ASSESSMENT OF PRODUCT DESIGN AND ENGINEERING STUDENTS ESSENTIAL SKILLS' FOR TOMORROW

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ABSTRACT

This paper explores the assessment of Critical and Creative Thinking skills among Product Design and Engineering (PDE) students, whose profession holds significant potential for addressing the complex challenges facing global societies. In today's globalized world, higher education institutions must equip students to solve both local and global problems. The lack of emphasis on assessing critical problem-solving skills has led to growing concerns among employers and organizations that graduates may not be adequately prepared to meet the demands of the 21st-century workplace, including PDE.

This paper uses a case study approach to evaluate the performance of final-year PDE students, specifically their Critical and Creative Thinking abilities. The study assesses two groups, Group A and Group B, which produce solutions focused on the marketplace and design sustainable solutions, respectively. The study concludes that solving wicked problems that require sustainable solutions demands a higher level of these skills. The study's findings are consistent with the Organization for Economic Co-operation and Development's 2022 report, which also highlighted low levels of CriT and CreT in students at the same level studied for this paper.

Keywords: Design engineering, Sustainability, Design for X (DfX), Case study

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1 INTRODUCTION

In today's world, with growing concerns about sustainability issues such as pollution and global warming, also known as wicked problems, there is an urgent need for product designers and engineers (PDE) to meet expectations of clients, governments, and consumers. As a result, these professionals are required to possess highly advanced critical (CriT) and creative thinking (CreT) skills to tackle these challenges effectively. However, two questions arise: (1) does our current tertiary education in PDE equip students with the necessary skills (CriT and CreT) to meet these demands? and, (2) should these skill levels increase when focusing on solving more complex problems? The answer to the first question is not straightforward, as it is impacted by a myriad of factors, such as program design, institutional culture, instructors, and students, to name a few. In general, there is evidence to suggest that tertiary education in PDE may not fully meet today's needs (World Economic Forum, 2020). According to this report by the World Economic Forum, there is a significant gap between the skills that employers require (which include critical and creative thinking) and the skills that graduates possess. The report notes that around 35% of the skills required for jobs across industries will change by 2025 due to deeper technological integration (p. 27). This suggests that tertiary education institutions need to continuously adapt their curricula to meet the evolving needs of employers. Specifically, in the field of PDE, employers are increasingly looking for candidates with a broad range of skills, including creativity, critical thinking, communication, collaboration, and digital literacy. Yet traditional tertiary education programs in this field may focus more on technical skills and less on those skills. To better guide us toward answering both of our questions, this paper examines the performance of students from final-year undergraduate or first-year master students without industry experience using a case study approach. It focuses on their CriT and CreT abilities and assesses two groups - Group A, focusing on low-cost solutions, and Group B, focusing on the future of our eco-system. The study concludes that: 1. Levels of CreT and CriT of the group studied are below the expected expert level, which corroborates with Organisation for Economic Co-operation and Development (OECD) (2022) report's findings; and 2. Higher levels of CriT and CreT do not necessarily relate to more sustainable solutions. Finally, the study highlights the importance of integrating the assessment of these skills into PDE education and equipping students with higher-level of creative and critical problem-solving skills to tackle complex challenges.

2 CREATIVE AND CRITICAL THINKING

There is ample research that supports the importance of CreT and CriT assessment and development in undergraduate students in tertiary education. In 2006, Robert J. Sternberg conducted a study titled "The Nature of Creativity". Sternberg identified several crucial creative thinking skills necessary for individuals to succeed in creative endeavours. He emphasized that creativity goes beyond generating new and useful ideas and also to effectively implement them. Sternberg identified five critical creative thinking skills that are vital for success. These includ specialized knowledge and skills (expertise), thinking beyond conventional ideas (imaginative thinking), taking calculated risks (willingness to take risks), being motivated internally (intrinsic motivation), and having access to resources and support (a supportive environment). The study highlights that creativity is fostered by a combination of skills and environmental factors. Another study by Runco (2007) found that CreT skills are essential for success in a variety of fields, including science, engineering, business, and the arts. The study found that creative thinkers are more likely to develop innovative solutions to complex problems and are more likely to succeed in their careers. Moreover, a study by Parnell et al. (2015) discusses that CreT and alternative approaches to problem-solving are necessary when dealing with wicked problems such as urban resilience and Green and Blue Infrastructure (GBI) benefits. Green infrastructure includes natural elements like parks and gardens, while blue infrastructure includes water features like rivers and wetlands. Both are important for sustainable urban design.

