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2023 CONFERENCE RESEARCH PAPERS

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Expanding Possibilities
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Kia ora

The TENZ 2023 Conference Team wish to thank the Keynote Speakers, the Workshop presenters, the Panel Discussion Facilitators, Research paper presenters, and the International and New Zealand Conference attendees for making the 2023 Conference such a successful event.

We would also like to thank Ian Hayes and the staff at Ao Tawhiti for making their innovative building and spaces available for us to host the conference.

We look forward to welcoming you to the 2025 TENZ Conference. Look out for information coming your way in 2024.

Ngā mihi,
The 2023 TENZ Conference Team

TENZ TECHNOLOGY EDUCATION NEW ZEALAND

Technology Education New Zealand (TENZ) is a non-profit professional, collaborative association, promoting and supporting all levels of technology education in Aotearoa New Zealand.

TENZ is organised by teachers for teachers and our aim is to enhance the learning and teaching of technology by creating a well-informed, well connected, supportive, and sustainable professional community that has a strong voice and provides effective advocacy for technology education.

To achieve our aims, we need the support of as many teachers as possible. So join us, and help grow and strengthen our national network supporting and promoting technology education across Aotearoa New Zealand.

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For Teacher Training to Foster AI Literacy among Japanese Teachers

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Abstract

AI has been evolving at an amazing speed and dramatically impacts our society. However, global society has just started a discussion about regulations, and people are required to acquire AI literacy to decide "how to utilize AI properly." Technology education is central to fostering students' AI literacy, but the unique context of Japanese schools makes it extremely hard. This requires Japanese teachers to collaborate in technology education, especially on AI, and this also requires those teachers to acquire AI literacy, knowledge, and skills to utilize AI in their teaching. Our research project aims to plan a teacher training program for this purpose, and the previous study surveyed AI literacy among Japanese teachers. In this study, we investigated their attitude toward AI use in classrooms, expectations for teaching improvements with AI, and a sense of burden in AI use in classrooms. The results showed that many Japanese teachers were worried that they would have more of a burden in acquiring knowledge about AI, operational skills of AI, and skills for planning and conducting an effective use of AI for better teaching. However, they showed a strongly positive attitude toward AI use in classrooms and answered many specific scenes and images that they could improve their teaching with AI. This suggests that the teacher training program must cover the three major worries mentioned above, and also providing ideas and examples to realize those specific expectations can boost the effects of the training program.

Keywords: teacher training, AI literacy, AI use in classrooms, expectations, burdens

1 Introduction

Advanced technologies such as big data, the Internet of Things (IoT), robotics, and artificial intelligence (AI) are rapidly penetrating various industries in our society. In particular, AI is the central cause of significant social changes. Generative AI, such as ChatGPT, BingAI, Bard, Midjourney, and Stable Diffusion, is a prominent example of its rapid evolution.

The pace of AI evolution is too fast, and, at the moment, global society has been unable to keep up with its speed. The debate on how AI should be used in society has just begun. It is expected to take many more years before rules are created and permeated into the global society and at the national level. For now, individuals are expected to decide "how to utilize AI" by themselves. Therefore, the importance of acquiring AI literacy to properly understand AI is increasing dramatically among all citizens.

While the definition of AI literacy is still debated among researchers, Long & Magerko (2020), based on 150 research papers and books on AI published through 2019, attempts a specific definition of AI literacy and present the 17 competencies that constitute AI literacy. According to the definition, AI literacy is "a set of competencies that enable individuals to evaluate AI technologies critically; communicate and collaborate effectively with AI; and use AI as a tool online, at home, and at work" (p. 2).

According to Long & Magerko (2020), the 17 competencies consisting of AI literacy include diverse knowledge and skills. For example, understanding the differences between AI intelligence and human or animal intelligence, the technologies in which AI is used and their advantages and disadvantages, and the processes in which AI learns and makes decisions. Also, the competencies include the ability to apply this knowledge, envision future applications of AI in society, judge the role of humans in the use of AI, and consider ethical issues related to the use of AI.

Education plays a vital role in the acquisition of such AI literacy. Therefore, one of the most relevant educational areas is technology education. One example of the ideal state of technology education is the *Standard Technological and Engineering Literacy* (STEL), a set of guidelines provided by ITEEA (2020). According to this guideline, students are expected to learn about the relationship between society and technology through a coherent PreK-12 curriculum to apply what they learn in the classroom to real-life situations and become active, engaged citizens who think about technology in today's society.

In the STEL guidelines, AI is included in "Computation, Automation, Artificial Intelligence, and Robotics," one of the eight areas to be addressed in technology and engineering education (pp. 91-96). This section explains that AI is so closely related to students' lives, such as signals, facial recognition, and email filtering, that students need to learn to use AI and various technologies to discover patterns and improve their tasks (p. 93).

However, technology education in Japanese schools is far from the ideal shown by ITEEA. Although there have been gradual improvements in the quality and quantity of AI education, there are still significant problems: study hours are minimal, and the curriculum is not continuous and systematic (Industrial Technology Education Society, 2021). For example, the core of Japanese technology education is the three-year "Technology and Home Economics" course in junior high school, which consists of only 70 hours of lessons in grades 1 and 2 and 35 hours in grade 3. This means that only one 50-minute class per week is devoted to technology in grades 1 and 2, and one 50-minute class every two weeks in grade 3.

Teachers with expertise in technology education only teach this junior high school "Technology and Home Economics" course, but the number of teachers is also insufficient. According to a report by All Japan Junior High School Principals (2017), 22.1% (2209 schools) of the technology (education) classes in "Technology and Home Economics" in junior high schools across Japan are taught by teachers who were out of license or with a temporary license.

Meanwhile, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has released "Tentative Guidelines for the Use of Generated AI at the Elementary and Secondary Education Level" (MEXT, 2023). This guideline requires teachers to acquire a certain level of AI literacy and to develop the knowledge and attitudes necessary for students to use generative AI appropriately through appropriate educational activities based on the students' developmental stage and actual conditions.

Therefore, it would be ideal to foster students' acquisition of AI literacy through learning in the subjects directly related to technology education. However, Japanese schools have limits to relying on specific subjects to accomplish it. Given the current state of Japanese society, where the acquisition of AI literacy by the population is a big challenge, it is highly probable that teachers need more AI literacy and skills to use it in the classroom. In addition, considering various problems in technology education in Japanese schools, students may need help to acquire sufficient AI literacy only through learning in subjects related to technology education, which have minimal study hours.

To create an environment in which students can fully acquire AI literacy in Japanese schools, teachers specializing in technology education will play a central role. Still, all teachers, regardless of their subject, must collaborate in technology education. To this end, each teacher must acquire AI literacy and the knowledge and skills to plan and implement effective teaching with AI in classrooms. This will promote the use of AI in the classroom in various subjects and increase opportunities for students to learn about and with AI, thereby improving the quality of AI-related technology education in Japanese schools. Ultimately, this will lead to the achievement of the Japanese government's goal of AI literacy acquisition for all citizens (Cabinet Office of Japan, 2018).

To achieve these goals, exploring practical ways to help teachers acquire AI literacy and the knowledge and skills necessary to plan and implement AI utilization for better teaching is essential. To this end, it is first necessary to understand the current status of AI literacy among Japanese teachers as a background factor. It is also required to investigate other factors to identify the content to be covered in the teacher training, such as the specifics of teachers' images of AI for use in the classroom, their concerns about using AI in the classroom, and the information and support they need to use AI in the classroom.

Our previous study attempted to understand the AI literacy of Japanese teachers (Motozawa *et al.,* 2022). However, in our literature review, we could not find any previous studies that quantitatively measured teachers' AI literacy, so we modified the scale from the Chai *et al.* (2020) study, which attempted to quantitatively measure AI literacy among secondary school students in China, to measure AI literacy among Japanese teachers.

The scale used in this previous study consisted of 29 items in the following seven categories: 1) AI Literacy (Lit; six items), which relates to a basic understanding of how AI works; 2) AI Anxiety (Anx; four items), which relates to concerns about the impact of AI; 3) Perceived Usefulness of AI (PU; four items), which asks whether one feels positive effects of AI use; 4) AI for Social Good (SG; four items); 5) Attitude toward Using AI (ATU; four items)"; 6) "Confidence in Teaching with AI (Confi; five items)"; and 7) "AI Optimism (OP; three items)," which asks about one's expectation that AI will have a positive impact on society shortly. Each category was equally weighted.

The results indicated that the Japanese teachers who participated in this study needed a higher level of AI literacy. Furthermore, the results also suggested the need to develop Japanese teachers' AI literacy, especially Lit and Confi, through active intervention in teacher training, regardless of their teaching experience.

