant footage, images, and interviews to start making the movie. Make sure the information fits the plan. Edit the video so that it tells a story that makes sense and is attractive. Add pictures, images, and sound effects to your story to make it more interesting. Check the quality of the video, the clarity of the audio, and the general production values to keep people interested.
Operate (O)	Launch and Promote the Campaign	The campaign can start when the video content is ready. Post the movies on social media, YouTube, or website. Come up with an advertising plan that will reach the right people. Think about using social media marketing, email outreach, or working with people with much impact. Keep an eye on how well the campaign is doing by keeping track of things like views, engagement, and audience comments.

Students work in groups on the last project. Each group has between four and five people. They have to write a research paper with Society 5.0 as the subject. Table 2 shows how a paper is written. As the groups go through this long process, they learn more about Society 5.0 and gain essential research, analysis, and communication skills. Their work as a group leads to research papers that are more than just academic exercises; they are also thoughtful additions to the conversation about Society 5.0 that improve the academic community's overall knowledge. In the end, through this rigorous procedure, we arrive at well-informed conclusions regarding the efficacy and influence of the intervention.

Table 2. CDIO process of paper writing

CDIO step	Activity	Details
Conceive (C)	Define the Research Problem	Start with a precise study question or problem for the paper. Make it clear what the goals and scope of the study are. Think about how important and valuable the study problem is in the bigger picture of the related field.
Design (D)	Plan the Research	Make a study plan that describes how the research will be done. Describe the tools, methods, and resources used to collect the data. Make a detailed study proposal or outline that shows how the paper will be organized, with sections and subsections.
Implement (I)	Carry Out the Research	Start collecting and analyzing data based on the research plan by doing experiments, surveys, literature reviews, or other related research methods. Keep careful records of the data, notes, and references.
Operate (O)	Write the Paper	Write the paper based on the study findings. Start with an introduction that explains the study problem and why it is essential. Set up the paper in a way that makes sense, using the design phase plan as a guide. The transitions between each part should be smooth. Explain the study's methods, results, and analysis clearly and concisely. Use graphs, tables, and charts to show essential points. Talk about how the results fit into the current literature and theories. Summarize the study, discuss its meaning, and suggest more research areas.

3. Results and Discussion

Table 3 presents a complete analysis of the gender composition among students in the two classes, providing valuable insights into the equilibrium or discrepancy in the representation of males and females. The data above holds significant importance in comprehending the demographic makeup of the student population and its possible influence on academic achievement and the dynamics inside the classroom. In the following sections, Table 4 to Table 6 provide a more comprehensive analysis of the academic performance of these courses. This is achieved by providing the distribution of grades across various evaluation parameters. The provided tables present a detailed analysis of student accomplishments, encompassing pre-tests, post-tests, individual assignments, and project assignments. Furthermore, these metrics offer a broad viewpoint by presenting the entire mean value, thus facilitating a comprehensive assessment of the educational achievements of each course. Through a comprehensive examination of the data shown in Table 4 to Table 6, in conjunction with the gender distribution data provided in Table 3, scholars and educators can acquire significant knowledge regarding the intricate relationship among gender, assessment performance, and overall scholastic achievement within these academic settings. These discoveries can potentially be crucial in influencing future pedagogical approaches and fostering inclusive learning environments.

Table 3. Distribution of the number of students by gender

Gender	Class A	Class B
Male	25	33
Female	15	7
Total	40	40

Table 3 presents a complete analysis of the demographic composition of students, categorizing them based on gender in two unique classes, Class A and Class B. The composition of Class A exhibits a gender distribution of 25 male pupils and 15 female students. In contrast, Class B exhibits a divergent distribution, accommodating 33 male students and seven female pupils. As a result, Class A has a combined enrolment of 40 students, consisting of 25 male students and 15 female students. Similarly, Class B likewise has 40 students, with 33 male students and seven female students. Significantly, an examination of these figures unveils a compelling juxtaposition between the two categories. Class A demonstrates a moderate gender imbalance, with a higher representation of male pupils than female students. In contrast, Class B demonstrates a more notable gender imbalance, characterized by a more significant proportion of males than females.

