



## Digital Intelligence for Technical Students: Use of Online Mind Map in Enhancing Design Thinking

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### Abstract

In a world dominated by digitalization, digital intelligence is critical. Digital intelligence is required for education, employment, and active participation in the community. Digitalization has transformed our way of thinking, feeling, and living, and its rapid evolution has made change, which was once the exception, the norm. As a result, change management has emerged as a fundamental skill for people in the 21<sup>st</sup> century. But far more important than this is the development of digital intelligence, which, to be developed, necessarily requires disruptive education. An online mind map is a visual aid that is becoming extremely prevalent in today's classrooms. Given the importance of empirical research and evaluation, it is perhaps surprising that so little effort has been directed toward the application of online mind map among technical students in enhancing design thinking. This study aims to examine Malaysian technical students' perspectives with regards to the use of online mind map in enhancing design thinking. 372 students of technical from selected public higher institutions were involved in this study. A quantitative method using an online survey was conducted for the students. The results from questionnaire items and open-ended items were analyzed using descriptive and inferential statistics and thematic analysis. The findings from the study revealed that the technical students had agreed that the online mind map helped them in enhancing their design thinking. The study makes important contributions on how the tool can develop design thinking in technical to address IR4.0 needs and produce balanced graduates to be globally competitive. Finally, this study contributes a new framework for technical students' design thinking.

**Keywords:** *digital intelligence, online mind map, technical, students*

### INTRODUCTION

The skill sets required for work and life are changing dramatically because of digital transformation. The effective use of digital technologies is also critical to achieving the Sustainable Development Goals. In all areas, teaching and learning must address the changes and challenges brought about by the introduction of Information and Communication Technologies (ICT). Education and training institutions at all levels must provide every citizen with knowledge, skills, and attitudes, as well as opportunities for lifelong learning, needed to live and work in an increasingly technologically driven environment. ICT can be a powerful tool for ensuring universal access to education and training. With digital technologies widely used in the workplace, digitalization is reshaping millions of jobs worldwide. TVET is a broad term that refers to aspects of educational development that include, in addition to the study of technologies and related sciences, general education, and the acquisition of practical attitudes, skills, understanding, and knowledge pertaining to professions in various sectors of economic and social life (UNESCO, 2002). Mclean and David (2009) define TVET as "the acquisition of skills and knowledge for the world of work in order to increase opportunities for socioeconomic development and productive empowerment in rapidly changing working environments and knowledge economics. TVET equips

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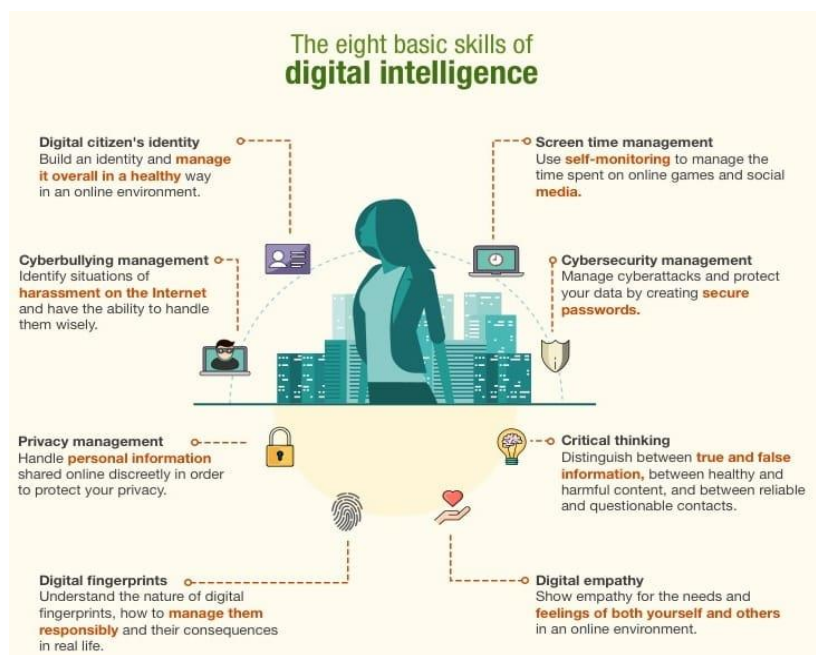


people with technical and vocational skills, as well as a wide range of knowledge, attitudes, and abilities that are recognised as essential for expressive contribution in work and life. To continue to be innovative and appealing, TVET must keep up with current technological developments and respond to digital economy demands by providing learners with new digital skills and competencies. Knowledge and skills are very prominent of any nation's social and economic growth. Besides, Afeti (2010) stated that TVET embraces the key to training the skilled and entrepreneurial workforce needed for the growing technological workforce. For next sections, this paper discussed the digital intelligence, online mind map and design thinking and, TVET and digitalization.