A study by Paul and Elder (2005) found that CriT skills are essential for effective decision-making in both academic and real-world settings. The study found that students who received training in critical thinking skills were better able to analyse complex problems, evaluate evidence and arguments, and make informed decisions. Hence, critical thinking is an essential skill that enables individuals to analyse information, make sound judgments, and solve problems effectively. It has been the subject of extensive research in the fields of psychology, education, and philosophy, among others. One of the most

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influential definitions of critical thinking comes from the philosopher Richard Paul, who describes it as "thinking about your thinking while you are thinking in order to make your thinking better" (Paul and Elder, 2006). It follows that, critical thinking involves metacognition, or the ability to reflect on one's own thinking processes. Research on CriT has identified several key components of the skill. These include identifying and analysing arguments, evaluating evidence, recognizing biases and assumptions, and making logical inferences (Facione, 2011). Some scholars have also emphasized the importance of creativity, curiosity, and intellectual humility in fostering CriT (Ennis, 1987; Paul and Elder, 2006).

According to a study by Bryson et al. (2018, pp. 214-223), CreT and CriT are essential for addressing wicked problems. Wicked problems are complex, multifaceted problems that are difficult to define and solve. They require innovative, interdisciplinary solutions that incorporate a range of perspectives and expertise. Their study found that successful solutions to wicked problems require a combination of CriT skills, such as analysis, evaluation, and synthesis, and CreT skills, such as ideation, imagination, and innovation. Similarly, a study by Mezirow (2000) found that critical thinking is essential for addressing complex problems and for developing transformative solutions. The study found that critical thinking involves questioning assumptions, analysing evidence, and considering alternative perspectives, which are all essential for developing innovative solutions to wicked problems. As brought by the latest report from the OECD (Van Damme and Zahner, 2022), currently the level of CriT of undergrads shows that "half of exiting students are performing at the two lowest levels" on CriT (p. 22). This scenario builds distrust in the ability of higher education institutions (HEIs) to reliably develop their students' CriT' levels needed for the global marketplace. Consequently, this distrust has been affecting not only education but industry and society at large. This may mean that it is not that undergraduate students have to become extremely intelligent but rather the actual level of students in general, is too low. Moreover, given the nature of wicked problems that society is now facing (e.g., sustainable development, and climate change among others), the level of CriT and CreT needs to increase to adequately address the challenge.

Taken together, these studies indicate that evaluating and enhancing students' Creative Thinking (CreT) and Critical Thinking (CriT) abilities is crucial for undergraduates in tertiary education. Developing these skills can help students become more proficient learners, adept problem-solvers, and inventive thinkers, and equip them for success in their academic and professional pursuits. By integrating CriT and CreT in the solution development process of programmatic design exercises, it is anticipated that students will generate more impactful and original solutions to complex and challenging problems.

3 DESIGNING FOR SUSTAINABILITY: ADDRESSING WICKED PROBLEMS IN PRODUCT DESIGN AND ENGINEERING (PDE)

While PDEs may contribute to some wicked problems, their role is just one part of a larger system that includes government policies, social norms, economic structures, and individual behaviours. For example, environmental degradation is a wicked problem that has been exacerbated by unsustainable PDE practices, but it also stems from larger societal and economic forces that drive overconsumption and resource depletion. However, there are some examples of how PDEs have contributed to wicked problems, as well as how they are working to address them. One example is the issue of air pollution, which is a wicked problem that has been exacerbated by the design and engineering of automobiles, power plants, and other industrial facilities. The automobile industry, for example, has been criticized for designing vehicles with inefficient engines and poor emissions controls, which has contributed to the high levels of air pollution in many cities (Tal, et al., 2019). However, there are also many examples of PDEs working to address this problem, such as by developing electric vehicles and other clean energy technologies. It is important to recognise that PDEs are not solely responsible for wicked problems and that these issues are often the result of larger societal and economic structures. Hence, "The responsibility for resolving wicked problems can no longer be delegated to any one professional group or sector" (Hancock, 2019). Addressing wicked problems requires a collaborative, interdisciplinary approach that involves a wide range of stakeholders, including designers, engineers, policymakers, and community members. Therefore, PDEs need to enhance the development of their CriT ad CreT levels to address wicked problems effectively and collaboratively. CriT involves analysing information and ideas carefully and objectively, while CreT involves generating new and innovative ideas. Both types of thinking are necessary for addressing wicked problems that are