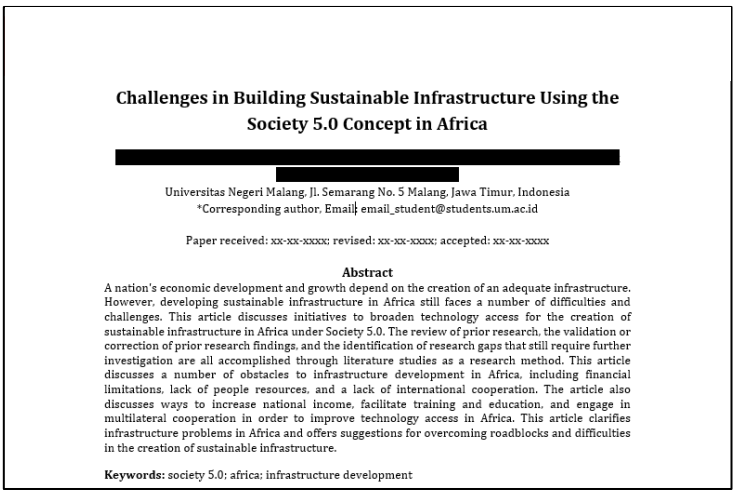
Table 4. Distribution of scores based on male gender.

Class	Pre-test	Post-test	Individual task	Project Assignments
A	84.8	81.4	81.2	87.2
B	84.3	84.1	82.2	87.7

Table 4 provides a complete analysis of score distributions, specifically focusing on male students in two prominent classes, namely Class A and Class B. The average score achieved by male students in Class A is a notable 83.7. The presented data has been obtained by a rigorous analysis, which includes the initial score of 84.8, the subsequent performance of 81.4, the individual assignments resulting in a score of 81.2, and the project assignment producing an excellent score of 87.2. Fig. 3 and Fig. 4 show the example of individual tasks and project assignments, respectively.

Fig. 3. Individual task

In contrast, the male students in Class B demonstrate a marginally superior mean score of 84.6. The composite score is derived from the pre-test marks (84.3), post-test scores (84.1), average scores of individual assignments (82.2), and exceptional scores of project assignments (87.7). While there is a slight difference in the average score between Class A and Class B, the discrepancy between the two is negligible. It is worth noting that the male students in both courses have a noteworthy average score that consistently hovers around the threshold of 84. This underscores their exceptional academic achievement and their unwavering commitment to their studies.



Challenges in Building Sustainable Infrastructure Using the Society 5.0 Concept in Africa

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Abstract

A nation's economic development and growth depend on the creation of an adequate infrastructure. However, developing sustainable infrastructure in Africa still faces a number of difficulties and challenges. This article discusses initiatives to broaden technology access for the creation of sustainable infrastructure in Africa under Society 5.0. The review of prior research, the validation or correction of prior research findings, and the identification of research gaps that still require further investigation are all accomplished through literature studies as a research method. This article discusses a number of obstacles to infrastructure development in Africa, including financial limitations, lack of people resources, and a lack of international cooperation. The article also discusses ways to increase national income, facilitate training and education, and engage in multilateral cooperation in order to improve technology access in Africa. This article clarifies infrastructure problems in Africa and offers suggestions for overcoming roadblocks and difficulties in the creation of sustainable infrastructure.

Keywords: society 5.0; africa; infrastructure development

Fig. 4. Project assignments

Table 5 presents a complete analysis of score distributions, explicitly examining the academic achievement of female students in two unique classes, Class A and Class B. Within Class A, the female students demonstrate a noteworthy mean score of 84.4. This noteworthy value is obtained through a thorough examination, considering a pre-test score of 81.0, post-test achievement of 84.6, an average score of 84.7 for individual tasks, and an astounding 87.3 for project assignments. On the other hand, female students enrolled in Class B demonstrate a mean score of 82.2. The composite score is derived from the pre-test outcomes, which were recorded at 74.7, and the post-test scores, which exhibited an increase to 84.6. Additionally, the average score for individual assignments was determined to be 82.3, while project assignments yielded a commendable score of 87.3. Although female students in Class A seem to perform better than their counterparts in Class B, the disparity in their mean scores does not reach statistical significance. The aggregated mean score for female students in both classes exhibits a surprising level of uniformity, consistently remaining close to the notable benchmark of 84. The consistency observed in this context highlights the commitment and intellectual abilities demonstrated by the female students in both classes