The following are the results about teachers' images of AI for use in the classroom, their concerns about using AI in the classroom, and the information and support they need to use AI in the classroom. First, Japanese teachers' images of AI that can be used in the classroom were diverse. However, most were found to be execution-based AI, such as automated grading, opinion aggregation, and question recommendation. In addition, those teachers showed a strong concern about acquiring sufficient knowledge and operational skills of AI, and they did not seem to have a concrete image of how they would utilize AI in their classes. Therefore, they may have excessive anxiety, such as "the teacher's significance of existence will disappear if AI is used. "

To consider specific training programs, it is necessary to clarify in what aspects of teaching they expect to be able to use AI, what kind of improvements they expect to occur in their teaching with AI, and what kind of burden they imagine will increase with the use of AI. Therefore, this study aims to examine more specific contents for the training programs by surveying Japanese teachers regarding their expectations for teaching improvements occurred by AI use and their sense of burden associated with the use of AI.

2 Method

2.1 Overview

The authors have so far been able to obtain data for a rough idea of the training program for Japanese teachers to acquire AI literacy and knowledge and skills necessary to use AI in the classroom effectively. However, to examine the contents to be covered in the training program, it is essential to clarify the following contents: (1) in what situations those teachers expect to be able to use AI in their classes, (2) what kind of improvement effects they expect from AI, and (3) what kind of burden they expect to be increased in the use of AI.

Therefore, this study conducted a questionnaire survey of Japanese teachers in several situations regarding their expectations and burdens for class improvement regarding the use of AI. The questionnaire was conducted online using Google Forms from June 2 to June 15, 2022. Because school teaching experience may influence these factors, this study collected data from teachers with different teaching experiences. By comparing these data, we collected primary data to examine the content of training programs based on teaching experience.

2.2 Participants

The participants were 47 Japanese graduate students majoring in pedagogy at a graduate school for teacher education. Some graduate students entered the program immediately after graduating from undergraduate school, while others joined the program while teaching at schools. Therefore, for this study, we determined that graduate students majoring in pedagogy at graduate school of teacher education were appropriate participants, as it was possible to distinguish between those with and without teaching experience. Of the 47 participants, 27 (12 males and 15 females) had teaching experience. One is from a preschool, 14 are from elementary school, seven are from junior high school, and five are from high school. Their average teaching experience was 15.2 years (*SD* 5.75). This survey also had 20 participants (11 males and nine females) without teaching experience. All participants were licensed to teach in either elementary, junior high, or high school in Japan, and the subjects of their licenses varied from Japanese arithmetic/mathematics, science, and social studies.

Because the AI literacy addressed in this study is one that all teachers should acquire regardless of the subject they teach, this study did not distinguish teachers based on the school types of the subjects or the subjects they were in charge of. As mentioned in the Introduction, technology education in Japanese schools is not a continuous and systematic curriculum, and the class hours taught by specialized teachers are minimal. Therefore, for students to fully acquire AI literacy and use it appropriately in their learning, technology education needs to accept a change to the current situation in Japanese schools. To this end, while teachers specializing in technology education should play a central role, teachers in charge of other subjects should also acquire AI literacy and the knowledge and skills to use AI in the classroom, practice it in their daily educational activities, and collaboratively promote technology education.

2.3 Questionnaire items

The questionnaire items used in this study are as follows. First, to confirm the participants' attitude toward the use of AI in their classes, this study created the following four question statements and asked them to answer the questions on a four-point Likert scale of 4 (strongly agree), 3 (partly agree), 2 (partly disagree), and 1 (strongly disagree).

1) I think "a class incorporating AI" has educational benefits.

2) Incorporating AI in my class to enhance educational quality is essential.

3) I want to use AI in my class.

4) I feel anxious about incorporating AI into my class.

In addition, this study asked the participants about a) their expectations for AI to improve their classes and b) their sense of burdens increased by the use of AI in the following four situations where AI could be used: "class preparation," "in-class teaching," "evaluation of learning activities," and "educational activities outside of the class." For these items, this study asked the following questions: "If I incorporate AI into my class, I think it will improve ________." and "If I incorporate AI into my classes, I feel burdened in ________." The four situations will be applied to the ________ part of the questions. These questions were also answered on a four-point Likert scale of 4 (strongly agree), 3 (partly agree), 2 (partly disagree), and 1 (strongly disagree). In addition, when the participants chose 4 (strongly agree) or 3 (partly agree), they were asked to provide specific details.

2.4 Analysis

This study first calculated the mean and standard deviation for the two groups (with and without teaching experience) for the four-point Likert scale data for the expectations and burdens. Then, a *t*-test was conducted on the data of the two groups to check for the influence of teaching experience. Finally, the three authors discussed and categorized the responses obtained for the open-ended responses.

3 Results and Discussion

3.1 Statistics and *t*-test results

Table 1 shows the statistical values of the responses of the groups with and without teaching experience to the following questions: attitude toward the use of AI in the classroom (Questions 1-4), expectations for teaching improvements in classes with the use of AI (Questions 5-8), and sense of burdens by the use of AI (Questions 9-12). Regarding the attitude toward using AI in the classroom, the group with teaching experience showed slightly higher values for Question 4. Regarding their expectations for improving classes through AI, the group without teaching experience was higher in Question 5. The group with teaching experience showed slightly higher values in Question 6, Question 7, and Question 8. Finally, regarding the sense of burden, all Questions 9 to 12 had higher scores for those with teaching experience.

A *t*-test was conducted between the two groups of participants with and without teaching experience for the values of questions 1 through 12. The *t*-test for Question 9 showed a significant difference between the groups at the 5% criterion ($t(45)=2.49$, $p<.05$, $d=.74$). Also, the test for Question 10 showed a significant difference between groups at the 1% criterion ($t(44.9)=2.87$, $p<.01$, $d=.83$).

These results suggest that teaching experience may have influenced the differences between the two groups regarding the burden of "class preparation" and "in-class teaching." However, no between-group differences were observed for the other questions (Question 1-8, 11, 12) ($t(45)$ =.09 to 1.14, *n.s.*, d = .03 to .32). Therefore, there seems to be little influence of teaching experience on the participants' attitude toward the use of AI in the classroom, their expectations for the improvement of teaching through the use of AI, and their sense of burden for "evaluation of learning activities" and "educational activities outside the classroom."

The average score for a sense of burden was less than 3 out of 4. Since the value is low, the degree to which the participants feel burdened could be stronger. These results suggest that teachers can acquire AI literacy, knowledge, and skills for using AI in classrooms effectively and efficiently, depending on the training content.

3.2 Results of the open-ended responses

Participants were asked to answer Questions 5-12 on a four-point Likert scale of 4 (strongly agree), 3 (partly agree), 2 (partly disagree), and 1 (strongly disagree), and those who chose 4 (strongly agree) and 3 (partly agree) were asked to provide specifics. The results are summarized in Tables 2 for expectations and Table 3 for burdens.

Table 1 Statistics and *t*-test results

No.	Question	with teaching experience (N=27)		without teaching experience (N=20)		*t*	ES(*d*)
		M	*SD*	*M*	*SD*		
1	I think that "a class incorporating AI" has educational benefits.	3.33	0.62	3.40	0.68	.35	.11
2	Incorporating AI in my class to enhance educational quality is essential.	3.33	0.62	3.35	0.67	.09	.03
3	I want to use AI in my class.	3.37	0.63	3.40	0.68	.15	.05
4	I feel anxious about incorporating AI into my class.	3.15	0.86	3.00	0.73	.62	.19
5	If I incorporate AI into my class, I think it will improve class preparation.	3.07	0.73	3.20	0.70	.60	.18
6	If I incorporate AI into my class, I think it will improve in-class teaching.	3.07	0.68	2.95	0.83	.57	.16
7	If I incorporate AI into my class, I think it will improve evaluation of learning activities.	3.15	0.72	3.05	0.69	.47	.14
8	If I incorporate AI into my class, I think it will improve educational activities out of the class.	3.07	0.78	2.90	0.85	.73	.21
9	If I incorporate AI into my class, I feel burdened in class preparation.	3.00	0.62	2.55	0.61	2.49*	.74
10	If I incorporate AI into my class, I feel burdened in in-class teaching.	2.56	0.64	2.10	0.45	2.87**	.83
11	If I incorporate AI into my class, I feel burdened in evaluation of learning activities.	2.22	0.64	2.05	0.39	1.14	.32
12	If I incorporate AI into my class, I feel burdened in educational activities out of the class.	2.19	0.48	2.10	0.64	.52	.16

p : *p*-value, ES(*d*): Effect Size(*d*), * $p<.05$, ** $p<.01$

As mentioned, the *t*-test results showed no significant difference between the two groups for the sense of expectation. In addition, the mean of the responses for the sense of burden was below 3 pt in most cases, and the number of open-ended responses obtained was small. Therefore, the received responses were classified by discussion among the three authors without dividing them into two groups (with and without teaching experience).