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complex and require a multidisciplinary approach. For example, a study by Brankaert and den Ouden (2017, pp. 621-635) examined the role of design thinking in addressing wicked problems. The authors found that design thinking, which emphasizes both CriT and CreT, can be an effective approach for addressing complex, systemic problems. Another study by Hsu and Chen (2018) examined the relationship between CriT and CreT and innovation in product design. The authors found that both types of thinking were important for innovation in product design, and that product designers who were able to integrate CriT and CreT were more likely to develop innovative solutions to problems.
In summary, the studies highlight the significance of cultivating CriT and CreT abilities among PDEs engaged in tackling wicked problems. By acquiring and developing these skills, PDEs can adopt a more methodical, interdisciplinary, and inventive approach to problem-solving, which is crucial in addressing the intricate issues that society is currently confronting. These studies affirm the notion that CriT and CreT skills should be fundamental to the professional education of PDEs, as they align with the 21st-century skills identified by Van Damme and Zahner (2022).

4 METHODOLOGY

This section summarizes the workshop's experiment where three rubrics were used to assess and evaluate participants on their CriT, CreT, and sustainability levels. The workshops were conducted in three different countries with a total of 74 participants. During these workshops, a design brief was presented, and participants provided solutions. They had 3 to 5 min to explain the process that led them to the solutions presented and during this moment had their CreT and CriT using rubrics developed by Shively (2018). Shively's rubrics are a tool used to evaluate the quality of a design. The tool used to evaluate the quality of a design is comprised of criteria that assess various elements, including clarity, coherence, and originality. Additionally, the level of sustainability of the solutions is evaluated as the third assessment, which is classified using a multi-level framework of innovation levels developed by Ceschin and Gaziulusoy (2019) and graded by three expert judges. During the workshops, two groups, Group A and Group B, are formed. Group A is tasked with finding profitable solutions, while Group B focuses on producing solutions that consider their impact on the ecosystem. It is important to note that this study started in early 2022 and will continue until late 2023.

4.1 Participants

The data for this paper was collected through a series of workshops using a case study approach with a total of 74 participants, consisting of 52 final-year undergraduate students and 21 first-year master students from international programs in PDE. without industry experience. This demographic was chosen as they were expected to have the professional skills necessary to tackle the current market demands. Out of all participants, 41 were female, 32 were male, and 1 chose not to answer. The age range of the participants varied from 20 to 29 years old. Among the participants, there were 25 Brazilians, 27 Portuguese, and 22 Indians. Participants are grouped randomly into two groups, A (45 participants) and B (29 participants), each with his/her own problem briefing to solve individually. It is made clear to the participants that they can access the internet for research; however, they cannot consult one another. Subsequently, each participant has 3 to 5 minutes to present both his/her solutions and the process engaged to develop the solutions.

4.2 Problem briefing

According to Halpern (2014) and Kuhn (2011), when assessing an individual's CriT and CreT skills, it is advantageous to provide a problem that they have some familiarity with. This is because previous knowledge or experience with a problem can assist individuals in comprehending its context, recognizing pertinent information, and generating possible solutions. Furthermore, presenting a problem that individuals have experience with can enhance their involvement in the task, resulting in greater motivation and a more thorough and insightful analysis of the problem (Halpern, 2014). Hence, the task for students is to design a classroom (physical or virtual) specifically for PDE students that addresses the challenges of living with COVID-19 or future pandemics. By using a familiar topic, the brief aims to effectively evaluate the students' creativity and critical thinking skills. Both briefings for groups A and B had the same information apart from the objectives. Group A's objective is " Offer an attractive, low-cost solution" and group B' is: "To offer a solution that has the well-being of our planet (humans, non-humans, and future generations) as the main objective".