Table 5. Distribution of values based on female gender

Class	Pre-test	Post-test	Individual task	Project Assignments
A	81.0	84.6	84.7	87.3
B	74.7	84.6	82.3	87.3

Table 6 provides a comprehensive overview of the distribution of overall scores attained by students in two separate courses, Class A and Class B. In Class A, the students exhibit a commendable mean score of 83.9, which is derived from a comprehensive analysis of their pre-test score (83.9), post-test performance (84.1), average individual assignment scores (82.6), and noteworthy project assignment scores (84.9). In comparison, the students in Class B demonstrate a somewhat superior mean score of 84.0. The composite score includes pre-test outcomes of 84.2, post-test scores of 84.7, average scores of 82.2 for individual assignments, and commendable ratings of 84.9 for project assignments. Based on the available data, Class B exhibits slightly superior overall scores to Class A, with a minimal discrepancy of merely 0.01. The slight disparity indicates a nuanced distinction in the scholastic achievement of the two groups. Upon closer examination of the pre-test and post-test results presented in Table 4 through Table 6, it becomes evident that there is a notable level of consistency. Class A's initial assessment score is 83.9, whereas the subsequent assessment score is 84.1. In contrast, the pre-test score of Class B is 84.2, while the post-test score shows a slight increase to 84.7. The observed convergence of these results suggests a general enhancement in student comprehension and

achievement after supplementary instruction or the culmination of the examination. The upward trajectory highlights the possible influence of easily obtainable educational resources, student readiness, and levels of preparedness for the post-assessment. Furthermore, a noteworthy pattern becomes apparent when examining the ratings of individual and project assignments in Table 4 and Table 6. The results consistently indicate that Class A and B project assignments earn higher grades than individual assignments. The tendency above indicates that students have the potential to demonstrate exceptional performance in collaborative projects or assignments that require intricate problem-solving skills, hence highlighting the efficacy of project-based learning methodologies. However, it is imperative to recognize that project activities must be evaluated carefully, considering their quality and complexity to guarantee significant learning opportunities.

Table 6. Distribution of overall student scores

Class	Pre-test	Post-test	Individual task	Project Assignments
A	83.9	84.1	82.6	84.9
B	84.2	84.7	82.2	84.9

Upon doing a comprehensive investigation, it is observed that gender-based disparities in student accomplishment exhibit a need for more statistical significance. Educators must acknowledge that gender has the potential to impact students' learning preferences and approaches. To facilitate the comprehensive growth and academic success of all students, irrespective of their gender, educators should modify instructional approaches to accommodate a wide range of learning preferences. It is imperative to acknowledge that disparities in academic achievement among classes A and B may arise from variables beyond the assessment modality, including changes in curricular content, instructional approaches, or contextual impacts specific to each class. It is imperative to examine these issues thoroughly to understand the discrepancies in student accomplishment and effectively improve learning programs. The observed trend of continuous enhancement from the pre-test to the post-test and the differentiation between individual and project-based tasks highlights the need to employ deliberate instructional approaches. Educators must evaluate their evaluation methodologies diligently, contemplate enhancements in teaching strategies, and keep cognizant of variables that could influence students' understanding and achievement. The ongoing assessment of the effectiveness of instructional approaches and evaluation methodologies can provide educators with the means to enhance student learning experiences and maximize overall academic performance.

The integration of data obtained from Table 4, Table 5, and Table 6 serves to emphasize our dedication to education and the significant influence of our instructional approaches. The data in Table 4 demonstrates a constant increase in scores from the pre-test to the post-test. This indicates our strong commitment to providing our students with ongoing and effective learning opportunities. Furthermore, the findings shown in Table 5 shed light on the gender-based disparities, highlighting our dedication to promoting inclusivity. The observed modest discrepancies in academic performance between male and female students align with our primary objective of ensuring equal opportunities for all individuals. The focus on the transformative impact of hands-on CDIO programs in Table 6 aligns with our objective to cultivate comprehensive graduates with engineering proficiency, problem-solving abilities, and collaboration skills necessary for success in the ever-changing engineering field. These tables jointly validate our institution's commitment to achieving quality, fostering innovation, and creating an inclusive educational environment that equips students to tackle present-day difficulties and adapt to the continuously changing future.