A considerable number of specific responses were received regarding expectations. The total number of responses by the situation was 43 for "class preparation," 39 for "in-class teaching," 37 for "evaluation of learning activities," and 33 for "educational activities outside of class." Among "class preparation," teacher workload reduction and work efficiency improvement received most of the answers (33 responses), including paperwork tasks (14 responses) and class preparation (13 responses). On "in-class teaching, " individual optimization (18 responses) had the biggest number of answers, followed by teacher workload reduction (9 responses) and improvement in the efficiency of evaluation (5 responses). On "evaluation of learning activities," the most common responses were diversification of evaluation methods, including data-based evaluation (7 responses), individualized evaluation (6 responses), and evaluation from multiple perspectives (5 responses). Other answers included automation and efficiency of evaluation (10 responses) and objectivity and accuracy of evaluation (9 responses). Finally, on "educational activities other than teaching," the most common response was teacher workload reduction and work efficiency improvement (14 responses), followed by Improvement in quality of learning (10 responses) and change in students' attitude toward learning (6 responses).

As the above results show, Japanese teachers' beliefs about the improvements that could be made by introducing AI into their classes are wide-ranging, and the number of responses is huge. The responses included things "substituted by AI," such as clerical work and attendance checks, and things that " AI expanding human capabilities," such as enabling teachers to provide more appropriate instruction based on AI-analyzed student learning status and more objective evaluations. Although our previous study showed that the level of AI literacy among Japanese teachers is low, they had some concrete images of how introducing AI will improve their teaching. In addition, their attitudes toward the use of AI in classrooms were quite positive.

Table 2 Specifics for the teaching improvement expectations

Question	Category		No. of Answers	Examples of Answers
If I incorporate AI into my class, I think it will improve class preparation. (43 responses)	Teacher workload reducion and work efficiency improvement	Paper work tasks	14	Improvement in work efficiency, effective use of time
		Class preparation	13	Collecting materials and data for class; preparing handouts; preparing data for board content; collecting and checking students' notebooks
		Evaluation	3	Collecting data for evaluation
		Others	1	Attendance check
	Individual optimization		10	Analysis of student learning and understanding; Quick feedback; Efficient class management
	Others		2	Predicting children's responses; Distance learning
If I incorporate AI into my class, I think it will improve in-class teaching. (39 responses)	Individual optimization		18	Individualized teaching and support for each student; more efficient classroom management; collaborative learning for students
	Teacher workload reduction		9	More time to check students' opinions; Other activities will be available.; It is easy to check the status of each student.
	Improvement in efficiency of evaluation		5	Immediate identification of errors by students
	Others		7	Improvement in students' concentration; More knowledge and deeper thinking among students; More specificity to teaching and learning activities
If I incorporate AI into my class, I think it will improve evaluation of learning activities. (37 responses)	Diversification of evaluation method	Data-based evaluation	7	Data accumulation and AI-based analysis of student learning
		Individualized evaluation	6	Facilitation in individualized evaluation; Students can easily see changes in their evaluations.
		Evaluation from multiple perspectives	5	Evaluation from multiple perspectives; Allows teachers to monitor student learning in areas that are difficult to quantify.
	Automation and efficiency improvement in evaluation		10	Faster evaluation and feedback; automation and visualization of evaluations
	Improvement in objectivity and accuracy of evaluations		9	More objective evaluation; Teachers can observe and check students' learning that teachers can't see on their own.
If I incorporate AI into my class, I think it will improve educational activities out of the class. (33 responses)	Teacher workload reducion and work efficiency improvement		14	Smooth understanding of students' attendance, physical condition, etc.; easier interaction and communication with students; more efficient operations
	Improvement in quality of learning		10	Club activities and homework are optimized individually.; more time for creative learning through more efficient basic learning; easier discussions and productions at events, etc.
	Changes in students' attitude for learning		6	Diversification of student interests; Students develop autonomous learning attitudes.; Student interest in technology grows and skills are developed.
	Others		3	Better understanding of needs from students, parents, and community; AI will take on the role of school patrols.

Regarding the sense of burden, we had only a small number of 4 (strongly agree) and 3 (partly agree) responses out of a 4-point Likert scale. Therefore, we also had a small number of open-ended responses. The number of responses to “class preparation" was the biggest (33 responses), followed by "in-class teaching" (17 responses), "evaluation of learning activities" (9 responses), and "educational activities out of the class" (8 responses). In "class preparation," learning how to operate AI had the most significant number of responses (21 responses), followed by thinking about how to use the system in class (7 responses), acquiring knowledge about AI (2 responses), and others (3 responses). In the "in-class teaching," there were few responses for learning how to operate AI (7 responses), thinking about how to use AI in the classroom (5 responses), acquiring knowledge about AI (4 responses), and others (1 response). In "evaluation of learning activities," the most common answers were maintaining the reliability of the evaluation (4 responses), learning how to operate AI (3 responses), and others (2 responses). In "educational activities out of the class," the answers were acquiring knowledge about AI (3 responses), operating procedures (2 responses), and others (3 responses).

The overall trend showed that the mean value of the sense of burden is not high, and the number of responses is small. Therefore, Japanese teachers do not seem to feel much of a burden regarding using AI in the classroom; rather, their sense of expectation exceeds their sense of burden. This suggests that Japanese teachers will favorably receive the teacher training program we are planning. In addition, if the training program increases their ability to use AI in their classrooms, we can expect to increase their motivation for the training by providing concrete images of what they can do with AI in classrooms.

The answers by the teachers were concentrated in the three areas of acquiring knowledge about AI, learning how to operate AI, and thinking about how to use AI in the classroom. This means they can be the primary needs for the training program. However, as far as the contents of the responses indicate, the teachers could not imagine specific teaching situations and methods of using AI in classrooms. Also, many teachers answered their worries and anxieties about things, such as changing familiar ways of teaching or learning new things for burdens.

Therefore, when we plan a teacher training program about AI, it must cover the three main categories shown in the responses for the burden and anxiety: They are 1) acquiring knowledge about AI, 2) learning how to operate AI, and 3) thinking about how to use AI in classrooms. Including contents of the various needs in response to "expectations” so that teachers can have as many concrete images of using AI as possible.

To alleviate teachers' concerns about the increased burden of using AI in classrooms, the training programs should introduce many concrete scenes of classes incorporating AI to promote the benefits of using AI in the classroom. However, it is probably not enough. The program should also provide more specific knowledge and operational skills required in those learning activities, information on what kind of learning is necessary, and how much time and effort are needed to develop such knowledge and skills. By making teachers feel they can do it, their motivation for the training will increase, making the program more effective.

Table 3 Specifics for the burdens of AI use in classrooms

Question	Category	No. of Answers	Examples of Answers
If I incorporate AI into my class, I feel burdened in class preparation. (33 responses)	Learning how to operate AI	21	It takes time to get used to it; It takes time to solve it because there are many things I don't understand in the beginning; It takes time to learn how to operate it.
	Thinking about how to use AI in the classroom	7	I don't know how to make the best use of it.
	Acquiring knowledge about AI	2	Too little knowledge about AI
	Others	3	Preparation and maintenance in advance
If I incorporate AI into my class, I feel burdened in in-class teaching. (17 responses)	Learning how to operate AI	7	I have a resistance or psychological burden to change from a familiar method to a new one, until I get used to it I am going to have a hard time.
	Thinking about how to use AI in the classroom	5	I don't know if I can use them effectively; I have concerns about using the apps and tools properly.
	Acquiring knowledge about AI	4	I need to learn to determine when AI should be used and how to teach students how to use AI.
	Others	1	Financial burden
If I incorporate AI into my class, I feel burdened in evaluation of learning activities. (9 responses)	Maintaining the reliability of the evaluation	4	I don't know what the criteria are for AI evaluations. There is a risk of incorrect grades being attached.
	Learning how to operate AI	3	Takes time to get used to AI; unsure if AI can be used to evaluate well
	Others	2	If I were in charge of creating a system of evaluation methods, It would be very difficult.
If I incorporate AI into my class, I feel burdened in educational activities out of the class. (8 responses)	Acquiring knowledge about AI	3	I need to learn more about AI; I don't know the background behind AI's decisions.
	Learning how to operate	2	It takes time to get used to it.
	Others	3	Preparation and maintenance in advance; Fostering Information Morale

4 Conclusion

To plan and implement a teacher training program to foster AI literacy among Japanese teachers, this study investigated the contents the training programs should cover. The authors conducted a questionnaire survey among Japanese teachers with different teaching backgrounds to determine their attitude toward AI use in classrooms, expectations for teaching improvements with AI, and a sense of burden in AI use in classrooms. The results of the survey were as follows.

