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Digital age: The importance of 21st century skills among the undergraduates

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The recent emphasis on refining the quality of higher education has incited insightful debates about numerous education reforms. Due to the demands of our ever-changing world, many institutions have begun to embed the 21st century skills into the curriculum design to better prepare the students for workplace success and lifelong career development. Despite its importance, there are disparities in regards to establishing an in-depth understanding of its significance. Thus, this study is aimed to investigate the perspective of undergraduate students in Malaysia on the importance of the 21st century skills for career readiness This study employed the quantitative research design wherein purposive sampling was utilized. The findings assert that data literacy is an essential skill to excel in the workplace, and similarly, problem-solving skill helps develop critical thinking skill, which contribute to the development of creative thinking skill. Recommendations are further deliberated.

KEYWORDS

21st century skills, digital age, undergraduates, workplace, curriculum

Introduction

Higher Education Institutions (HEIs) are deemed as among the prominent catalysts in nurturing the skills demanded by various industries. Whether they are taught directly or indirectly, these skills are often predominantly embedded into the curriculum to cultivate important characteristics for students to be successful, both in the context of their education and eventually work (Ball et al., 2016). 21st century skills characterize and denote a representation of the past professional skills which are now deemed obsolete due to the rapid technological change (Kereluik et al., 2013; Mahmud and Wong, 2022). These skills are defined by broad categories comprising of thinking (e.g., creativity and innovation, critical thinking, problem solving, decision making, learning to learn), working with others (e.g., communication, collaboration/teamwork), facility with tools (e.g., information literacy, communications technology literacy), and general life skills (e.g., citizenship, life and career management, personal and social responsibility, cultural awareness). Typically, these skills are embedded into the

design of higher education curriculum in preparation to join the workforce. Numerous educational and economic organizations have acknowledged the collective demand for the 21st century skills (World Economic Forum, 2016; Van Laar et al., 2017). Nevertheless, it is argued that developing the skills can be challenging (Jang, 2016; Winberg et al., 2019). In this regard, students must be equipped with the 21st century skills like data literacy, problem-solving, programming, and creative thinking for them to remain competitive (Lavi et al., 2021). In the workforce, employees with these skills are more likely to be valued by employers (Habets et al., 2020; Rios et al., 2020). The emergence of advanced technologies has contributed to the significant emphasis placed on the 21st century skills. Researchers predict that activities such as translating languages, driving a truck, working in retail, and even working as a surgeon will be replaced by Artificial Intelligence (AI) with better performance in the next 10 years (Grace et al., 2018). The majority of HEIs have recognized the need to make changes to the existing curriculum in preparation for the needs of the 21st century, including the emphasis on new skills. As part of an ongoing effort for educational reform at the institutional level, numerous HEIs are actively engaging stakeholders to enhance and revamp the necessary 21st century skills development. Therefore, it is important for students to prepare themselves to avoid from being eliminated by their future workplace. Graduates who keep up and adhere with their organizations (i.e., employers) by completing assigned tasks with excellent performance are believed to be well-equipped with the 21st century skills, subsequently justifying its importance for graduates to secure and develop their career progression (Ghafar, 2020). Despite the established significance of acquiring the 21st century skills, it is surprising to notice that many people have limited exposure to it. The majority of them believe that such issue resulted from the absence of clear and proper guidance on how to develop these critical skills, thus making them to feel helpless despite their eagerness to learn. Eventually, these people will lose advantage over others who are well-equipped with the 21st century skills when dealing with problems in the modern society (Joynes et al., 2019). Previous studies revealed that 21st-century skills are essential to be acquired due to its importance in the workforce and society. However, there are limited assessments that can evaluate 21st century capabilities. Meanwhile, standardized examinations can only examine a small portion of the critical skills and information acquired by students. According to Silva (2009), the 21st century skills are not new yet it is essential as younger employees must be able to identify and analyze information from other sources and use it to make decisions and create new ideas. Therefore, it is important to raise the awareness of undergraduate students in grasping 21st century skills. Thus, this study aims to examine the importance of the 21st century skills required by undergraduate students in the digital age.