## LITERATURE REVIEW

### Digital Intelligence

Digital Intelligence is the sum of social, emotional, and cognitive abilities required for digital life. It primarily possesses the necessary skills, knowledge, and ability to become acquainted with one's emotions and behaviour to deal with the challenges and demands of the digital age. The most recent concept describing technology-related skills is digital intelligence. The evolution of the Fourth Industrial Revolution (IR 4.0) is entirely based on modern technology. TVET also drives technology. Because TVET not only creates technology through the pull of demand and innovation, but it also disseminates it through the transfer of knowledge and skills.



**Figure 1.** The Eight Basic Skills of Digital Intelligence

Figure 1 shows the Eight Basic Skills of Digital Intelligence. The Eight Basic Skills of Digital Intelligence are: (1) digital citizen identity that illustrates the skills to form and manage a healthy identity online and offline with integrity, (2) screen time management focuses on the ability to control one's screen time, multitasking, and participation in social media and online games, (3) cyberbullying management entails the ability to detect situations of cyberbullying and handle the situation intelligently, (4) cybersecurity management emphasises the ability to safeguard one's data by creating strong passwords and to carry out various cyber-attacks, (5) privacy management

entails the ability to handle all personal information shared online in a discrete manner in order to protect one's and others' confidentiality, (6) critical thinking expresses the ability to distinguish between good and bad content, true and false information, and trustworthy and questionable online contacts, (7) digital footprints emphasises the ability to comprehend the nature of digital footprints and their real-world implications, as well as to responsibly manage them and (8) the ability to express empathy for one's own and others' needs and feelings online is referred to as digital empathy. These basic skills of digital intelligence are important for the promotion of IR 4.0 advances.

### **Online Mind Map and Design Thinking**

Mind mapping technique refers to “the technique of storing, editing and organizing information generally on paper, by means of using key words and key images” (Buzan, 2009). On the other hand, Novak (2009) explains the mind mapping techniques are used to inspire students, accomplish applications. Besides, in learning environments, students must evaluate new information and connect concepts. Today, as digital natives, frequently use and prefer digital media, which has aided in the development of their mind maps. Laampere, Matsak, and Kippar, (2006) entail that mind maps can be recognized in a digital form. This type of mind map is generally known as an online mind map. This technique, as an alternative, provides students with competent and dynamic learning that allows them to develop and organize their ideas using higher order thinking skills. The technique proposes significant innovations in the use of online mind maps in technology education, such as the ability to create and analyze maps with different perspectives, easy sharing, minimal tool requirements, visual prosperity, and portability, and so on (Papushina, Maksimenkova & Kolomiets, 2017).

One of the tools for design thinking is the online mind map. Design thinking is also regarded as a practice-based activity and a method of making sense of things because it employs deductive or inductive reasoning to solve problems (Dorst, 2011). Design thinking is both a process and a mindset, and it includes nine distinct futures: 1) ambiguity; 2) curiosity; 3) constructiveness; 4) collaboration. 5); candor 6) iteration; holism; 8) non-judgmental approach; and 9) empathy (Baek and Gremett, 2011; Luka, 2014). Online mind maps are used to generate, visualize, structure, and categorize ideas to find patterns and insights that can be used to provide key design criteria that people gather in ways that allow themes and patterns to emerge. Thus, this technique contributes to the design thinking processes. However, the number of studies on the use of online mind map in enhancing design thinking among TVET students is also quite limited in literature. This tool makes better use of information and communication technology (ICT). Furthermore, technology has recently entered human life at such a rapid pace that all activities are now conducted through digital platforms (Bayles et al., 2021). As a result, the use of digital-based learning media such as digital mind-maps will be oriented toward teaching and learning process. As a result, the learning process will be more vivid because it can transfer information and learning content (Trisiana, 2020). The digital mind map, according to the technical students, has the potential to stimulate the learning of technical skills among technical students (Karim & Mustapha, 2022).