3.1. CDIO for Reshaping Engineering Education and Social Informatics

The core of CDIO programs centers around active and experiential learning, which is critical in augmenting students' comprehension of engineering principles and their capacity to apply theoretical knowledge to real-life problems. This instructional approach is characterized by its dynamic nature, as it actively involves students and provides them with immersive, real experiences. These experiences facilitate a more profound comprehension of intricate engineering ideas. CDIO programs allow students to actively engage in project design, construction, implementation, and operation [26]. This active participation enables students to connect academic knowledge with its practical application effectively, thereby bridging the gap between theory and practice. An illustrative instance pertains to the intersection between smart cities and urban planning. The analysis of various smart city projects and their effects on urban settings is undertaken by students. The authors discuss how technology contributes to the advancement of sustainability, transportation, and the overall standard of living within urban areas. They also deliberate upon the societal and ethical ramifications of implementing

smart city initiatives. Using authentic case studies in the instruction of social informatics can enhance students' comprehension of the intricate interplay between technology and society while also cultivating their abilities in critical thinking and ethical reasoning [27]. Active participation in these activities enables students to cultivate problem-solving skills, enhance critical thinking, and acquire adaptability to address complex engineering challenges. CDIO programs facilitate a transformative learning experience wherein students develop into proactive creators and innovators, possessing the necessary confidence and proficiency to flourish in their engineering pursuits. CDIO programs have emerged as a significant catalyst in engineering education, leading to a profound reconfiguration of conventional instruction and knowledge acquisition methods. Promoting active involvement, enhancing problem-solving abilities, facilitating multidisciplinary collaboration, and cultivating essential soft skills enable students to attain improved outcomes. CDIO programs have been found to produce graduates with technical expertise in engineering, strong communication skills, and leadership abilities.

These graduates are well-equipped to thrive in the constantly changing and dynamic engineering. As a result, CDIO programs have proven to be instrumental in enhancing the quality of education and learning [28], yielding long-lasting advantages for both students and the engineering profession. The modification of social informatics education necessitates the incorporation of inventive methodologies that accurately mirror the dynamic characteristics of technology and its influence on the broader social fabric. Instructors can enhance their teaching methods by including real-time case studies and interactive simulations rather than relying only on traditional lectures and texts. Educators can employ contemporary, tangible instances, such as the expeditious dissemination of false information through social media platforms amidst a crisis, such as a pandemic, to foster active participation among students in dialogues concerning the broader ramifications of technological advancements on society. Moreover, educators can foster cooperative endeavors that necessitate students' examination and formulation of resolutions for present-day social informatics dilemmas. These problems encompass the development of morally upright artificial intelligence algorithms and the establishment of protocols for the safeguarding and confidentiality of data. By incorporating these dynamic and pertinent components into the educational program, the instruction of social informatics can enhance students' abilities and understanding to tackle the intricate challenges arising from the convergence of technology and society in the contemporary, rapidly evolving digital landscape. CDIO programs substantially impact the development of graduates who possess in-demand social informatics skills specifically designed to fulfill the needs of the business [29]. As a result, these graduates become extremely desirable to potential employers, boosting their employability. These programs provide students with a comprehensive technical foundation and expose them to a well-rounded learning environment where they engage with practical social informatics concerns. Through conceptualization, design, implementation, and operation, students gain practical expertise and comprehensive comprehension of the complex dynamics between technology and society by undertaking projects that tackle urgent challenges within the industry. The CDIO program equips graduates with diverse skills, making them highly valuable to employers who require individuals capable of effectively navigating the intricate realm of digital transformation, ethical considerations, and societal impacts. These skills have become increasingly essential in today's job market, which is heavily influenced by technology.

CDIO programs serve as a transformative environment in which the future cohort of engineering leaders is developed, carefully molding students into versatile professionals with a wide range of skills, including technical expertise, effective communication aptitude, and a solid understanding of the complexities of social informatics. CDIO programs guarantee that graduates acquire the necessary technical skills for engineering excellence and the ability to negotiate the complex intersection of technology and society by effectively incorporating these aspects into the educational process. The comprehensive methodology employed in this educational approach imparts students with the fundamental abilities to interpret and tackle the intricate obstacles posed by the era of digitalization. This equips them with the capacity to assume leadership roles in engineering pursuits, characterized by technical expertise and a strong sense of ethical and social responsibility. CDIO programs serve as the platform where future technical leaders are developed and honed into individuals with visionary capabilities adept at promoting innovation while effectively navigating the complex dynamics of our technology-centric society. Overall, the CDIO Initiative furnishes engineering students with a comprehensive and balanced educational experience, equipping them with the necessary skills and knowledge to thrive in their prospective professional endeavors.