Literature review

Previous studies defined the 21st century skills as a broad set of knowledge, skills, work habits, and character traits that educators, school reformers, college professors, and employers believe to be critically important for students to succeed in today's world, particularly in collegiate programs as well as contemporary careers and workplaces (The Glossary of Education Reform, 2016; Rajaratenam, 2019; Davis, 2021). The basic premise behind the concept of the 21st century skills is that students must be taught with in-demand and universally applicable skills. Therefore, educational institutions like schools, colleges, and universities must prioritize on the effective teaching of such skills to students. In other words, 21st century students need to learn relevant skills that reflect the demands placed upon them in the global modern world rather than skills learned by students in the 20th century (Aabla, 2017). In the subsequent paragraphs, four 21st century skills are deliberated to homogenize the current educational initiatives with the fourth industrial revolution and its associated innovations and technologies (Miranda et al., 2021). In a similar vein, a conceptual framework, TPACK framework by Koehler et al. (2014), and 21st century framework developed by Education Performance and Delivery Unit Malaysia (PADU) were also utilized the guiding principles. One of the critical 21st century skills required by university students is data literacy, which is the ability to read, understand, and interpret data. It plays an important role in social studies education where the prevalence of data visualization encountered by students will only be increased by the improvement and access to technologies. In this regard, educational institutions like schools are regarded as a preferable place to begin accumulating data literacy knowledge as it helps individuals to engage on the inundation of information at an earlier age (Raffaghelli, 2020; Robertson and Tisdall, 2020; Shreiner, 2020). Some universities even offer extra workshops to improve data literacy skill among their students along with recommending and providing them with access to data literacy tools. this subsequently enables them to master the skill before entering the job market. Furthermore, data literacy skill also acts as a data-sharing tool. According to Enakrire (2020) and Palsdottir (2021), researchers equipped with data literacy skill are more likely to understand the existing data presented and link various data together to convert it into useful information for their own use. For instance, studying the number of COVID-19 cases every day facilitates the effort to tabulate a graph that illustrates the amount of daily confirmed cases of COVID-19 that allows researchers to examine the trend and prepare for upcoming situations. Therefore, being proficient in data is an important skill for university students to stay competitive in the 21st century. The popularity of data visualization viewed by students will only grow as a technology that improves and becomes more accessible. Furthermore, researchers equipped with data literacy skill are more likely to

comprehend current data and combine disparate datasets to create usable information.

Often referred as the ability to identify underlying problems and actively seeking for solutions, problem-solving has been propounded as another crucial skill to be acquired by students in the 21st century. Within the education sector, several authors (Furino, 2012; Karakoyun and Lindberg, 2020; Demir, 2021) mentioned that problem-solving has been highlighted as an essential skill in schools after the digital literacy skill and it is now introduced into students' learning process to stimulate their higher-order thinking skills. Based on the recent systematic review studied by Mahmud et al. (2021), it reveals that the students possess different skills, including strategic thinking and problem-solving skills in the aftermath of the COVID-19 crisis. This can be further exemplified when schools started to modify their syllabus by inserting higher-order thinking questions to encourage students to think deeply and more critical. Moreover, problem-solving is the most investigated 21st century skill after digital literacy and critical thinking particularly when it comes to determining the 21st century skills within individuals. Generally, there are many ways to assess the problem-solving ability of a person. A commonly used method is performance test (Arslangilay, 2019; Van Laar et al., 2020) by recording the number of attempts that a person used to solve a problem. In summary, past studies advocate on the need for students to equip themselves with problem-solving skill in this modern era. Following such awareness, the education sector has also begun to include higher-order thinking questions to boost problem-solving skill among their students. Additionally, problem-solving skill is highly involved in 21st century studies to examine its significance to the era of big data.

Another important 21st century skill that has been emphasized in the curriculum is programming, which refers to the ability of writing a computer program to ease in data processing. Programming skill can foster the skills and attitudes that are strongly associated with 21st century and digital competency. Therefore, basic computing courses should be introduced since primary school because it builds cognitive dimensions and benefits students with programming and computer skills along with other learning competencies across various subjects at an early age, which are essential for their future career. It also provides students with impactful learning experience, which can be proven by the high level of students' overall satisfaction (Kunpitak, 2019; Theobold and Hancock, 2019; Nouri et al., 2020; Wong and Cheung, 2020). Moreover, programming skill is broadly needed in various sectors nowadays. Instead of the need for coding skill among programmers, there are numerous careers that require coding skill. Important infrastructures such as healthcare, communication, transportation, and defense also expect improvement in software technologies to support their digital platforms (Mittal, 2020). For instance, the medical department uses mathematical modeling to predict how social distancing can affect the number of COVID-19 cases. Hence, the result can be analyzed and efficient regulations of hygiene measures can be introduced to the public to reduce the number of cases. In conclusion, programming skill is one of the important 21st century skills that should be acquired by students as it builds their cognitive dimension, provides them with fruitful learning experience, and prepares them for their professional careers.

The ability to think creatively is crucial because it allows individuals to see problems and situations in innovative ways. However, the development of students' creative thinking skill has received limited attention. As a result, many graduates struggle to secure job opportunities due to a lack of creativity (Wyse and Ferrari, 2014). As creativity is dependent on information and does not occur in a second, many employees wish that they are more creative and were exposed to creative thinking during their schooling years. However, people rarely use their creative thinking skill to its full potential. Some academics even claim that the educational system inhibits their creativity as most educational institutions do not focus on teaching, practicing, and applying current information to generate creative ideas and problem-solving solutions. Furthermore, creative thinking skill allows people to stand out at the workplace when providing constructive ideas to deal with problems. As mentioned by Anjarwati et al. (2018), Atmojo and Sajidan (2020), and Azid and Md-Ali (2020), thinking fluently, which correlates to creative thinking, enables people to solve problems with a wide range of solutions. This is because they can easily produce ideas and solutions when faced with challenges. In such instance, more solutions can be generated with their ability to think outside the box instead of merely generating one or two general ideas. Occasionally, producing unique solutions is the way to achieve differentiation which allows one to be prominent from others. Generally, people who are well-equipped with creative thinking skill can integrate different situations quickly as compared to others as well as having the ability to generate various kinds of ideas when they are faced with problems. Therefore, it is important to invest prominent attention on equipping students with creative thinking skill to avoid them from having a lack of imagination towards an object as well as the tendency to avoid any challenges in the future.