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4.3 Assessments

The material from all presentations is recorded on video, which is then used by the three judges assigned to each student to evaluate their performance. The first two rubrics developed by Shively (2018), are meant to assess students' CreT and CriT, and have 14 criteria (6 for CreT and 8 for CriT). Shively's rubrics (Tables 1 and 2) have several advantages. Firstly, they offer a clear and concise framework for assessing critical and creative thinking skills, which helps instructors, judges and students understand what is expected of them. Secondly, the rubrics are comprehensive, covering a broad range of skills such as analysis, interpretation, evaluation, inference, and problem-solving, resulting in a more holistic evaluation of student thinking abilities. Thirdly, they can be adapted to different contexts and subjects, making them versatile and practical. Finally, the rubrics promote objectivity in grading by providing explicit criteria for evaluation, which ensures that all students are evaluated fairly while reducing subjectivity. In this case study, the number of ideas was established to align with what is typically expected of students in their usual classes. In terms of creative strategies, students were encouraged to incorporate their preferred techniques for idea generation.

Table 1. The Components of critical thinking to develop assessment criteria. Source: Shively (2018, p. 153).

	Novice	Developing	Expert
Summarizes the topic or argument	Does not organize information, leading to inadequate understanding	Inconsistently demonstrates an ability to organize information, leading to inadequate understanding	Consistently demonstrates an ability to organize information, leading to an adequate understanding
Considers previous assumptions	Assumptions are defined, but not explained as having significance to the position	Assumptions are defined and linked to topic ideas, but not clearly explained or elaborated upon	Assumptions, defined, linked to topic ideas, and clearly explained or elaborated upon
Communicates point of view	Does not identify own position on the issue	Identifies own position on the issue, drawing support from experience	Identifies own position on the issue, drawing support from experience, and information not available from assigned sources
Provides evidence of research	No evidence was provided to support the argument	Accepts evidence at face value, even if incorrect, inadequate, or misrepresented to support the argument	Information is gathered from appropriate and credible sources to support the argument
Analyses data	No analysis of a topic. Student only lists or defines concepts of topic	Demonstrates ability to analyse and make interpretations of the topic	Demonstrates ability to analyse and elaborate on interpretations of the topic
Considers other perspectives and positions	No identification of other perspectives and positions	Identifies other perspectives and positions	Identifies and assesses other perspectives and positions
Draws implications	Cannot explain or testify to the impact of new information	Explains or testifies to the impact of new information	Explains the impact of learning new information, making predictions, and generating new ideas
Assesses conclusions	No reflection of idea evolution on argument development	Limited reflection of idea evolution on argument development	Extensive reflection of idea evolution on argument development

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Table 2. Sample rubric anchoring assessment criteria on the definition of creativity. Source: Shively (2018, p. 151).

	Novice	Developing	Expert
Fluency	Students considered one idea	Students considered 3 to 5 ideas	Students considered 5 or more ideas
Flexibility	Students considered one type of idea	Students considered several types of ideas	Students considered many types of ideas
Originality	Students developed a common idea that many other students would have suggested and/or replicated an existing idea	Students developed an interesting idea that several other students would have suggested and/or minimally added to an existing idea	Students developed a unique idea that few other students suggested and/or substantially built upon an existing idea in a unique way
Specific creativity strategy	Students randomly selected and implemented a creative thinking strategy, and/or they were unable to leverage the strategy to improve their ideas	Students selected and implemented a creative thinking strategy to develop their ideas. They explained how the strategy supported their creativity	Students deliberately selected and implemented a creative thinking strategy to develop their ideas. They explained how the strategy supported their creativity
Elaboration	Students added minimal details and improvements to their ideas	Students added a few details and improvements to their ideas	Students added many significant details and improvements to their ideas
Usefulness	Students proposed ideas that may meet the end-users needs in certain conditions	Students proposed ideas that would meet the end-users needs	Students proposed ideas that would meet the end-user's needs and significantly add value to their lives

For creating average score charts, judges rate each level with a number (1 for Novice, 2 for Developing, and 3 for Expert). This procedure is applied to the 5 levels of the Design for Sustainability (DfS) framework by Ceschin and Gaziulusoy (2019), which is utilized to assess students' solutions. These are the full 5 levels of DfS:

1. Material/Component Innovation: Design interventions aimed at improving products through new material development, replacement, and enhancement.
2. Product Innovation: Improving or creating new products by considering their entire life cycle, from material extraction to disposal.
3. Product-Service System Innovation: Focusing on integrated combinations of products, services, value chains, and business models beyond individual products.
4. Spatio-Social Innovation: Addressing innovation in human settlements and their communities on different scales from neighbourhoods to cities.
5. Socio-Technical System Innovation: Encapsulating design interventions that promote radical changes in fulfilling societal needs, such as nutrition and mobility, to support transitions to new socio-technical systems.