Apparently, the use of online mind map technique is also associated with students' design thinking. Meiner and Leifer (2012) encompass human-centric methodology of design thinking which entails from multiple disciplines, including design, social sciences, engineering, and business. Moreover, they also add this approach permits multidisciplinary iterative improvement and collaboration to produce innovative systems, products and services. According to this viewpoint, design thinking is a mindset that approaches a case with divergent perspectives in an interdisciplinary manner and generates feasible and creative solutions to the heart of diverse problems. According to Kruger and Cross (2006), this mind-set is framed as a process by the

common solution-based thinking pattern of creative industries' design processes. Design thinking is a structured approach to enhancing and generating ideas by navigating the process from identifying challenges to building and finding a solution (IDEO, 2012). It is a profoundly human methodology that relies on designers' instinctive ability to interpret what learners observe and develop ideas that are emotionally meaningful to what they are designing for (Burcahan 1992). The current study, which differs from previous studies by addressing the online mind map in education to improve students' design thinking, is thought to fill the gap of knowledge in the field.

### **TVET and Digitalization**

Technical and Vocational Education and Training (TVET) in Malaysia is rapidly expanding and must become the backbone of national education in order for Malaysia to become a developed nation. This is evident in the growing number of polytechnics, vocational colleges, and other centers of excellence that provide technical and vocational education. This TVET field can also be introduced at the secondary school level by providing Vocational Education, Technical Education, and Skills. Aside from that, the participation of the Private Skill Training Institute (ILKS) and the Institute of Public Skill Training (ILKA) in promoting TVET programs helps to improve the quality and accessibility of TVET in Malaysia.

The social and economic implications of technology are vast and rapidly expanding. Because the volume of information is rapidly increasing, experts predict that 90% of the world's population will be connected to the internet within the next 10-15 years. These modifications herald exciting possibilities. However, there is some uncertainty because our toddlers will be at the center of this dynamic shift. The digital transformation of TVET and skill systems extends far beyond the online delivery of training products and services. A holistic and coordinated approach to digitalization should be taken, examining each high-level function of a national skills system and its digitalization potential. With continued digitization of processes within industry, it is critical that there are provisions for upskilling and reskilling of a workforce in new age technologies at various stages of careers to keep them abreast of the latest developments in digital technologies. TVET pedagogies will be modified to accommodate new-age skills such as increased automation, artificial intelligence, blockchain, simulation, and gamification. As a targeted solution to the looming challenges posed by 4IR, industry-led TVET programs and incentive-linked schemes for industry to upskill the workforce in new-age skills can be explored. This points to the need for interventions to improve TVET system digital readiness and to prepare youth for Industry 4.0 through digital skills. A high-level global overview of how digitalization is affecting TVET, and skills systems is based on consultations with key stakeholders in a number of countries and international organizations to provide insights into the nature and scope of digitalization, as well as how it is likely to affect the management, delivery, assessment, and certification of technical and vocational education and training (Gretch, 2020). Therefore, TVET instructors must be aware of new and evolving digital trends and tools, as well as be able to effectively teach these to students as they prepare to enter the future workforce.

### **RESEARCH METHOD**

Research methods should make readers be able to reproduce the analysis. Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described. Figures are sequentially numbered commencing at 1 with the figure title and number below the figure as shown in Figure 1.

In this study, we employed a survey design using the online questionnaire as an instrument. There were 327 Malaysian technical students from selected public higher institutions involved in this study. The study aims to examine the technical students' perspectives with regards to the use

of online mind map in enhancing design thinking. The adapted questionnaire was created based on Lin & Faste (2012) and Meinel & Leifer (2012) models. The three designed sub-concepts were to determine the technical students' perspective on the use of online mind map. For the second concept, three sub-concepts were also included as questionnaire items to measure the technical students' perspective on the use of online mind map in enhancing design thinking. The questionnaire was divided into five parts: (A) student demographic (6 items), (B) technical students' perspectives on the use of online mind map (18 items) and (C) technical students' perspectives on the use of online mind map in enhancing design thinking (18 items). For the final part (D), it included three open-ended items. 45 items were designed for this survey questionnaire. They also need to answer 3 items for open-ended for part D of the questionnaire.