3.2. Difficulties and Prospects of Engineering Education CDIO Programs

Undoubtedly, CDIO programs exhibit considerable potential in engineering education [30]. However, it is imperative to acknowledge and address certain crucial factors that warrant further investigation in future research endeavors. The CDIO framework strongly emphasizes active learning and the practical application of engineering principles [31]. However, it presents a challenge when assessing the diverse range of skills and abilities produced through this approach. Further investigation is warranted to examine more intricate and efficacious evaluation techniques that may comprehensively encompass the entire range of learning achievements, surpassing conventional grading systems. Furthermore, to ensure the fair distribution of advantages provided by CDIO programs, it is imperative to acknowledge and rectify any potential discrepancies in access and outcomes. There is a need for a more comprehensive examination of the potential impact of various student demographics and backgrounds on their experiences and accomplishments within CDIO situations. This entails exploring approaches to enhance inclusivity and diversity within the programs.

In conclusion, given the substantial need for faculty engagement and inventive approaches in the CDIO framework, the following research endeavors should prioritize developing faculty training programs and establishing support structures. Understanding strategies to inspire and empower educators in adopting CDIO pedagogy and fostering successful interdisciplinary collaboration is paramount for these initiatives' long-term success and expandability. By focusing on these crucial domains, forthcoming investigations can make valuable contributions to the continuous improvement and enhancement of CDIO programs, guaranteeing their ability to mold the upcoming cohort of comprehensive engineering practitioners. The CDIO programs undoubtedly serve as a catalyst for change in engineering education. However, it is crucial to recognize their limitations and proactively tackle these difficulties through thorough research and deliberate implementation strategies to harness their capabilities thoroughly. By implementing this approach, it is possible to augment the educational encounters of engineering students and guarantee that individuals who complete their studies possess a wide range of abilities and a moral perspective essential for effectively navigating the intricate and constantly changing convergence of technology and society. By adopting this approach, CDIO programs can effectively serve as a driving force for promoting constructive transformations in engineering education. Consequently, these programs can cultivate individuals with exceptional technical skills and strong ethical and social awareness, enabling them to assume leadership roles in our progressively technology-oriented society.

4. Conclusion

In summary, upon contemplation of the transformative capacity of CDIO programs within the realm of social informatics, it becomes apparent that these pioneering educational methodologies possess the fundamental means to cultivate a novel cohort of engineers who not only excel in technical proficiencies but also possess a deep comprehension of the societal ramifications of technology. CDIO programs enable students to effectively traverse the complex intersection of technology and society by incorporating hands-on, interdisciplinary learning experiences into the curriculum. The comprehensive methodology employed in this approach cultivates fundamental abilities to analyze intricate social informatics issues, promote creativity, and facilitate the development of ethical and responsible technology progress. Future research in social informatics education should prioritize several crucial aspects. First and foremost, it is imperative to investigate the enduring effects of CDIO programs on individuals who have pursued a specialization in social informatics. How do these graduates contribute to resolving real-world societal difficulties, and what job paths do they pursue? Furthermore, it is crucial to critically evaluate the efficacy of specific instructional approaches employed in CDIO programs, such as interactive simulations and real-time case studies, about their impact on developing students' critical thinking abilities and ethical reasoning skills within social informatics. Moreover, it is imperative for academics to thoroughly investigate the possible impact of CDIO programs on facilitating collaboration among technical disciplines and social sciences. This would establish a dynamic interdisciplinary setting whereby students can effectively collaborate to address intricate societal challenges. Through a thorough examination of these factors, future studies have the potential to yield significant knowledge regarding the ongoing development of CDIO programs. This knowledge can be instrumental in preparing graduates to excel in their technical engineering skills and cultivate a strong sense of social awareness and responsibility. Consequently, these graduates can make substantial contributions to social informatics.

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References

[1] C. Thyssen, J. Huwer, T. Irion, and S. Schaal, "From TPACK to DPACK: The 'Digitality-Related Pedagogical and Content Knowledge'-Model in STEM-Education," *Educ. Sci.*, vol. 13, no. 8, p. 769, Jul. 2023, doi: 10.3390/educsci13080769.