Research methodology

This study had employed the quantitative research design by distributing a self-developed survey to the undergraduate students to examine their perceptions towards the importance of data literacy skill, problem-solving skill, programming skill, and creative thinking skill in the digital era. The survey used in this study comprised four sections pertaining to data literacy skill, problem-solving skill, programming skill, and

creative thinking skill. Cronbach's Alpha and Explanatory Factor Analysis (EFA) was conducted to determine both the reliability and validity of the instrument used. The data collected from the survey was analyzed using descriptive statistics. In this regard, frequency and percentage was used to calculate the number of respondents who considered data literacy, problem-solving, programming, and creative thinking as important 21st century skills. The Graduate Tracer Study Executive Report 2010 by the Ministry of Higher Education discovered that 24.6% of the 174, 464 graduates were jobless 6 months after graduation (Ministry of Higher Education [MoHE], 2021). The circumstance raises questions on the HEIs "product," and this is consistent with the study target population–students pursuing their undergraduate courses in Malaysia. The group was purposively sampled, and deemed suitable as the study probed at scrutinizing the importance of the 21st century skills among the undergraduates, considering the immense number of graduates entering the labor market. The study began by reviewing past articles and studies on the 21st century skills to identify the existing arguments and empirical evidence. This was done by extracting information from more than 300 academic journals and transferring it into a review matrix, which helped in the process of constructing the research objective and research questions. The survey questionnaire was then designed, finalized, and validated. It was then distributed to the targeted respondents *via* social media such as Telegram, WhatsApp and Instagram. A total of 101 completed survey questionnaires were gathered from undergraduate students between 18 and 25 years old who enrolled in a bachelor's degree course in Malaysia. The respondents provided their responses to 25 items using a 5-point Likert scale, from strongly disagree (1) to strongly agree (5). All data were then processed and analyzed in order to find the answers to the research questions.

Findings and discussion

Table 1 shows the analysis results on the importance of data literacy skills among the undergraduate students in the digital age. It can be seen that the majority of respondents agreed with Item 1 where data literacy skill can be applied to solve numerous problems in the social studies sector, such as to predict future outcomes. Following that, 44 respondents strongly agreed with Item 2 while 18 respondents had stated their neutral stand. This suggests that people are now living in a big data era; therefore, it is better to equip this skill at the first opportunity to fit into the current situation. A study by Robertson and Tisdall (2020) mentioned that introducing data literacy into the school curriculum is highly recommended because the younger generation is curious about data, possesses a high concern about data sharing issues, and wishes to have a deeper understanding about the matter. Furthermore, 47.5% of the respondents strongly agreed with Item 3. As data becomes more accessible, students are willing to investigate data and use their data understanding in different contexts. This not only allows them to express themselves but also makes them become more knowledgeable and skillful (Deahl, 2014). As a result, these students are more intelligent when dealing with challenges. In addition, Item 5 had the highest percentage of respondents (55.4%) who strongly agreed with the notion. This might due to the fact that students are dissatisfied with their current data literacy knowledge and would like to have a closer approach to this skill. This is supported by Bhargava and D'Ignazio (2015) who stated that data literacy tools can better assist learners' competency in data literacy by providing a stronger support system. On the contrary, Item 4 had the most disagreeing respondents (3.0%). One potential reason for this result is that respondents consider data literacy as an indispensable skill in school, especially when dealing with data for their coursework. As noted by Sickler et al. (2021), students require data literacy skill to transfer the underlying meaning of professional and large-scale data into their coursework based on their understanding. According to Chinien and Boutin (2011), data literacy is recognized as one of the most beneficial skills for the 21st century as it brings positive impact to a valuable knowledge-based economy.

Table 2 presents results on the significance of problem-solving skill among the undergraduate students in the big data era. It was found that 90.1% of the respondents agreed with Item 1 where problem-solving skill should be embedded in the curriculum of undergraduate courses. This is because the majority of university students wish to excel in this skill. According to Rodzalan and Saat (2015), lecturers are encouraged to provide students with challenging tasks that can prompt them to perform critical thinking when solving the assigned problems. Whereas, Item 2 received the highest number of strong agreement from a total of 65 respondents. One possible reason is that students believe that the problem-solving process can stimulate other 21st century skills within them, such as innovation and perseverance. As noted by Furino (2012), problem-based learning provides students with the opportunity to experience potential problems that they may encounter in real life. Next, 13 respondents held a neutral stance on Item 3 while 46 and 42 respondents agreed and strongly agreed with the notion. Such result can be due to the students' mindset where improvement in ICT literacy skill can lead to better thinking skill, which indirectly links to the improvement in problem-solving skill. This is supported by Karyotaki and Drigas (2016) who believe that ICT tools can provide support to students during the entire problem-solving process to enhance their elaboration and the making of evidence-based reasoning. Meanwhile, Item 4 yielded the highest number of agreement (94.1%) where 43 respondents agreed and 52 respondents strongly agreed with the statement. One possible explanation is that when solving a problem in a group, students need to actively engage with their groupmates and think critically to

TABLE 1 Data literacy skill.