In part A, students must list three main reasons why they should use an online mind map during their studies. Next, three factors need to be stated for enhancing design thinking when using online mind maps (part B). Part C required students to list three factors, in addition to the online mind map, that will improve design thinking. Section B and Section C items were scored on a 5-point Likert scale: strongly agree (5), agree (4), uncertain (3), disagree (2), and strongly disagree (2). (1). SPSS version 27 was used to analyze the data. Thematic analysis was used to examine the open-ended items (Miles & Huberman, 1994). The instruments were validated by three experts in the field. For this study, the reliability of the instrument was determined by using Cronbach Alpha coefficient,  $\alpha = 0.98$ .

## FINDINGS AND DISCUSSION

The empirical data of the study were presented in four parts which were the students' profile, perspectives on the use of online mind map, perspectives on the use of online mind map in enhancing design thinking and open-ended items. For the first part, the students' profile as shown in Table 1 and show that the total of the respondents for the study is 372. They were 162 (43.5%) male students and 210 (56.5%) female students involved in this study. 60.2 % were from the age group of 17-19 years. Next, 31.5% of the respondents were in the age group of 20-22 years. Only 6.7% respondents came from the age group of 23-25 years followed by 1.6% from the age group of 25 years and above. Regarding the location where they stay, 69.1% stay in the city followed by 18.3% were in rural. 12.6% of the respondents were in suburban areas. According to the table, 96.8% of respondents enjoyed the technical courses they took. 3.2% said they disliked the course. The online mind map was mentioned by 88.7% of those polled. Only 11.0% said they were unaware of the online mind map. 70.4% of respondents said they had used an online mind map before, while 29.3% said they had not. Finally, 86.8% mostly responded that they agreed that the online mind map is important for design thinking whereas only 5.1% said the tool is not important for design thinking.

**Table 1.** Students' Profile

<b>Characteristics</b>	<b>Frequency</b>	<b>%</b>
<b>Gender</b>		
Male	162	43.5
Female	210	56.5
<b>Age (years)</b>		
17-19 years	224	60.2
20-22 years	117	31.5
23 -25 years	25	6.7
25 years and above	6	1.6

<b>Hometown Location</b>		
City	257	69.1
Rural	68	18.3
Suburban	47	12.6
<b>Enjoy technical courses taken</b>		
Yes	360	96.8
No	12	3.2
<b>Familiar with online mind map</b>		
Yes	331	89.0
No	41	11.0
<b>Experience using online mind map</b>		
Yes	263	70.7
No	109	29.3
<b>Importance of online mind map for design thinking</b>		
Yes		
No	323	86.8
	19	5.1

For the next parts, the findings were shown in Table 2 and Table 3. For Table 2, the findings displayed the technical students' perspective on the use of online mind maps. Table 3 described the findings on the technical students' perspectives on the use of online mind map in enhancing design thinking. The interpretation of mean values in this study was divided into five categories: strongly agree (4.21-5.00), agree (3.41- 4.20), uncertain (2.61-3.40), disagree (1.81-2.60), and strongly disagree (1.00-1.80). We described the three highest and three lowest means of the items based on the findings. We described the three highest and three lowest means of the items based on the findings.

### Perspectives on the Use of Online mind map

For the second part, the findings presented about the technical students' perspectives on the use of online mind map. The first highest mean was in item 10. The respondents greatly agreed ( $M = 4.26$ ;  $SD = 0.75$ ) and said that the online mind maps make learning process at ease. Next, the respondents also agreed that ( $M=4.15$ ,  $SD=0.80$ ) they draw ideas, create lines, and use images simply (item 5). The final highest mean was shown in item 6. The respondents mostly decided ( $M=4.14$ ,  $SD=0.82$ ) that using the online mind map saves time a lot. Using online mind mapping makes it easier to restructure mind maps and makes the process of creating mind maps faster and easier (Dominik, 2014). Evidently, the online mind map application can aid students' learning because it simplifies and shortens the learning process.