Since the different levels of innovation are interconnected, and the new version proposed and used in this paper is used to convert from five levels to three levels. The first level is about improving individual product qualities by creating new materials or improving existing ones. This level also focuses on improving existing products or developing new ones, while taking into account the entire product life cycle. The second level involves integrating products, services, stakeholder value chains, and business models beyond individual products. This level considers the context of innovation in human settlements and communities. The third level aims to bring radical changes in how societal needs are met and supports transitions to new socio-technical systems. The participants' solutions were evaluated based on these definitions, and the results are represented in three levels for better understanding. You can find more information about these levels in section 5 of the Results and Discussion section of this paper.

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5 RESULTS AND DISCUSSION

The authors reached out to different universities in different countries to participate in their 2-hour problem-solving workshop. Each workshop involved participants (who are students) and judges (local professors) gathering at their usual classroom while virtually receiving instructions from the main author of this paper. At first, students were introduced to all the steps of this workshop and then divided into two big groups, Group A and B. Despite being divided into big groups, students were told to work by themselves and were allowed to consult the internet. Then the physical briefings were given by the local professor, each student having his/her own copy. The information presented in both briefings for groups A and B was identical, except for their respective objectives. Group A was tasked with providing a low-cost and appealing solution, while Group B's objective was to propose a solution that prioritizes the well-being of the planet, including both human and non-human life, as well as future generations. After being assigned the task, the participants were granted a 30-minute time frame to create their solutions. Following this, they were allowed 3 to 5 minutes each to present the mental process which led to their solution. The workshops were limited to 20 participants to ensure they did not surpass the 2-hour time constraint. Participants had the freedom to devise any solution they deemed fit, provided it fulfilled the requirements outlined in the briefing. The solutions ranged from simple product enhancements at the material or component level to intricate and sophisticated socio-technical systems.

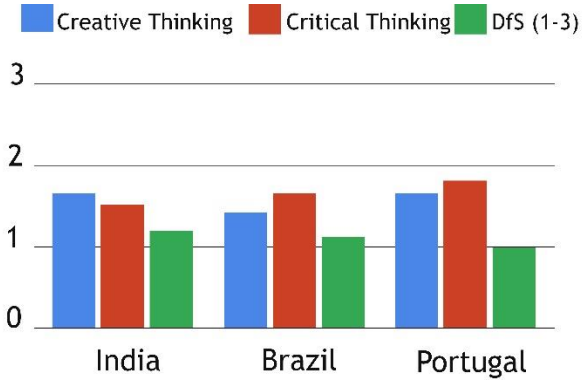

Figure 1. CreT, CriT and DfS scores for three countries: India, Brazil, and Portugal Levels 0-1: Novice; 1-2: Developing; and 2-3: Expert. DfS Levels are: 1 - Product/Material innovation; 2 - Service and Social innovation; and 3 - Transitions support.

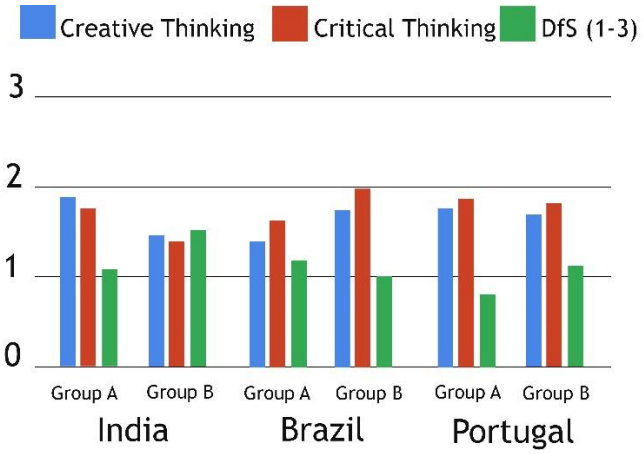

Figure 2. Groups A and B scores of the three countries (India, Brazil, and Portugal) on three metrics: CreT, CriT, and DfS