- Overall, the value of the sense of expectation tended to be higher than that of the sense of burden. This indicates that Japanese teachers have a relatively positive attitude toward introducing AI in their classes and have strong expectations for improving educational quality through the introduction of AI.

- Specific responses regarding the sense of expectation were numerous, and overall, the focus was on reducing the burden on teachers and optimizing learning individually.
- About the sense of burden, answers were concentrated on three elements: acquiring knowledge about AI, learning how to operate AI, and understanding and learning how to use AI in the classroom effectively. A significant difference was found between teachers with and without teaching experience only in "class preparation" and "in-class teaching."

When the authors plan a teacher training program on AI literacy for Japanese teachers based on these results, the main contents for the program are 1) acquiring knowledge about AI, 2) learning how to operate AI, and 3) thinking about how to use AI in classrooms, in the responses or the burden and anxiety. In addition, the program should meet the various needs shown in the open-ended answers for the expectation of teaching improvements and provide many concrete images of AI use in classrooms. Also, the results showed teachers with teaching experience need more specific content about "class preparation" and "in-class teaching."

However, the results suggest that many teachers are concerned about the increased burden of acquiring knowledge of AI and skills to use AI in the classroom, and we need to consider specific measures to alleviate their sense of burden. This will be one of our future research topics. Also, the limitation of this study was the characteristics of Japanese teachers participating in it. Since the subjects were graduate students majoring in pedagogy with different teaching backgrounds, future research should investigate whether surveying teachers working at school can obtain the same results. In addition, since the number of subjects was small (47 teachers), it is necessary to increase the number of subjects and conduct a follow-up survey. We want to contribute these results to planning and implementing the teacher training programs.

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Structure of Critical Thinking in Technological Assessment and Utilization

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Abstract

This study considered “perspectives and ways of thinking pertinent to technology,” a learning perspective unique to technology education in the Japanese curriculum. It comparatively examined the subjects of science and social studies related to the natural and social sciences in the teaching contents of junior high school technology education. Furthermore, this study aimed to analyze the characteristics of critical thinking in technology assessment and utilization by comparing the teaching contents in each subject and examining the structural factors that foster the competencies of technological assessment and utilization.

The results demonstrated that the perspectives and ways of thinking related to technology include both the social scientific aspects of technology use and the natural science aspects of the principles and laws that support technology, optimizing technology from the learning perspective involves understanding and thinking based on both aspects as an important learning perspective unique to technology studies. Furthermore, the teaching contents of the natural and social aspects included in the perspectives and ways of thinking about technology is positioned in science and social studies. They were extracted for being closely related to the characteristics of electricity and motion, electricity use, ingenuity, electric circuits, the state of technology, and other related content. Furthermore, critical thinking in technology assessment and utilization requires the ability to judge things objectively from the perspective of science and the ability connect events and to view things from multiple perspectives in the social sciences and is characterized the complex structural of combining knowledge and methods toward decision-making with their ability support. Furthermore, letting each of these ways of thinking play out in critical thinking’s cognitive process fosters the competencies related to technology assessment and utilization.

Introduction

The development of competencies is a priority in many countries. Critical thinking is positioned as one of the leading competencies. In Japan, the importance of critical thinking has been discussed in various contexts, such as the nuclear power plant accident. In addition, risk literacy questions the literacy of using scientific and technological systems and is considered an important current issue related to technology assessment and utilization in technology education.

Previous research analyzed the characteristics of teaching contents in Japanese technology education from the perspective of critical thinking. It was determined that technology assessment and utilization required higher-order thinking, which combines and puts to work forward and backward thinking, knowledge, and methods, (Obayashi & Ohtani, 2023). Also, prior research suggested that the development of competencies in technology assessment and utilization comprises three processes; thus, it is critical to develop appropriate teaching methods appropriate for each process to cultivate technology assessment and utilization competencies (Obayashi Ohtani, 2022).

To clarify in greater detail technology assessment and utilization, this research focuses on the natural science and social science aspects of technology and analyzes the structural characteristics for fostering technology assessment and utilization competencies. In particular, it considers “perspectives and ways of thinking pertinent to technology,” which is a learning perspective unique to technology education in the Japanese curriculum. Using science and social studies as subjects related to the natural and social sciences, it conducts a comparative analysis of the teaching contents of junior high school technology education. In addition, the study analyzes the critical thinking aspects of technology assessment and utilization by comparing the teaching contents in each subject, and examining the structural characteristics to foster technology assessment and utilization competencies.

Perspectives on the Study of Technology in the Japanese Curriculum and its Relation to Other Subjects

The Japanese curriculum is regulated by the Courses of Study established by the Ministry of Education, Culture, Sports, Science, and Technology once every ten years. The Courses of Study currently in effect were revised in 2017. To describe the current status of the teaching contents for technology assessment and utilization in the Japanese curriculum, this chapter discusses the new overall curriculum policy and perspectives on learning in technology education and discusses the positioning of science and social studies. In the 2017 revision of the Courses of Study, global trends related to the development of general capabilities and competencies were considered and the objectives and contents of each subject area were reorganized into three pillars: “Ensure that knowledge and skills are acquired,” “Develop the pupils’ abilities to think, make judgments, and express themselves,” and “Cultivate the motivation to learn and humanity.” The goals and contents of each subject were organized based on these three pillars. To cultivate these qualities and abilities, utilizing the “perspectives and ways of thinking” of each subject is important. This viewpoint or way of thinking provides a unique perspective on a particular subject and is at the core of the essential meaning of learning each subject.

Technology education in Japan is developed primarily during the three years of junior high school. Students studied four technology topics over three years: materials and processing, biological growth, energy conversion, and information technology. For example, in the case of energy conversion technology, the perspectives and ways of thinking pertinent to technology are described in more detail as follows: “to capture phenomena in daily life and society from the viewpoint of their relation to technology of energy conversion, to optimize the method of converting and transmitting energy by paying attention to social demands, safety from production to use and disposal, output, conversion efficiency, environmental load, energy conservation, economic efficiency, and by taking into account the characteristics of electricity, motion, heat, and fluids.”

Technology is not simply an application of natural science; its development and use are determined by examining the requirements and conditions from multiple aspects. Taking power-generation technology as an example, wind power generation has the advantage of being environmentally friendly, but it also has the limitation of natural science of low energy conversion efficiency compared to thermal power generation or nuclear power-generation technologies. Additionally, the development and use of the technology are determined by considering multiple aspects, including the cost of installation, maintenance, and operation, weather effects, safety in the event of an accident, resources required for energy, and topographical constraints of the installation site. Thus, viewpoints such as “demands from society, safety from production to use and disposal, and so on” represent the social scientific aspects of technology use, while viewpoints such as “characteristics of electricity, motion, heat, and fluid” represent the natural scientific aspects such as principles and laws that support technology use. Furthermore, thinking about optimizing technology mechanisms, such as methods of converting and transmitting energy, from the perspective of learning involves both social and scientific aspects, an important learning dimension unique to technology studies.

In the Japanese curriculum, the natural science aspects are considered closely related to science in elementary and junior high school education. Science is studied from the third grade of elementary school; in elementary and junior high school, which are compulsory education levels, students study content related to materials and energy, life, and the earth. In particular, the energy content is strongly related to the natural science perspective and ways of thinking relevant to the technology of energy conversion, as electricity and its use as well as motion and energy content are part of the curriculum.

The social sciences are closely related to social studies in elementary and junior high school education. Social studies are covered starting in the third grade of elementary school. In elementary school, students learn about the geographical environment and people's lives, history, and the structure and workings of modern society and people's lives. In junior high school, students study geography, history, and civics. Technology is considered closely related to the social science viewpoints and ideas related to the use of electricity as infrastructure, innovations related to industrial production, and so on.

These perspectives and ways of thinking pertinent to technology include social science and natural science aspects of the principles and laws supporting technology. Thinking about how to optimize technology mechanisms from the perspective of learning that involves understanding and thinking in both dimensions is unique to technology studies. Considering how to optimize technology, taking into account both social and scientific understandings and learning, is considered unique to technology studies. Furthermore, the contents related to these aspects is closely related to the content related to scientific understanding of energy in the natural science aspect, and to the content related to the geographical environment, the structure and function of modern society and people's lives in the social science aspect. Therefore, by focusing on the relationship of the contents between these fields of study and conducting a comparative analysis, it can be clarified the detailed structural characteristics of the technology assessment and utilization.

The next section focuses on the teaching content of energy conversion in technology education in the sciences and social studies.

Teaching Contents in Science and Social Studies Related to Energy Technology in the Japanese Curriculum

As mentioned above, there are both natural science and social science perspectives and ways of thinking related to technology. This chapter focuses on the relationship between science studies as related to the natural science aspect and social studies related to the social sciences, and applies the teaching contents to the technology of energy conversion.