Item		5	4	3	2	1
1	I think data literacy should play an important role in social studies education.	43 (42.6%)	46 (45.5%)	12 (11.9%)	0	0
2	I think data literacy skill should be embedded within the school curriculum as early as possible.	44 (43.6%)	39 (38.6%)	18 (17.8%)	0	0
3	Data literacy skill broadens the range of possibilities by connecting the development of awareness, skills, and knowledge.	48 (47.5%)	46 (45.5%)	7 (6.9%)	0	0
4	It is expected that students should have data literacy skills to recognize and identify certain problems, interpret the data, determine strategy, implement and evaluate course of accomplishment.	42 (41.6%)	47 (46.5%)	9 (8.9%)	3 (3.0%)	0
5	Universities should offer courses relevant to data literacy skills by recommending and providing access to the data literacy tools.	56 (55.4%)	32 (31.7%)	11 (10.9%)	2 (2.0%)	0
Total		233 (46.1%)	210 (41.6%)	57 (11.3%)	5 (1.0%)	0
Mean		46.60	42.00	11.40	1.00	0.00
Standard deviation		5.73	6.44	4.16	1.41	0.00

TABLE 2 Problem-solving skill.

Item		5	4	3	2	1
1	I think problem-solving skills should be embedded in the undergraduate curriculum.	59 (58.4%)	32 (31.7%)	9 (8.9%)	1 (1.0%)	0
2	I believe that problem-solving skills must be incorporated into the learning process for young students to develop 21st-century skills.	65 (64.4%)	29 (28.7%)	7 (6.9%)	0	0
3	Institutions should improve the assessment of student's digital information and technical skills and other aspects of ICT literacy skills to improve student's problem-solving skills.	42 (41.6%)	46 (45.5%)	13 (12.9%)	0	0
4	The inclusion of problem-solving skills could build higher-order thinking skills and increase collaborative problem-solving skills.	52 (51.5%)	43 (42.6%)	6 (5.9%)	0	0
5	Problem-solving skills are necessary to find solutions to problems in my future professional careers.	62 (61.4%)	32 (31.7%)	7 (6.9%)	0	0
Total		280 (55.45%)	182 (36.04%)	42 (8.32%)	1 (0.2%)	0.00
Mean		56.00	36.40	8.40	0.20	0.00
Standard deviation		9.19	7.57	2.79	0.45	0.00

produce an ideal solution. Therefore, it is suggested to include problem-solving skill into the curriculum as it is crucial for the acquisition of the 21st century skills (Demir, 2021). Following that, Item 5 had the second-highest number of strong agreement with a total of 62 respondents who strongly agreed with the statement. This is because at the workplace, individuals are often required to solve problems in a good manner to avoid conflicts between employees. According to Karakoyun and Lindberg (2020), problem-solving is the second most important skill after digital literacy in the 21st century workforce. Meanwhile, no disagreement was recorded for Items 2 to 4. The respondents who held a strong agreement for all 5 items contributed to an average of 91.5% of agreement.

Table 3 contains results on the importance of programming skill for the undergraduate students in the big data era. It can be seen that Item 1 yielded 80.2% of agreement from the respondents. This is because almost everything is digitalized nowadays and this makes programming as among the highly demanded skill for one to keep pace with the current trends. Other than developing computational skill, programming education can also aid in fostering a more general character attitude that is related to the 21st century skills and digital competency (Nouri et al., 2020). Furthermore, Item 4 received an agreement of 79.2% from the respondents. One possible reason is that the young generation must be equipped with programming skill to keep up with the digital transformation where programming skill is broadly needed in various sectors nowadays. Moreover, the importance of programming skill in this big data era is no longer limited to programmers but also various other careers. This is supported by Mittal (2020) who stated that important infrastructures such as healthcare, communication, transportation, and defense also expect improvement in software technologies to support their digital platforms. Whereas, 85 respondents agreed with Item 5, which deduced that programming encompasses the ability to write codes as well as the ability to analyze a situation and recognize critical components, model data, and processes in order to design

TABLE 3 Programming skill.

Item		5	4	3	2	1
1	Programming skill is strongly associated with the 21st-century skills and digital competence.	46 (45.5%)	35 (34.7%)	19 (18.8%)	1 (1.0%)	0
2	I think programming skill is broadly needed in various sectors nowadays.	48 (47.5%)	36 (35.6%)	12 (11.9%)	5 (5.0%)	0
3	I think programming skills should be included in primary school education.	32 (31.7%)	28 (27.7%)	31 (30.7%)	8 (7.9%)	2 (2.0%)
4	I think the young generation must equip with programming skills to keep pace with the digital transformation.	31 (30.7%)	49 (48.5%)	19 (18.8%)	1 (1.0%)	1 (1.0%)
5	Programming skills will enhance and complement my thinking skill, problem-solving skills and creativity.	42 (41.6%)	43 (42.6%)	14 (13.9%)	2 (2.0%)	0
Total		199 (39.4%)	191 (37.8%)	95 (18.8%)	17 (3.4%)	
Mean		39.80	38.20	19.00	3.40	0.60
Standard deviation		7.89	8.04	7.38	3.05	0.89

TABLE 4 Creative thinking skill.