[2] M. Rohde, C. Müller, T. Ludwig, G. Stevens, V. Pipek, and V. Wulf, "Socio-Informatics: A Practice-Based Research and Design Paradigm," *Socio-Informatics Des. Soc. Pract. A Condens. Anthol. 25 Years Res.*, p. 14.

[3] A. Sestino, A. Kahlawi, and A. De Mauro, "Decoding the data economy: a literature review of its impact on business, society and digital transformation," *Eur. J. Innov. Manag.*, Aug. 2023, doi: 10.1108/EJIM-01-2023-0078.

[4] N. I. Melnikova and O. A. Romanovskaya, "The Russian concept of social informatics in light of information technology innovation: a systematic review," *Acta Inform. Pragensia*, vol. 10, no. 3, pp. 301–332, 2021. doi: 10.18267/j.aip.172

[5] Z. Smutny and M. Dolezel, "Social Informatics Challenges Connected with Generational Changes and the Design, Acceptance and Use of ICT," in *2019 International Conference on Engineering Technologies and Computer Science (EnT)*, 2019, pp. 75–79, doi: 10.1109/EnT.2019.00021.

[6] A. W. Dunbar, "Every information context is a CRiTical Race information Theory opportunity: informatic considerations for the information industrial complex," *Digit. Transform. Soc.*, Jul. 2023, doi: 10.1108/DTS-02-2023-0013.

[7] V. Wulf, A. Weibert, K. Aal, S. Rüller, and M. Rohde, "The Praxeological Research Programme of Socio-Informatics–the Siegen School," *Acta Inform. Pragensia*, vol. 10, no. 3, pp. 333–348, 2021. doi: 10.18267/j.aip.171

[8] Y. Wang, Y. Song, Z. Ma, and X. Han, "Multidisciplinary considerations of fairness in medical AI: A scoping review," *Int. J. Med. Inform.*, vol. 178, p. 105175, Oct. 2023, doi: 10.1016/j.ijmedinf.2023.105175.

[9] Y. Yang, C. Zhang, K. Zhao, and Q. Wang, "The shifting role of information processing and management in interdiscipline development: From a collection of tools to a crutch?," *Inf. Process. Manag.*, vol. 60, no. 4, p. 103388, Jul. 2023, doi: 10.1016/j.ipm.2023.103388.

[10] Z. Ba, Y. Cao, J. Mao, and G. Li, "A hierarchical approach to analyzing knowledge integration between two fields—a case study on medical informatics and computer science," *Scientometrics*, vol. 119, no. 3, pp. 1455–1486, Jun. 2019, doi: 10.1007/s11192-019-03103-1.

[11] P. Fichman, M. R. Sanfilippo, and H. Rosenbaum, *Social informatics evolving*. Springer Nature, 2022.

[12] Z. Smutny and V. Vehovar, "Social Informatics Research: Schools of Thought, Methodological Basis, and Thematic Conceptualization," *J. Assoc. Inf. Sci. Technol.*, vol. 71, no. 5, pp. 529–539, May 2020, doi: 10.1002/asi.24280.

[13] A. Gamble, "Artificial intelligence and mobile apps for mental healthcare: a social informatics perspective," *Aslib J. Inf. Manag.*, vol. 72, no. 4, pp. 509–523, Jun. 2020, doi: 10.1108/AJIM-11-2019-0316.

[14] I. Krasonikolakis, M. Tsarbopoulos, and T.-Y. Eng, "Are incumbent banks bygones in the face of digital transformation?," *J. Gen. Manag.*, vol. 46, no. 1, pp. 60–69, Oct. 2020, doi: 10.1177/0306307020937883.

[15] S. Paparini *et al.*, "Case study research for better evaluations of complex interventions: rationale and challenges," *BMC Med.*, vol. 18, no. 1, p. 301, Dec. 2020, doi: 10.1186/s12916-020-01777-6.

[16] E. B. Tugtekin and M. Koc, "Understanding the relationship between new media literacy, communication skills, and democratic tendency: Model development and testing," *New Media Soc.*, vol. 22, no. 10, pp. 1922–1941, Oct. 2020, doi: 10.1177/1461444819887705.