From Figure 1, in terms of CreT, Portugal scored the highest at 1.68, followed by India at 1.67 and Brazil at 1.55. While the difference in scores between the countries is not significant, it is notable that Portugal has the highest score, which could indicate a higher level of creativity for this particular batch of students. Regarding CriT, Portugal again had the highest score at 1.79, followed by Brazil at 1.72 and India at 1.58. The difference in scores is slightly larger in this case, suggesting that there may be more significant differences in CriT skills between these countries than in their CreT skills. The levels

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of DfS (1.27 India, 1.14 Brazil, 0.99 Portugal) decreases while there is an increase of CriT (1.58 India, 1.72 Brazil, 1.79 Portugal). However, CreT appears to be unaffected. (1.67 India, 1.55 Brazil, 1.68 Portugal). Additionally, an increase in CriT it was also noted that the content of the solutions is only slightly different from what was adopted during COVID between 2020 and 2021 worldwide. Overall, these findings suggest that there may be some differences in the levels of CreT and CriT skills across the three countries. According to Figure 2, Group A in India had significantly higher scores in Creative Thinking (1.8) and Critical Thinking (1.67) compared to group B, while group B had a higher score in DfS (1.55) than group A (1.07). However, Brazil, group B had higher scores in Creative Thinking (1.7) and Critical Thinking (1.96) than group A, while group A had a higher score in DfS (1.22) than group B (1.02). In Portugal, the differences were less pronounced, with group A having slightly higher scores in Creative Thinking (1.69) and Critical Thinking (1.8) than group B, while group B had a slightly higher score in DfS (1.2) than group A (0.88). In this respect, one can say that Portugal and India seem to perform similarly, while Brazil performs differently.

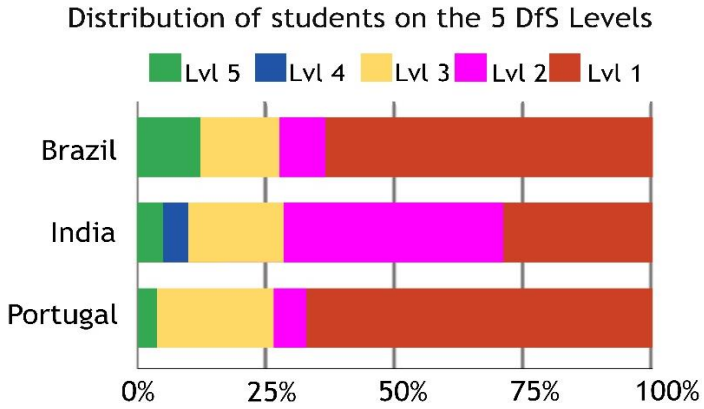

Figure 3. Distribution of students across different levels of DfS in each country

Figure 3 shows the performance of students from Brazil, India, and Portugal across the 5 levels of DfS. Level 5 registered the lowest number of students, with Brazil having three students and India and Portugal each having one. At Level 4 on DfS, only one student from India obtained high scores in both creative and critical thinking. Brazil and Portugal did not have any students at this level. Level 3 had the highest number of participants, with Brazil having the most students. Brazil's students scored the highest in creative thinking, while Portugal's students scored the highest in critical thinking. Level 2 recorded the second-lowest number of participants, with Portugal securing the highest scores in both creative and critical thinking. Level 1 had the highest number of participants, with Brazil having the most students, and Portugal recording the highest score in both creative and critical thinking. The standard deviation (Figure 4) of creative thinking was 1.468, indicating a spread-out score distribution. Similarly, the critical thinking standard deviation was 1.5, signifying a comparable spread.

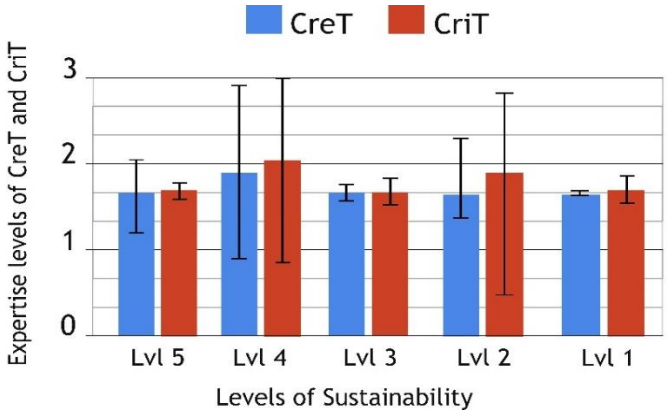

Figure 4. The average values of CreT and CriT for all countries across each level of sustainability and the standard deviation for CreT and 1.50 for CriT