**Table 2.** Technical students' perspectives on the use of online mind map

Item	Construct	M	SD	Interpretation
<b>Speed and Efficiency</b>				
1	Online mind map creates ideas faster	3.93	0.79	Agree
2	Online mind map stores ideas efficiently	4.01	0.79	Agree
3	Using the online mind map is quicker than using pen and paper	3.91	0.98	Agree
4	Online mind map gives more space than using pen	4.03	0.89	Agree

	and paper			
5	I draw ideas, create lines and use images simply	4.15	0.80	Agree
6	Using online mind map save my time a lot	4.14	0.82	Agree
<b>Appearance and Mechanics</b>				
7	Online mind map helps me to create ideas very well	3.73	0.87	Agree
8	Online mind map helps me draw ideas easily	4.02	0.80	Agree
9	Online mind map saves and stores data easily	3.98	0.80	Agree
10	Online mind maps make learning process at ease	4.26	0.75	Strongly agree
11	Online mind map drags one node into another and make links easily	4.00	0.79	Agree
12	Online mind map is a prospective digital tool	4.01	0.79	Agree
<b>Ontology and Concept Mapping</b>				
13	Online mind map gathers ideas in a technical way	4.00	0.80	Agree
14	Online mind map enhances my knowledge of concepts	4.09	0.81	Agree
15	I know the relationships across ideas using the online mind map	4.01	0.80	Agree
16	Online mind map creates ideas competently	3.91	0.82	Agree
17	Online mind map helps me to align my ideas	4.05	0.83	Agree
18	Online mind map is a useful tool to link and arrange ideas	4.08	0.78	Agree
<b>Total average</b>		3.93	0.79	Agree

Based on the three lowest means, the respondents barely agreed ( $M=3.73$ ,  $SD=0.87$ ) that online mind map helps me to create ideas very well in item 7. The respondents said ( $M= 3.91$ ,  $S.D =0.98$ ) that using a online mind map is faster than using pen and paper for the second lowest mean (item 3). Finally, the respondents also agreed ( $M= 3.91$ ,  $SD =0.82$ ) that online mind map creates ideas competently (item 16).

### Perspectives on the Use of the Online mind map in Enhancing Design Thinking

The third part, as in Table 3, showed the findings of the technical students' perspectives on the use of the online mind map in enhancing design thinking. The respondents also believed that their prior knowledge is important for design thinking (item 17) based on construct curiosity. The results were ( $M= 4.13$ ,  $S.D =0.78$ ). For item 12, the students also agreed that using the online mind map in a variety of creative ways can help them improve their design thinking ( $M=4.10$ ,  $SD =0.83$ ). Respondents mostly agreed that mind maps help them think creatively and critically when completing assignments and projects (item13). The results showed the means ( $M= 4.06$ ,  $SD= 0.80$ ) for this item. In short, the online mind map can enhance the technical students' design thinking skill.

**Table 3.** TECHNICAL students' perspectives on the use of online mind map in enhancing design thinking

Item	Construct	M	SD	Interpretation
<b>Iterative</b>				
1	Online mind map can develop my design thinking skills.	4.08	0.77	Agree
2	Online mind map is a useful application for enhancing design thinking skills	4.06	0.77	Agree

3	I develop my new ideas on design thinking using the online mind map.	3.98	0.83	Agree
4	Online mind map helps me in creating new ideas for enhancing my design thinking.	4.07	0.81	Agree
5	Digital mind develops my critical thinking for enhancing my design thinking	3.97	0.81	Agree
6	I believe the online mind map can enhance my design thinking	4.05	0.76	Agree
<b>Ambiguity</b>				
7	I create ideas and knowledge myself	4.00	0.79	Agree
8	I design ideas individually using the online mind map	3.99	0.82	Agree
9	I think new ideas individually in enhancing my design thinking	3.99	0.78	Agree
10	Online mind map helps me to solve my problems in my studies	4.02	0.80	Agree
<b>Creative</b>				
11	I create innovative ideas through the online mind map with the help of my lecturer	4.00	0.79	Agree
12	Using the online mind map in various creative ways can enhance my design thinking.	4.10	0.83	Agree
13	Online mind maps support me to think creativity and critically in completing my assignments and projects	4.06	0.80	Agree
14	I feel determined to generate more creative ideas for design thinking	3.96	0.84	Agree
<b>Curiosity</b>				
15	I discover and convert complex information individually	3.94	0.83	Agree
16	Online mind map is a useful inquiry-based learning technique for design thinking skills	4.03	0.77	Agree
17	My previous knowledge is important for design thinking.	4.13	0.78	Agree
18	My previous knowledge can create new knowledge in design thinking through online mind map practice.	4.05	0.79	Agree
<b>Total average</b>		3.93	0.79	Agree