[17] A. R. Rajabzadeh, M. Mehrtash, and S. Srinivasan, "Multidisciplinary Problem-Based Learning (MPBL) Approach in Undergraduate Programs," 2022, pp. 454–463. doi: 10.1007/978-3-030-96296-8_41

[18] D. J. Tedick and R. Lyster, *Scaffolding language development in immersion and dual language classrooms*. Routledge, 2019. doi: 10.4324/9780429428319

[19] S. White, S. White, and K. Borthwick, "Blended professionals, technology and online learning: Identifying a socio-technical third space in higher education," *High. Educ. Q.*, vol. 75, no. 1, pp. 161–174, Jan. 2021, doi: 10.1111/hequ.12252.

[20] A. Ghosh, A. Nafalski, Z. Nedic, and A. P. Wibawa, "Learning management systems with emphasis on the Moodle at UniSA," *Bull. Soc. Informatics Theory Appl.*, vol. 3, no. 1, pp. 13–21, May 2019, doi: 10.31763/businta.v3i1.160.

[21] I. Blau, T. Shamir-Inbal, and O. Avdiel, "How does the pedagogical design of a technology-enhanced collaborative academic course promote digital literacies, self-regulation, and perceived learning of students?," *Internet High. Educ.*, vol. 45, p. 100722, Apr. 2020, doi: 10.1016/j.iheduc.2019.100722.

[22] G. Garcés and C. Peña, "Adapting engineering education to BIM and industry 4.0: A view from Kolb's experiential theory in the laboratory," *Ingeniare*, vol. 30, no. 3, pp. 497–512, 2022, doi: 10.4067/S0718-33052022000300497.

[23] A. Deguchi *et al.*, "What is society 5.0," *Society*, vol. 5, no. 0, pp. 1–24, 2020. doi: 10.1007/978-981-15-2989-4_1

[24] A. Beniiche, S. Rostami, and M. Maier, "Society 5.0: Internet as if People Mattered," *IEEE Wirel. Commun.*, vol. 29, no. 6, pp. 160–168, Dec. 2022, doi: 10.1109/MWC.009.2100570.

[25] A. P. Wibawa, F. A. Dwiyanto, T. Widiyaningtiyas, I. Made Wirawan, W. S. Gunawan Iriyanto, and A. S. Ahmar, "Utilization Visualgo.net as a Data Structure Learning Media based on CDIO," *J. Phys. Conf. Ser.*, vol. 1028, no. 1, 2018, doi: 10.1088/1742-6596/1028/1/012064.

[26] S. Kulkarni, S. Patil, and R. Pawar, "Adoption of the conceive-design-implement-operate approach to the third year project in a team-based design-build environment," *Procedia Comput. Sci.*, vol. 172, pp. 559–567, 2020, doi: 10.1016/j.procs.2020.05.068.

[27] S. Namasivayam, M. H. Fouladi, D. T. K. Tien, and J. A. S. Moganakrishnan, "Design Engineering as a Means to Enhance Student Learning in Addressing Complex Engineering Challenges," in *Design Education Today*, Cham: Springer International Publishing, 2019, pp. 249–270. doi: 10.1007/978-3-030-17134-6_11

[28] A. Van den Beemt *et al.*, "Interdisciplinary engineering education: A review of vision, teaching, and support," *J. Eng. Educ.*, vol. 109, no. 3, pp. 508–555, Jul. 2020, doi: 10.1002/jee.20347.

[29] E. F. Crawley and A. E. Hosoi, "Moving Forward with the New Engineering Education Transformation (NEET) program at MIT-Building community, developing projects, and connecting with industry," 2019.

[30] S. Julius Fusic, N. Anandh, D. Anitha, T. Sugumari, and H. Sri Vinodhini, "Impact of implementing project-based assignment (PBA) in CDIO framework for computer numerical control application course," *Comput. Appl. Eng. Educ.*, vol. 30, no. 5, pp. 1577–1590, Sep. 2022, doi: 10.1002/cae.22545.

[31] H. Arruda and É. R. Silva, "Assessment and Evaluation in Active Learning Implementations: Introducing the Engineering Education Active Learning Maturity Model," *Educ. Sci.*, vol. 11, no. 11, p. 690, Oct. 2021, doi: 10.3390/educsci11110690.