So far, the participants in the study scored below level 3, which is lower than what is expected from final-year undergraduate or first-year master's students who do not have industry experience. This study's findings align with the OECD report, suggesting that the current tertiary education in PDE may

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not adequately prepare students with the CriT and CreT skills required for solving complex problems. However, having higher levels of CriT and CreT does not necessarily guarantee more sustainable solutions. While these skills are vital for effective problem-solving, they need to be complemented with contextual knowledge and the ability to collaborate with others. In other words, CriT and CreT alone are not enough to solve complex problems, but they are essential.

6 LIMITATIONS AND FUTURE WORK

Shively's rubrics have some limitations that need to be considered. Firstly, they primarily focus on CriT and CreT skills and may not be sufficient for evaluating other significant learning outcomes like communication or collaboration. Secondly, the rubrics may not allow for enough flexibility in grading or evaluation, which could be an issue for students who approach problems or assignments in a unique or unconventional way. Despite these limitations, Shively's rubrics are still useful for evaluating students' thinking skills, but it is recommended to use them in conjunction with other assessment tools to ensure a more comprehensive evaluation of student learning. When it comes to CriT, it is important to note that CriT skills are not domain-specific, and individuals with strong critical thinking skills should be able to apply them across a range of situations and contexts (Paul and Elder, 2006). Therefore, it may also be valuable to evaluate critical thinking skills with problems that are unfamiliar to individuals to assess their ability to transfer their skills to new situations (Halpern, 2014; Paul and Elder, 2006). It should be noted that factors such as teaching methods, cultural values, and socioeconomic factors may influence these differences, and therefore, the scores cannot provide a definitive picture of the skills of the populations of these countries. Nonetheless, the data suggests that there may be differences in the levels of these skills between different groups within each of the three countries. There is certainly room for improvement in the development of these skills among students. Providing students with the necessary tools to tackle complex challenges may involve incorporating more opportunities for hands-on, experiential learning and emphasizing the development of collaborative skills alongside CriT and CreT.

7 CONCLUSION

This paper's data shows variations in CreT and CriT levels among students at different levels of Design for Sustainability (DfS). Portugal has the highest CreT and CriT levels at Level 5, followed by India and Brazil, but the small number of students at this level prevents firm conclusions. At Level 4, Brazil and Portugal have no students, and India has only one, making it impossible to analyze correlations. At Level 3, Brazil has the highest number of students with moderate CreT and CriT levels, followed by Portugal and India. At Level 2, Portugal has the highest levels of both CreT and CriT, followed by India and Brazil, however the mixed findings and the small number of students makes it difficult to draw firm conclusions. At Level 1, Brazil has the highest number of students, followed by Portugal and India, with Portugal showing the highest CreT and CriT levels. Notwithstanding, the data suggests a correlation between CreT and CriT and DfS, with higher levels of both observed at higher levels of DfS. It is further noted that, the group studied performed below the expected expert level in terms of their CriT and CreT skills, consistent with broader trends reported by the OECD. We can also conclude that higher levels of CriT and CreT do not necessarily translate to more sustainable solutions.

Incorporating CriT and CreT skills into product design and engineering programmes therefore appears crucial for creating a sustainable future. These skills are essential for developing innovative solutions to complex problems, designing products with a holistic perspective that considers social and environmental implications. By teaching CriT and CreT more effectively in PDE curricula, students can learn to think more broadly and address complex issues with social, environmental, and economic implications. This prepares them for 21st-century challenges and enables them to create products that are functional, aesthetically pleasing, sustainable, equitable, and socially responsible. It is imperative for product design and engineering programmes worldwide to review and enhance their critical and creative assessment in their curricula to nurture and equip designers and engineers to address wicked problems and pave the way for a sustainable future. Failing to do so risks the future of design and reduces sustainable efforts to a process model for commercial gain. Therefore, CriT and CreT skills are crucial for society to address complex issues effectively.

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