Item		5	4	3	2	1
1	The development of creative thinking skill has less focus in educational settings.	29 (28.7%)	31 (30.7%)	36 (35.6%)	5 (5.0%)	0
2	Creative thinking skill is a required skill needed by 21st-century employers.	42 (41.6%)	47 (46.5%)	12 (11.9%)	0	0
3	Creative thinking skill helps us to stand out at school and workplace, specifically when we can provide constructive ideas.	50 (49.5%)	38 (37.6%)	11 (10.9%)	2 (2.0%)	0
4	Creative thinking skill makes us think from various perspectives and generate completely new ideas when dealing with problems as required in 21st-century.	52 (51.5%)	39 (38.6%)	9 (8.9%)	1 (1.0%)	0
5	Institutions should adopt problem-based learning to enhance creative thinking skill within students.	49 (48.5%)	38 (37.6%)	13 (12.9%)	1 (1.0%)	0
Total		222 (44.0%)	193 (38.2%)	81 (16.0%)	9 (1.8%)	0.00
Mean		44.40	38.60	16.20	1.80	0.00
Standard deviation		9.40	5.68	11.17	1.92	0.00

specific programs. As mentioned by Wong and Cheung (2020), programming skill can strengthen students' thinking skill, problem-solving skill, and creativity by requiring them to set up their own games, subsequently enhancing their programming knowledge during the programming curriculum. Ergo, given the importance of attaining these skills, it can be postulated that programming is one of the 21st century skills that has great importance for future generations, being a process of applying various command sets for computer programming, problem solving and performing a specific task by computers (Business Dictionary, 2017). The majority of respondents agreed with almost all of the items except for Item 3 where 30.7% of the respondents had a neutral stand while 9.9% of them disagreed with the statement. A possible explanation for this result is the respondents believe that primary students are too young to learn programming skill. According to Antonitsch (2015), there is another viewpoint that sees potential disadvantages in children's development when they are exposed to the computer at an early age. Such viewpoint can be found in both the educational thought of anthroposophical philosophy and the well-known scientific publications. All the items received disagreement from a small proportion of respondents.

Table 4 presents results on the importance of creative thinking skill for the undergraduate students in the big data era. For item 1, 60 respondents agreed, 36 respondents were neutral, and 5 respondents disagreed that the development of creative thinking skill has less focus in the educational system. Elder and Paul (2001) have emphasized the importance of fostering creative thinking skill in students' education because it allows them to handle both academic and non-academic situations with proper solutions. This indicates that educational institutions should put more attention on practicing critical thinking skill as it allows students to think critically and effectively find solutions, thus helping them to succeed in the future career path. Meanwhile, the majority of respondents agreed with Item 2 where creative thinking is not only important to their daily life but also to jobs that require interaction between individuals. Finkelman (2001) highlighted that professionals who work in the human health field, such as psychologists, counselors, and educationists, must think critically in both practice and management. Creative thinking also leads to higher leadership skill, particularly in managerial roles. Next, Item 3 received a high agreement level from the respondents. Despite the ability to generate ideas from their own experience and knowledge, individuals with creative thinking skill can also obtain ideas from their surroundings (Allen and Gerras, 2009), thus enabling them to identify the perfect solution to any difficulties experienced in the future. Besides, Item 4 had the highest percentage of agreed respondents (90.1%).

One reason for this result is that the respondents believe that individuals with creative thinking skill can immediately generate unique ideas when seeing a problem at first glance. According to Atmojo and Sajidan (2020), individuals with creative thinking skills can produce alternative solutions to problems easily while tend to obey the originality rule of ideas. Furthermore, 86.1% of the respondents agreed with Item 5. One possible explanation is that problem-based learning requires students to think out of the box and from various perspectives to obtain the desired solution. As noted by Anjarwati et al. (2018), problem-based learning encourages high students involvement by motivating them to find self-concept. It also allows students to think and solve problems creatively using their own ideas.