Tables 1 and 2 show the teaching contents of science and social studies corresponding to the technology of energy conversion. Because energy-related contents in elementary school is systematically and comprehensively dealt with in junior high school, this study was targeted to Field One science content related to energy. As for social studies, the content was related to the field of geography and civics in elementary and junior high school.

The technology teaching contents, shown in Tables 1 and 2, comprises three learning processes or items. The first process is “Technologies that support life and society,” which is the understanding of existing technologies. In this process, students learn about the social aspects of technological ingenuity, including social demands, safety from production to use, disposal, and so on, and the elements of principles and laws, including the characteristics of electricity, motion, and heat, related to the method of converting and transmitting energy.

The second process is “Problem Solving through Technology,” which refers to solving problems in daily life and society through technology. In this process, the students find problems in daily life, determine the issues to be solved, and develop their own way of thinking and understanding to develop a solution. In the study of energy conversion technology, the students learn to design electric circuits and mechanical mechanisms.

Table 1 Items and matters of energy technology in the junior high school technology education and contents of corresponding science studies

Items and matters of energy technology in Junior high school technology education	Contents of corresponding Field One of Science studies	
Learning item 1 Technologies that support life and society a To understand the principles and laws of electricity, motion, heat, etc., and the basic technological mechanisms involved in the conversion and transfer of energy, etc., and the need for maintenance and inspection through exploring technologies that support life and society.	Characteristics of electricity	Learning item 3 Electric current and its use a To understand the following and to acquire skills in observation and experimentation of things and phenomena related to electric currents and magnetic fields, while relating them to daily life and society through observation and experiment. (a) Electric current (b) Electric current and magnetic field b To plan methods to solve phenomena related to electric currents and magnetic fields with an outlook, to conduct observations and experiments, analyze and interpret the results, and find and express the regularity and relationship between electric currents and voltage, the function of electric currents, static electricity, and electric currents and magnetic fields through observation and experiment concerning electric current and its use.
	Characteristics of motion	Learning item 5 Motion and energy a To understand the following and to acquire skills in observation and experimentation of motion and energy of objects in relation to daily life and society through observation and experiment. (a) Equilibrium, synthesis, and decomposition of forces (b) Regularity of motion (c) Mechanical energy b To conduct observations, experiments, etc. with an outlook on motion and energy, to analyze and interpret the results, and to find and express the regularities and relationships among the equilibrium, synthesis and decomposition of forces, the motion of objects, and mechanical energy through observation and experiment concerning motion and energy of objects. Also, to reflect on the process of exploration.
Learning item 1 Technologies that support life and society b To think about the ingenuity of problem solving in technology by exploring technologies that support life and society.	Use of energy technology	Learning item 7 Science, Technology, and Humans a To understand the following in relation to daily life and society, and to acquire the skills to observe and experiment with them through observation and experiment concerning relationship between science and technology and human beings. (a) Energy and matter b To conduct observations and experiments with an outlook on energy and materials used in daily life and society, to analyze and interpret the results, and to scientifically consider and make judgments about how to preserve the natural environment and state of science and technology through observation and experiment concerning relationship between science and technology and human beings.
Learning item 2 Problem Solving through Technology a To be able to safely and properly fabricate, mount, inspect, and adjust through problem solving through technology.	Electric circuit	Learning item 3 Electric current and its use a To understand the following and to acquire skills in observation and experimentation of things and phenomena related to electric currents and magnetic fields, while relating them to daily life and society through observation and experiment concerning electric current and its use. (b) Electric current
Learning item 2 Problem Solving through Technology b To find a problem, set a task, conceive an electric circuit or a mechanical mechanism, etc., and materialize the design, as well as to consider the process of fabrication and the evaluation, improvement, and modification of the results through problem solving through technology.	—	—
Learning item 3 Social Development and Technology a To understand the concept of technology in relation to life, society, and the environment through thinking for development of future society and state of technology.	—	—
Learning item 3 Social Development and Technology b To assess technology and consider appropriate selection, management use, as well as improvements and applications based on new ideas through thinking for the future development of society and state of technology.	State of technology	Learning item 7 Science, Technology and Human Beings a To understand the following in relation to daily life and society, and to acquire the skills to observe and experiment with them through observation and experiment concerning relationship between science and technology and human beings. (a) Energy and matter (b) Conservation of the natural environment and use of science and technology b To conduct observations and experiments with an outlook on energy and materials used in daily life and society, to analyze and interpret the results, and to scientifically consider and make judgments about how to preserve the natural environment and state of science and technology through observation and experiment concerning relationship between science and technology and human beings.

Table 2. Items and matters of energy technology in the junior high school technology education and contents of corresponding social studies

Items and matters of energy technology in junior high school technology education	Contents of corresponding Social studies	
Learning item 1 Technologies that support life and society a To understand the principles and laws of characteristics of electricity, motion, and heat etc., and the basic technological mechanisms involved in the conversion and transfer of energy, etc., and the need for maintenance and inspection through exploring for technologies that support life and society.	—	—
Learning item 1 Technologies that support life and society b To think about the ingenuity of problem solving in technology through exploring technologies that support life and society.	Use of energy technology	Grade 4 of elementary school Learning item 2 Projects that support people's health and living environment a To acquire the following knowledge and skills through pursuing and solving learning problems. (a) To understand that businesses that supply drinking water, electricity, and gas are promoted to ensure a safe and stable supply, and that they help maintain and improve the healthy lives of people in the community. b To acquire the following abilities of thinking, judgment, and expression by pursuing and solving learning problems. (a) To grasp the situation of projects for supplying drinking water, electricity, and gas, focusing on the supply system, routes, and cooperation of people inside and outside the prefecture, and to think about and express the roles played by these projects.
		Junior High School Geographical Area of Study “Various Regions of Japan” Learning item 2 Regional characteristics and regional divisions of Japan a To acquire the following knowledge and skills by pursuing and solving problems focusing on distribution and region. (c) To understand the characteristics of Japan's resources, energy and industries based on the current status of resource and energy use in Japan, trends in domestic industries, and issues related to the environment and energy. b To acquire the following abilities of thinking, judgment, and expression by pursuing and solving problems focusing on distribution and region. (a) To consider and express each of the items from (i) to (iv)* multilaterally and from multiple perspectives, focusing on the commonalities, differences, and distribution among the regions. (b) To consider and express the regional characteristics of Japan in a multifaceted and multidimensional manner, focusing on the regional divisions based on items (i) to (iv)*, and relating them to each other. * (i) Natural environment (ii) Population (iii) Resources and energy (iv) Transportation and communication
	Ingenuity	Grade 5 of elementary school Learning item 3 Industrial production in Japan a To acquire the following knowledge and skills by pursuing and solving learning problems. (b) To understand that people involved in industrial production support industrial production by making various efforts to produce excellent products in response to consumer demand and social changes. b To acquire the following abilities of thinking, judgment, and expression by pursuing and solving learning problems. (b) To grasp the ingenuity and efforts of people involved in factory production, focusing on the manufacturing process, cooperative relationships among improvements, and superior technology, and to think about and express the workings of these efforts.
Learning item 2 Problem Solving through Technology a To be able to safely and properly fabricate, mount, inspect, and adjust through problem solving through technology.	—	—
Learning item 2 Problem Solving through Technology b To find a problem, set a task, conceive an electric circuit or a mechanical mechanism, etc., and materialize the design, as well as to consider the process of fabrication and the evaluation, improvement, and modification of the results through problem solving through technology.	—	—
Learning item 3 Social Development and Technology a To understand the concept of technology considered in relation to life, society, and the environment through thinking for development of society in the future and the state of technology.	—	—
Learning item 3 Social Development and Technology b To assess technology and consider appropriate selection, management use, as well as improvements and applications based on new ideas through thinking for development of society in the future and state of technology.	State of technology	Junior High School Civics Area of Study “Issues for Us and International Society” Learning item 1 Increasing world peace and human welfare a To acquire the following knowledge and skills by pursuing and solving problems focusing on conflict and consensus, efficiency and fairness, coordination, sustainability, etc. (b) To understand the importance of economic, technological cooperation in solving problems such as the global environment, resources and energy, and poverty.

The third process is “Social Development and Technology,” which refers to thinking about new technologies. In this process, students cultivate the attitude for thinking about new technologies to improve daily life and create a sustainable society. In the study of energy conversion technology, new energy technologies such as electric cars are studied, and learning considers technological assessment, selection, management use, improvement, and application. This process is particularly concerned with technology assessment and utilization and plays an important role in fostering technological literacy as described by AAAS (1990) and ITEA (1996).

Table 1 shows the teaching content of technology studies and related science contents. The first process involves content on “Learning item 3: Electric current and its use” and “Learning item 5: Motion and energy” in science. Similarly, the teaching content related to the use of technology, electric circuits, and the state of technology is extracted. Table 2 shows the social studies content related to the teaching content of technology studies. Social studies involve the teaching content related to the use of energy technology, ingenuity, and the state of technology.