From the table, it showed the lowest mean in item 15. The respondents only just agreed ( $M=3.94$ ,  $SD=0.83$ ) that they discover and convert complex information individually. Next, the respondents just agreed ( $M=3.96$ ,  $S.D=0.84$ ) that they felt determined to generate more creative ideas for design thinking (item 14). For item 5, the results showed ( $M=3.97$ ,  $S.D=0.81$ ) that the digital mind develops their critical thinking for enhancing my design thinking. We also investigated the relationship between two variables (i) technical students' perspectives on using online mind maps and (2) the use of digital map in enhancing design thinking. Thus, the overall mean for online mind map was ( $M=4.02$ ;  $SD=0.64$ ) and the overall mean for technical students' design thinking was ( $M=4.03$ ;  $SD=0.66$ ) for both constructs: (i) online mind map and (iii) technical students' design thinking, as shown in Table 4. The findings revealed that technical students' perspectives were positive on the use of online mind maps ( $M=4.02$ ;  $SD=0.64$ ) and design thinking ( $M=4.03$ ,  $S.D=0.66$ ).



**Table 4.** Mean and Standard Deviation Results

Constructs	Mean	Standard Deviation
Use of Online mind map	4.02	0.64
TECHNICAL Students' Design Thinking	4.03	0.66

In terms of the results for the correlation between both constructs as shown in Table 5. The results of Pearson Correlation indicated a positive association ( $r= 0.91$ ;  $p<0.05$ ) between the use of online mind map and technical students' design thinking.

**Table 5.** Pearson Correlation Results

Variable	Use of Online mind map	
	r	p-value
Technical Students' Design Thinking	0.91	0.000

### Open-ended Items Results

The results of the open-ended items were presented in the final section. Respondents must answer three open-ended questions. Thematic analysis was used to analyse the findings in Table 6. We asked the students to state three main reasons why they use online mind maps during their studies (item A). Three themes emerged for these results: (i) simple tool, (2) time saver, and (3) increased creativity. This item received the highest rating from technical students for the easy tool theme. The next reason given by technical students for using the online mind map during their learning was time savings. They also stated that the online mind map could boost creativity in their studies, as the third most frequent theme emerged. The digital tool promotes creativity and speeds up work (Karim & Mustapha, 2020).

The students gave creativity and design ideas the highest rating of the three factors listed in item B that improve design thinking when using online mind mapping. Then there was a second factor: the evolution of ideas as the theme emerged from item B. The students ranked better understanding as the third most important factor. In addition, the tool is used for understanding basic information features at an intangible level and linking information with multiple concepts.

**Table 6.** Open-ended Items Results

Open-ended Items	Rank	Main Themes	Frequency (f)
A. 3 main reasons to use online mind maps during studies	1	Easy tool	235
	2	Save time	80
	3	Increase creativity	57
B. 3 aspects that enhance design thinking when using digital mind maps	1	Creativity and design ideas	82
	2	Development of ideas	66
	3	Better understanding	43
C. 3 factors besides the online mind maps that will enhance design thinking.	1	Training and practices	97
	2	Learn other skills	43
	3	Digital technology application	31

The final question (item C) asked about what other aspects, aside from online mind maps, will improve design thinking. Training and practice were ranked as the most important factors by respondents, followed by learning other skills to improve design thinking. Another factor that technical students agreed can improve design thinking is the use of digital technology.

## CONCLUSIONS

The study was carried out for investigating technical students' perspectives about using online mind maps as a tool to improve design thinking. According to the empirical findings, respondents favored the use of online mind maps. The tool has the potential to improve technical students' design thinking skills. Furthermore, the findings confirmed a positive relationship between the online mind map and technical students' design thinking. The open-ended item results support the questionnaire item findings in terms of the benefits of the online mind map. However, some areas should be researched further in the future, particularly in the field of digital intelligence for technical students. Educators may gain insight into how to improve technical students' design thinking based on these findings. As a result of this study's empirical data and conceptual framework, a new pedagogical framework in the technical field could be developed.

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