Conclusion

In summary, this research aims to identify the importance of data literacy, problem-solving, programming, and creative thinking skills in the big data era from the perspective of undergraduate students in Malaysia. The findings indicate that the majority of respondents agreed that data literacy is indeed a necessary skill in the digital world because it allows people to effectively deal with data-related issues. It was also found that data literacy skill possesses an important role in educational institutions. Therefore, the respondents proposed that data literacy skill should be integrated into the school curriculum to expose it to the young generation and cultivate their interests to data at an early age. Additionally, data literacy is also known as a medium for data sharing. Such skill is particularly helpful for students to interpret any forms of data. Hence, it is important to equip students with data literacy skill so that they can easily disclose information presented in raw data. For young learners to gain the 21st century skills, problem-solving skill should be incorporated into the learning process. The survey results showed that problem-solving skill should be included in the curriculum for students to increase their academic achievement and become more adventurous and creative. Furthermore, the findings also showed that problem-solving skill can help to develop critical thinking skill and improve collaborative problem-solving skill. Thus, students must be exposed to problem-solving skill as they will be required to solve problems and issues in their future careers. The results also reported an overall agreement on the strong interrelation between programming skill and the 21st century skills. Programming has become an essential skill in the 21st century. Therefore, every individual should be equipped with such skill to keep pace with the digital revolution as every sector now requires a digital platform, which is linked to the use of programming skill in platform design. As most educational institutions have begun to introduce programming skill into their curriculum, most respondents agreed that programming skill can strengthen their thinking skill, problem-solving skill, and creativity. They further advocate that the younger generation should be introduced to programming at the early stage skills for them to keep up with the digital transition. However, a small proportion of the respondents believe that it is unnecessary to embed programming skill into primary school education. From the findings, this study concludes that students should have creative thinking skill because it is a must-have ability to remain competitive and relevant in the 21st century. However, most educational institutions are lacking in the attention to creative thinking skill, hence causing graduates to face significant difficulty to secure their jobs. Thus, students must be encouraged to develop creative thinking skill as it allows them to generate unique ideas. This is in line with the respondents' agreement that creative thinking enables them to think and produce solutions to 21st century problems from various perspectives.

Recommendations

Due to the importance of data literacy skill in this data-saturated world, students will require such skill to study and process the open data for them to be relevant. It is recommended that problem-solving skill to be incorporated into the learning process in which real-life situations can be utilized to solve problems independently while receiving minimal guidance. This will train them to expect future events and be prepared to handle any potential problems and issues in the future. However, problem-solving skill is limited to specific courses only. Therefore, educational institutions may want to revise their curriculum to integrate problem-solving skill across a wider range of areas. Echoing similar notion, programming skill should be introduced at school level as students will likely start to develop interest at that juncture. For instance, schools can organize free programming courses and host programming competitions to encourage students' participation and interest in programming. This will cultivate an impactful learning experience to students and boost their interest in this field. In addition, this study also found that creative thinking skill can develop students' creativity to solve real-life problems. Thus, it is recommended for the government to improve the current education system by integrating more problem-based learning to improve students' creative thinking skill such as group-based activities to apply real-life solutions. This in turn will prompt them to think creatively in solving the assigned tasks with their group members, which will eventually help them to simulate creative solutions when faced with similar problems in the future workplace. Consequently, this will produce future employees with the competency to provide

constructive and creative solutions to problems. Besides, educators must also be encouraged to review best strategies for engaging students to develop the 21st century skills by connecting the content to real-life experiences to promote the sound application of the 21st century skills in actual field of work. Today, technology holds the power of transforming our present into a radiant future. Evolving skills set such as digital literacy and digital citizenship needed to undergo digital transformation are in high demand. There is a need to have a common understanding of digital literacy and skills that can be adopted by all stakeholders as a global standard, which can be seen as part of digital intelligence (DQ), which is recognized by the IEEE SA (2021). Therefore, it is recommended for future research to elicit further elaboration from a research emulating a tracer's study to track the progress of 21st century in order to gain more insights for more accurate conclusions to be drawn. Future research can also use cluster sampling to ensure that the number of participants from each age group is the same. This will ensure the accuracy of responses as all age groups will be equally represented, thus eliminating bias among the respondents. In conclusion, the education system should consider problem-based learning as a possible technique to enhance creative thinking skill among students.

Data availability statement

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

MM: conceptualization, data curation, and writing – original draft. SW: formal analysis and writing – review and editing. MM and SW: investigation and methodology. Both authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Aabla, B. (2017). A review on 21st century learning models. *Int. Interdiscip. J. Educ.* 6, 254–263. doi: 10.12816/0036081

Allen, C. D., and Gerras, S. J. (2009). Developing creative and critical thinkers. *Mil. Rev.* 6:77.

Anjarwati, P. G., Sajidan, S., and Prayitno, B. A. (2018). Problem-based learning module of environmental changes to enhance students' creative thinking skill. *Biosaintifika J. Biol. Biol. Educ.* 10, 313–319. doi: 10.15294/biosaintifika.v10i2.12598

Antonitsch, P. K. (2015). "A cautious look at coding in primary education," in *The proceedings of international conference on informatics in schools: Situation, evolution and perspectives—ISSEP 2015*, (Ljubljana: University of Ljubljana), 74–81.