As described above, the natural and social teaching contents related to the perspectives and ways of thinking about technology are positioned in the sciences and social studies. The content was extracted as being closely related to electricity and motion, the use of electricity, ingenuity, electric circuits, and the state of technology, among others. Therefore, the next chapter addresses the teaching content of these subjects and examines the structural characteristics of critical thinking in fostering the competencies of technology assessment and utilization.

Critical Thinking Structure in Developing Technological Assessment and Utilization Competencies

Based on the relationship between the sciences and social studies and the perspectives and ways of thinking about technology, this chapter presents the results of an analysis of the structural characteristics of critical thinking in technology assessment and utilization. According to T. Kusumi (2018) and based on work on critical thinking by Ennis (1987), Brookfield (1987), Fascione (1990). Halpern (2007), and Sternberg (1986), critical thinking can be categorized into the following four elements: Reasonable, Reflective, Goal-directed, and Integrated thinking. Additionally, according to our prior study, integrated thinking was suggested as being deeply related to the development of the competencies of technology assessment and utilization in the previous study; accordingly, the following six additional items were identified with reference T. Kusumi and Sternberg's thoughts: Reasoning, Judgment, Decision-making, Creativity, Problem solving, and Concept acquisition.

Furthermore, this study analyzed the structural characteristics of critical thinking in technology assessment and utilization through an awareness survey of teachers specializing in the subjects of technology, science, and social studies at junior high schools. The study was based on the four elements in critical thinking and the six items in integrated thinking. A survey was conducted to question the necessity and relevance of critical thinking to activities involving teaching contents in each subject area.

Multiple comparisons and cross curricular comparison of the four elements of critical thinking revealed a high need for integrated thinking in all subjects, with a greater need for reflective thinking in science than in other subjects, whereas reasonable and goal-directed thinking were more needed in social studies. In addition, cross curricular comparison of the six items of integrated thinking based on multiple comparisons and quantification theory type II analysis revealed that reasoning and judgment were highly relevant in each subject, while concept acquisition was highly relevant to both science and social studies teaching contents and decision-making was highly relevant to technology studies.

Based on the results of this and previous studies, this chapter discusses the structural characteristics of critical thinking in competency development for technology assessment and utilization. Previous studies found that integrated thinking was particularly closely related to the teaching contents for technology assessment and utilization, characterized by high-standard critical thinking, which works with thinking-back reflecting and forward-thinking in both knowledge and methods. It is also suggested that the development of competencies in technology assessment and utilization comprises three processes, and that it is critical to develop the teaching methods appropriate to each process.

Based on these results, the structural characteristics of critical thinking in the development of technology assessment and utilization competencies are considered as follows. Figure 1 shows the structure of critical thinking in competency development for technology assessment and utilization.

The first is thinking about moving things forward and processing them through reasonable and goal-directed thinking. This kind of thinking in technology studies is consistent with the features of critical thinking in social studies, such as thinking rationally and independently. In the area of technology assessment and utilization, development and decisions are made by considering the social aspects of using technology, such as social demands, safety, environmental impact, and economic efficiency. Thus, a necessary competency is relating events and thinking from multiple perspectives, which is supported by social studies thinking.

The second is using reflecting thinking to look back and reflect. This kind of thinking in technology studies is consistent with critical thinking in science, which employs reflective thinking from a scientific perspective. When assessing and utilizing technology, the principles and laws that support technology are considered, and the competency to calmly judge things, which is supported by thinking in science, is necessary.

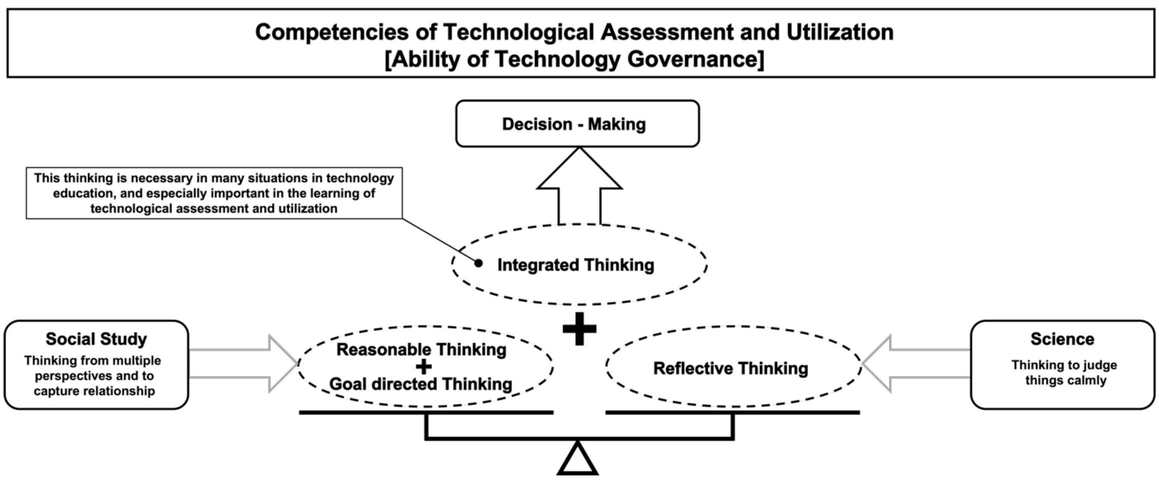

Figure 1. Structure of Critical Thinking in the Developing of the Competencies of Technological Assessment and Utilization

The third is integrated thinking, which works and combines knowledge and methods based on reasonable, goal-directed, and reflective thinking. Integrated thinking plays the important role of combining the knowledge and methods necessary for each type of critical thinking, as well as the knowledge and methods related to technology assessment and utilization. Integrated thinking in technology studies, which combines knowledge and methods, is a unique feature of the subject, such as decision-making.

Therefore, critical thinking in technology assessment and utilization is considered to have a complex structural characteristic of decision-making by combining knowledge and methods. Additionally, it requires the thinking skills of science to judge things objectively and of social studies to understand relationships among events and from multiple perspectives.

The development of technology assessment and utilization competencies requires fostering thinking to move things forward and process them and to look back and reflect on things. Thus, to understand the future development of society and the state of technology, it is necessary to foster higher-order thinking that combines knowledge and methods related to each of these processes and the knowledge and methods related to technology assessment and utilization toward decision-making, while maintaining a balance so that these types of thinking are not biased.

Fostering complex thinking in technology assessment and utilization requires instructional methods to stage each type of thinking entailed in the above three cognitive processes in the execution of critical thinking.

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Development of STEM Electrical Teaching Materials Utilizing the PPDAC Cycle

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Abstract

At present, the benefits of living in an advanced scientific and technological society are very evident. However, in the real world, various challenges exist like the Great East Japan Earthquake, the Kumamoto Earthquake, and the global spread of SARS-Cov-2. In these times of unpredictable and difficult challenges, school education needs to provide children with opportunities to actively confront various changes and work with others to solve problems. The goal is to be able to reconstruct objectives in the midst of complex changes in the situation. This means that it is essential to educate children across national borders, including Japan and the Philippines, to acquire scientific literacy from a cross-curricular perspective so that they can overcome similar challenges in the future, as emphasized in STEM education for the next generation. For example, focusing on the field of electricity, issues such as resources for electricity production, proper use of electricity, and the rising cost of electricity are present in our daily lives. Thus, education that comprehensively teaches about familiar issues is important. As part of the view, this study focused on the field of electromagnetism because many students consider this topic difficult. And, it designed a fun, safe, and vivid observation experiment lesson plan for students through the work of creating simple handmade experimental apparatus. The lesson was initially implemented with Japanese university students in July 2022. The purpose of this is to verify the degree of students' appreciation for electricity brought about by the presence or absence of winding work experience and to further analyze students' impressions of the LED light experiment. Then, from the perspective of educational data science, teaching materials were developed to understand the current situation, find issues and modifications, using the PPDAC cycle "Problem, Plan, Data, Analysis, Conclusion". In August 2022, the teaching materials were implemented for the local teachers at a state university in the Philippines to get their impressions. In the current fiscal year, the researchers plan to implement teaching materials for secondary school and university students in both Japan and the Philippines.