Arslangilay, A. S. (2019). 21st century skills of CEIT teacher candidates and the prominence of these skillsin the CEIT undergraduate curriculum. *Educ. Policy Anal. Strateg. Res.* 14, 330–346. doi: 10.29329/epasr.2019.208.15

Atmojo, I. R. W., and Sajidan. (2020). Effectiveness of CEL-badis learning model on students' creative-thinking skills: Case on the topic of simple food biotechnology. *Int. J. Instr.* 13, 329–342. doi: 10.29333/iji.2020.13323a

Azid, N., and Md-Ali, R. (2020). The effect of the successful intelligence interactive module on Universiti Utara Malaysia students' analytical, creative and practical thinking skills. *S. Afr. J. Educ.* 40, 7–8. doi: 10.15700/saje.v40n3a1743

Ball, A., Joyce, H. D., and Anderson-Butcher, D. (2016). Exploring 21st century skills and learning environments for middle school youth. *Int. J. Sch. Soc. Work* 1. doi: 10.4148/2161-4148.1012

Bhargava, R., and D'Ignazio, C. (2015). "Designing tools and activities for data literacy learners," in Proceedings of the wed science: Data literacy workshop, Oxford. doi: 10.15353/joci.v12i3.3280

Business Dictionary (2017). *Business Dictionary*. Available online at: http://goo.gl/IVH6Nq (accessed August 1, 2021).

Chinien, C., and Boutin, F. (2011). *Defining essential digital skills in the canadian workplace . Human resources and skills development Canada.* 87. Available online at: http://en.copian.ca/library/research/digi_es_can_workplace/digi_es_can_workplace.pdf (accessed December 15, 2021).

Davis, B. (2021). *Research paper: What are the benefits of 21st century? Mvorganizing.* Available online at: https://www.mvorganizing.org/what-are-the-benefits-of-21st-century/ (accessed June 10, 2022).

Deahl, E. S. (2014). Better the data you know: Developing youth data literacy in schools and informal learning environments. *SSRN Electron. J.* doi: 10.2139/ssrn.2445621

Demir, Ü (2021). The effect of unplugged coding education for special education students on problem-solving skills. *Int. J. Comput. Sci. Educ. Sch.* 4, 3–30. doi: 10.21585/ijcses.v4i3.95

Elder, L., and Paul, R. (2001). Critical thinking: Thinking to some purpose. *J. Dev. Educ.* 25:40.

Enakrire, R. T. (2020). Data literacy for teaching and learning in higher education institutions. *Lib. Hi Tech News* 38, 1–7. doi: 10.1108/LHTN-01-2020-0005

Finkelman, A. W. (2001). Problem-solving, decision-making, and critical thinking: How do they mix and why bother? *Home Care Provid.* 6, 194–198. doi: 10.1067/mhc.2001.120987

Furino, B. (2012). Perspectives on student problem solving and 21st century skills developed at the precollege level. *J. Washington Acad. Sci.* 98, 23–34.

Ghafar, A. (2020). Convergence between 21st century skills and entrepreneurship education in higher education institutes. *Int. J. High. Educ.* 9, 218–229. doi: 10.5430/ijhe.v9n1p218

Grace, K., Salvatier, J., Dafoe, A., Zhang, B., and Evans, O. (2018). When will AI exceed human performance? Evidence from AI experts. *J. Artif. Intell. Res.* 62, 729–754. doi: 10.1613/jair.1.11222

Habets, O., Stoffers, J., Heijden, B. V. D., and Peters, P. (2020). Am i fit for tomorrow's labor market? The effect of graduates' skills development during higher education for the 21st century's labor market. *Sustainability* 12:7746. doi: 10.3390/su12187746

Jang, H. (2016). Identifying 21st century STEM competencies using workplace data. *J. Sci. Educ. Technol.* 25, 284–301. doi: 10.1007/s10956-015-9593-1

Joynes, C., Rossignoli, S., and Fenyiwa Amonoo-Kuofi, E. (2019). *21st century skills: Evidence of issues in definition, demand and delivery for development contexts*. Brighton: Institute of Development Studies.

Karakoyun, F., and Lindberg, O. J. (2020). Preservice teachers' views about the twenty-first century skills: A qualitative survey study in Turkey and Sweden. *Educ. Inf. Technol.* 25, 2353–2369. doi: 10.1007/s10639-020-10148-w

Karyotaki, M., and Drigas, A. (2016). Online and other ICT-based training tools for problemsolving skills. *Int. J. Emerg. Technol. Learn.* 11, 35–39.

Kereluik, K., Mishra, P., Fahnoe, C., and Terry, L. (2013). What knowledge is of most worth: Teacher knowledge for 21st century learning. *J. Digit. Learn. Teach. Educ.* 29, 127–140. doi: 10.1080/21532974.2013.10784716

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., and Graham, C. R. (2014). "The technological pedagogical content knowledge framework," in *Handbook of research on educational communications and technology*, (New York, NY: Springer Science + Business Media), 101–111. doi: 10.1007/978-1-4614-3185-5

Kunpitak, P. (2019). The flipped classroom in 21st century learning for development of learning skills algorithm analysis of basic programming C language. *IJIE (Indonesian Journal of Informatics Education)* 2, 77–84. doi: 10.20961/ijie.v2i2.24402

Lavi, R., Tal, M., and Dori, Y. J. (2021). Perceptions of STEM alumni and students on developing 21st century skills through methods of teaching and learning. *Stud. Educ. Eval.* 70:101002. doi: 10.1016/j.stueduc.2021.101002

Mahmud, M. M., and Wong, S. F. (2022). Stakeholder's perspectives of the twenty-first century skills. *Front. Educ.* 7:931488. doi: 10.3389/feduc.2022.931488

Mahmud, M. M., Wong, S. F., and Ismail, O. (2021). "Emerging learning environments and technologies post Covid-19 pandemic: What's next?," in *The international conference on information, communication & cybersecurity*, (Cham: Springer), 308–319. doi: 10.1007/978-3-030-91738-8_29

Ministry of Higher Education [MoHE] (2011). *Graduate tracer study executive report 2010*.