Keywords: STEM education, Electrical Teaching Material, simple handmade experimental apparatus, PPDAC Cycle, Educational Data Science

1. Introduction

At present, the benefits of living in an advanced scientific and technological society are enormous. However, various challenges in the real world exist such as the global spread of SARS-Cov-2. To overcome these unpredictable and difficult challenges and to shape the society of the next generation, Japan's Courses of Study emphasize the importance of science and technology education from the perspective of developing the qualities and abilities required to meet the various challenges of our time in a cross-curricular manner (Ministry of Education, Culture, Sports, Science and Technology, 2018). In the Philippines, on the other hand, science is formally taught from Grade 3 to Grade 10. And in 2012, the Philippines introduced the K to 12 education system. Students in STEM courses are offered specializations in science. The science curriculum recognizes the important role science and technology play in everyday human activities. Science concepts are categorized into a variety of topics and are designed to develop scientific, technological, and environmental literacy. Thus, both Japan and the Philippines emphasize the importance of acquiring literacy to interrelate knowledge, skills, etc. learned in school, apply them in learning and in life, and make them work in a comprehensive manner. This coincides with the emphasis on STEM (Science, Technology, Engineering, and Mathematics) education to help a new generation of children overcome similar challenges in the future. In other words, in a way that transcends the borders of Japan, the Philippines, etc., there is a need for education that emphasizes the development of scientific literacy, which is fostered across subject areas as follows.

In light of this, to help children of the new generation to overcome similar challenges in the future there is a need for education to emphasize building scientific literacy from a cross-curricular perspective as highlighted in the STEM (Science, Technology, Engineering, and Mathematics) education. According to the Framework for K-12 Science Education, a theoretical pillar of STEM education in the United States, STEM education has three dimensions: domain core concepts, cross-disciplinary concepts, and practices (NRC, 2012). Particularly, it is one in which new concepts are generated by weaving together fragmented concepts in which questions are resolved and new questions are formulated. This is a kind of education that enables students to acquire highly comprehensive conceptual knowledge through continuous learning, including self-learning. Also, it is an education that enables students to learn by themselves in the end. Questions that arise from the learners are used as clues to utilize scientifically incorrect concepts. Furthermore, it is essential to generate new creative questions by creating cognitive conflicts and solving the questions of the students together with their teachers (Yamaoka, 2022). According to Novak, Mintzes, and Wandersee (1998), cognitive conflict is described as a situation in which two or more incompatible ideas cannot fit together in the mind when integrating or making sense of the school knowledge and everyday knowledge. These ideas often arise not from logical or scientific methods, but from scientifically incorrect ideas and perspectives that emerge from everyday experience. This way of thinking is called a naive concept, an intuitive understanding that is born and accumulated in a person's thinking from an early age, which is often seen in children. For example, some of the findings of Osborn et al. (1985), in a typical case study, are shown in Figure 1.

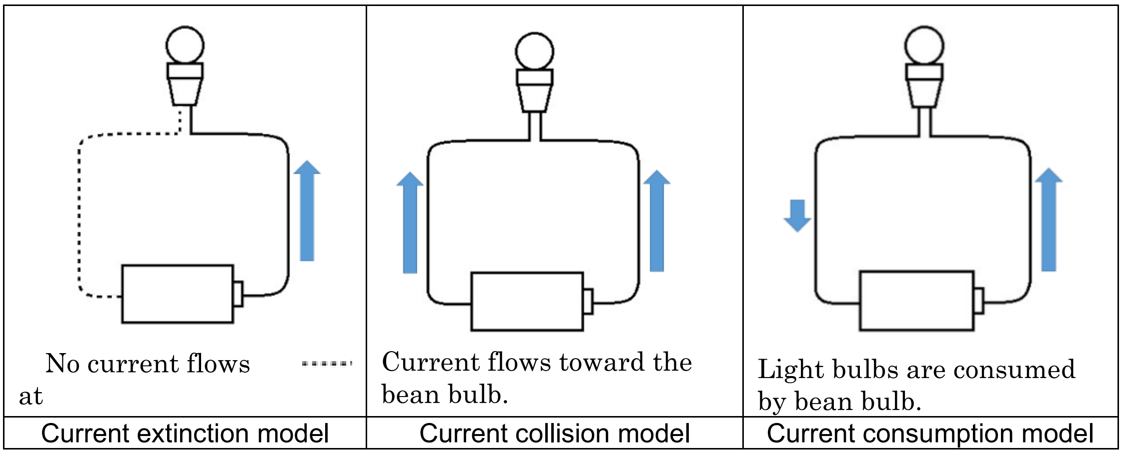

Figure 1. Typology of children's ideas before learning about electric circuits (Based on Osborn et al., 1985, prepared by the author)

Osborne & Freyberg (1985) report that children do not always think in the scientific way that teachers expect and that their ideas are often very similar, even though there are considerable differences in age and learning experiences. It is very interesting to note that these same trends are obtained even if the children's upbringing environment is different for instance in Japan and other countries of the world. Yamaoka, Okino, and Matsumoto (2022), reported that the results of the survey of national science university students showed that the most common time to embrace naive concepts was during elementary school for both male and female participants. As described above, education should emphasize the development of scientific literacy from a cross-curricular perspective, utilizing questions raised by learners and elementary concepts.

Since 2015, we have been developing teaching materials for elementary school students and practicing classes while referring to STEM practice methods and utilizing cognitive conflicts. Specifically, we have been developing and implementing a number of teaching materials for elementary and secondary school students such as using magnetic top and LED-based IC crafts as examples employing a trial-and-error process. In June 2022, during a visit to Osumi Educational Support Institute (OES Institute) the researcher encountered a winding machine, while in July of the same year, he received an order from the OES Institute. In the same month, he actually had an opportunity to have an actual visit at the

OES Institute in Osaka and studied STEM education. Moreover, he visited a school in the Philippines and introduced the educational materials to university instructors. The teaching materials were implemented for local teachers at a state university in the Philippines in August 2022.

In doing so, we planned to listen deeply to the learners' opinions from an educational data science perspective, utilize questions and rudimentary concepts raised by the learners, and make the materials emphasize the development of scientific literacy from a cross-curricular perspective. The process of problem solving does not necessarily take place in a single experiment or investigation. While many iterative processes have been introduced, we focused on the PPDAC cycle. According to this statistical association (2012), the PPDAC cycle is a problem-solving process used in education in New Zealand and is an adaptation of the PDCA cycle used in the field of quality control in postwar Japan. In this study, we developed teaching materials using the PPDAC (Problem, Plan, Data, Analysis, and Conclusion) cycle, which consists of understanding the current situation, finding problems, and making corrections.

2. Purpose of the Study

The researchers of this study aim to develop a lesson plan and attempt to produce handmade teaching materials in the field of electricity from the perspective of educational data science using the PPDAC cycle to understand the current situation, find issues, and make revisions.

3. Method

3-1. Date of Implementation and survey target

Fifty-three students composed of 39 males and 14 females in the second grade of elementary education teacher applicants enrolled in the Faculty of Education at a private university in Aichi Prefecture, Japan were the participants of the study. Classroom practices were conducted from June to July 2022 using the implementation process shown in Table 1.

Table 1.
Lesson Design

	Implementation Process		
Schedule	June 2022	July 2022	After Class
Implementation content	Simple Motor	Winding work experience	Questionnaire survey

※ Class (N=53)

The number of subjects surveyed in Table 1 is 53 (N = 53). The actual classes were divided into two classes for the purpose of class evaluation: the experimental group (N=29) and the control group (N=24). The lesson design is shown in the study of Yamaoka, Osumi, and Umemoto (2023), and the implementation and evaluation are shown in the study of Yamaoka, Faustino, and Pawilen (2023). Although the students were divided into experimental and control groups, both classes were taught by the same teacher and had the same lesson content. Therefore, in Table 1, the two classes are described as a combined class of 53 students. And, this paper then focuses on the survey on PPDAC that is implemented after class. It was conducted in the following specific manner. After class, a survey questionnaire was distributed using Microsoft Forms on the current status, problem finding, and correction using the PPDAC cycle from the perspective of education data science.

3-2. PPDAC Cycle

The PDCA (Plan, Do, Check, Action) cycle is often utilized in Japanese educational settings. However, Miki (2017) stated that without action, nothing will be accomplished. Therefore, this study examined the smooth operation of the PPDAC cycle as shown in Table 2 from the perspective of educational data science.

Table 2.
PPDAC Cycle

cycle	Specifics of each cycle
Problem	Established issues to solve problems. Set specific numerical values (KGI, performance target indicators, etc.) as “indicators” that will serve as standards for clearing issues.
Plan	Plan the research methodology to achieve the “indicators.”
Data	Check for missing data and abnormal values and process them appropriately, add variables, etc.
Analysis	Investigate problems and causes. Search for the hints for measures from the results.
Conclusion	Find areas for improvement from analysis results and consider measures.

In the PPDAC cycle, once the conclusion (derivation of results) is completed, it is essential to set the next tasks and lead to a new cycle, depending on the extent to which the initial problems have been improved. From this perspective, we developed a questionnaire shown in Figure 2.