Miranda, J., Navarrete, C., Noguez, J., Molina-Espinosa, J. M., Ramírez-Montoya, M. S., Navarro-Tuch, S. A., et al. (2021). The core components of education 4.0 in higher education: Three case studies in engineering education. *Comput. Electr. Eng.* 93, 1–27. doi: 10.1016/j.compeleceng.2021.107278

Mittal, S. (2020). *Coding: 21st century skill for smarter India. Business world*. Available online at: http://bweducation.businessworld.in/article/Coding-21st-Century-Skill-For-Smarter-India-/15-10-2020-331787/ (accessed June 10, 2022).

Nouri, J., Zhang, L., Mannila, L., and Norén, E. (2020). Development of computational thinking, digital competence and 21st century skills when learning programming in K-9. *Educ. Inq.* 11:14. doi: 10.1080/20004508.2019.1627844

Palsdottir, A. (2021). Data literacy and management of research data – a prerequisite for the sharing of research data. *ASLIB J. Inf. Manag.* 2:322. doi: 10.1108/AJIM-04-2020-0110

Raffaghelli, J. E. (2020). Is data literacy a catalyst of social justice? A response from nine data literacy initiatives in higher education. *Educ. Sci.* 10:233. doi: 10.3390/educsci10090233

Rajaratenam, R. M. (2019). *Columnist. Tap into 21st century skills*. https://www.nst.com.my (accessed June 10, 2022).

Rios, J. A., Ling, G., Pugh, R., Becker, D., and Bacall, A. (2020). Identifying critical 21st-century skills for workplace success: A content analysis of job advertisements. *Educ. Res.* 49, 80–89. doi: 10.3102/0013189X19890600

Robertson, J., and Tisdall, E. K. (2020). The importance of consulting children and young people about data literacy. *J. Media Lit. Educ.* 12, 58–74. doi: 10.23860/jmle-2020-12-3-6

Rodzalan, S. A., and Saat, M. M. (2015). The perception of critical thinking and problem-solving skill among Malaysian undergraduate students. *Proced. Soc. Behav. Sci.* 172, 725–732. doi: 10.1016/j.sbspro.2015.01.425

Shreiner, T. L. (2020). Building a data literate citizenry: How US state standards address data and data visualizations in social studies. *Inf. Learn. Sci.* 121, 909–931. doi: 10.1108/ILS-03-2020-0054

Sickler, J., Bardar, E., and Kochevar, R. (2021). Measuring data skills in undergraduate student work: Development of a scoring rubric. *J. Coll. Scie. Teach.* 50, 25–32.

Silva, E. (2009). Measuring skills for 21st-century learning. *Phi Delta Kappa.* 90, 630–634. doi: 10.1177/003172170909000905

The Glossary of Education Reform (2016). *21st century skills*. Available online at: https://www.edglossary.org/21st-century-skills/ (accessed August 1, 2021).

Theobold, A., and Hancock, S. (2019). How environmental science graduate students acquire statistical computing skills. *Stat. Educ. Res. J.* 18:68. doi: 10.52041/serj.v18i2.141

Van Laar, E., Van Deursen, A. J. A. M., Van Dijk, J. A. G. M., and De Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. *SAGE Open* 10:9. doi: 10.1177/2158244019900176

Van Laar, E., Van Deursen, A. J., Van Dijk, J. A., and De Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Comput. Hum. Behav.* 72, 577–588. doi: 10.1016/j.chb.2017.03.010

Winberg, C., Adendorff, H., Bozalek, V., Conana, H., Pallitt, N., Wolff, K., et al. (2019). Learning to teach STEM disciplines in higher education: A critical review of the literature. *Teach. High. Educ.* 24, 930–947. doi: 10.1080/13562517.2018.1517735

Wong, G. K.-W., and Cheung, H.-Y. (2020). Exploring children's perceptions of developing twenty-first century skills through computational thinking and programming. *Interact. Learn. Environ.* 28, 438–450. doi: 10.1080/10494820.2018.1534245

World Economic Forum (2016). *The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution. Global Challenge Insight Report*. Cologny: World Economic Forum.

Wyse, D., and Ferrari, A. (2014). Creativity and education: Comparing the national curricula of the states of the European Union and the United Kingdom. *Br. Educ. Res. J.* 41, 30–47. doi: 10.1002/berj.3135