PPDAC Cycle: (Problem, Plan, Data, Analysis, and Conclusion)
A class was conducted to produce a magnetic top. Ultimately, we wanted to convey to the students in this class how grateful we are for electricity. However, since the frame is turned by a dry cell battery, the opinion was expressed that the result is a motor using a dry cell battery. We thought that if we did not do this, we might not be able to convey the appreciation of electricity.

1. [Problem] What kind of teaching strategy should we use to intentionally create a situation in which students think about how much they appreciate electricity?
2. [Plan] What kind of plan will you make to solve the problem?
3. [Data] What kind of data can be obtained to solve the problem?
4. [Analysis] How will you analyze the data?
5. [Conclusion] What conclusion have you reached?

Figure 2. The questionnaire used in the class.

Prior to implementing this PPDAC cycle, students have been working on simple motors in a real class. As an application, magnetic top was also introduced in class. Therefore, we set up a situation where the students started with a situation where, assuming they were teachers, they were going to make a magnetic top. In this case, there were some points that did not go well in the class, so we envisioned a challenge: what kind of curriculum should we create?

4. Results and Discussion

4-1. Classroom practice of winding work experience

The class focused on the use of a simple motor and a winding operation experience as shown in Table 1. In the winding experience, an acrylic pipe was cut with an acrylic cutter, which was easy to use in the experiment, to a length of about 30 cm, and enameled wire was coiled around the acrylic pipe 1,000 times using a winding machine as shown in Figure 3. On the other hand, a LED lighting experiment using a self-made hand-waving power generator pipe is shown in Figure 4.

Figure 3. Experiencing winding work **Figure 4.** Experiments using a handmade apparatus

Take note that Osumi (2019) states that with a coil of 1,000 windings, a faint LED was confirmed at 600 winding when a ferrite magnet was used. Based on this, we also tried a case using a neodymium magnet, and the lighting was confirmed after 450 windings. There are topics that can be conducted as future research in junior high school or as a research project in high school. In this way, the students were encouraged to make their own experimental plans based on new questions that may arise and to take on new challenges, which is considered to be part of the process of inquiry required in STEM Education.

4-2. Results of the PPDAC Cycle

The researchers administered an open-ended questionnaire to students using Microsoft Forms for the PPDAC cycles after the class. Table 3 presented the results on the Problem part of the cycle that focused on the question: What teaching strategies should be used to intentionally create situations in which students think about how grateful they are for the electricity?

The results of the questionnaire presented below suggest that one of the solutions to meaningfully implementing the content is to integrate it into daily life activities. Integrating the lesson about electricity into their daily lives help students see the importance of the lesson to their lives. In this case, they could learn to value the use of electricity and they will have the opportunity to think of electrical products they use in their daily activities.

Table 3.

The results of the Problem part of the cycle.

Examples of Distinctive Responses.	Number of responses	Classification
Learn when and what we use electricity in our daily lives. Have students think about the electrical products they use in their daily lives as examples.	16	Relevance to daily life
Explain the difference between a normal top and a magnetic top.	12	Explanation of Phenomena
Have them generate their own electricity with a manual generator and think about how much effort it would take to produce this amount of electricity.	8	Relevance to daily life
Think about what happens when electricity runs out.	6	Relevance to daily life
Think about whether it is possible to rotate the frame with something other than electromagnets. Make batteries other than dry cell batteries (lemon batteries, charcoal batteries).	6	Scientific Experiments
Dry cell batteries are also a source of power and energy.	5	Energy-related

The next step in the cycle focuses on Plan. Table 4 showed the results of the answer to the question: “What kind of plan will you make to solve the problem?”. The plan that students will identify on this part is based on the identified problem shown in Table 3. Many of the respondents mentioned that they will design lesson plans based largely on the actual use of electricity and its relevance to their daily lives. Hence, the table showed that students appreciate more the learning of electricity if the teacher will use an experiential learning strategy in the classroom.

Table 4.

The results of the Plan part of the cycle.

Examples of Distinctive Responses	Number of responses	Classification
When you actually generate electricity, you learn how hard it is and how much you appreciate it.	17	Relevance to daily life
Think about what places electricity is used in our daily lives.	12	Relevance to daily life
Consider the case with and without batteries.	9	Energy related
Teach a lesson on the difference between a motor and a magnetic top.	7	Explanation of Phenomena

Try methods other than electromagnets.	5	Scientific Experiments
Summarize that dry cell batteries are used everywhere in our daily lives.	2	Relevance to daily life
Students can learn about the history of dry cell batteries and the process of electricity production.	1	Explanation of Phenomena

Table 5 focused on answering the question: “What data can be obtained to solve the problem?”. This question is part of the Data part of the cycle used in this study. The respondents of the study believed that data may be obtained by conducting scientific experiments on current, voltage, and power generation. The data gathered can be used for analysis and finally making a final conclusion on the study of electricity. Further, we saw that the respondents commented on taking scientific data by exploring the rational speed of the motor and learning the principles on their own by disassembling the motor.

Table 5.

The results of the Data part of the cycle.

Examples of Distinctive Responses	Number of responses	Classification
Examine data based on scientific experiments on current, voltage, and power generation.	15	Scientific Experiments
Examine how the motor turns, such as what kind of devices can be used to make it turn faster or longer.	10	Scientific Experiments
How much electricity do you use in your daily life? For example, how much do you use your phone or how much do you use electronic devices? Ask them to answer this question along with the amount of time they use the device.	8	Relevance to daily life
Have you ever disassembled a motor or know how a coil works?	7	Explanation of Phenomena
Test your understanding of electricity with quizzes, etc.	5	Explanation of Phenomena
Take a survey on power generation.	5	Explanation of Phenomena
Learn about actual thermal power generation, wind power generation, and other data.	3	Energy-related

The next process of the cycle is the Analysis part. This part answers the question: “How will you analyze the data?” In this step, the participants were asked to deepen their scientific understanding by learning the principles and to relate it to their daily life, their usual use of electricity, and whether there are many areas where they can save money from the proper use of electricity as shown in Table 6.

Table 6.

The results of the Analysis part of the cycle.

Examples of Distinctive Responses	Number of responses	Classification
Analyze principles about motors and coils.	15	Explanation of Phenomena
Analyze how much electricity people usually use by separating data on electrical devices used in daily life by time of use.	9	Relevance to daily life
Using a voltmeter and an ammeter, graph the limit of rotation.	8	Scientific Experiments
Are there areas in your daily life where you can save money? Are there things that can be done without using electricity?	6	Relevance to daily life
Thinking about what would actually happen if there was no electricity, and considering the disaster site, etc., I will list some of the things that would be necessary.	3	Relevance to daily life
Test your understanding of electricity with quizzes, etc.	3	Explanation of Phenomena
Many of the opinions expressed will be summarized and the principle of the motor will be analyzed.	3	Explanation of Phenomena
How does the power change with what kind of connection?	3	Scientific Experiments
Know the difference between manual and electric energy efficiency.	3	Energy-related

In Table 6, the participants were asked to deepen their scientific understanding by learning about the principles, and to relate this to their daily lives, their usual use of electricity, and whether there are areas where they can save money.

The final part of the cycle is the Conclusion part. In this part, the question: “What conclusions were reached?” will be answered. In Table 7, the researchers conclude the importance of developing a lesson plan that focuses on developing students’ thinking about the importance of electricity by relating it to their daily lives and also thinking of ways how to save electricity.

Table 7.

The results of the Conclusion part of the cycle.

Examples of Distinctive Responses	Number of responses	Classification
When you run something, you need electricity. Electricity is essential to the modern world.	14	Relevance to daily life
Electricity is not infinite. Therefore, we need to conserve electricity as much as possible in our daily lives.	12	Relevance to daily life
From the results of experiments, we can understand that the appearance of movement changes depending on the magnitude of electricity.	11	Scientific Experiments
It is an opportunity to think about the circuits of various electrical appliances.	9	Explanation of Phenomena
Magnetic top does not move without electric energy.	7	Energy-related

In Table 7, the final lesson plan was designed to make the students think about how grateful they are for electricity by relating it to their daily lives and also to think about saving electricity.

The items in Tables 3 to 7 were largely categorized under the following: relevance to daily life, scientific experiments, explanation of phenomena, and energy related. Table 8 showed the re-tabulation of the data.

Table 8.

PPDAC Cycle

	Problem	Plan	Data	Analysis	Conclusion
Relevance to daily life	30 (2.3*)	31 (2.6**)	8 (-4.5**)	18 (-1.4)	26 (1.1)
Explanation of Phenomena	12 (-0.5)	8 (-1.9)	17 (1.3)	21 (2.7**)	9 (-1.6)
Scientific Experiments	6 (-2.1*)	5 (-2.5*)	25 (5.0**)	11 (-0.2)	11 (-0.2)
Energy related	5 (-0.2)	9 (1.8)	3 (-1.2)	3 (-1.2)	7 (0.8)

※ Numbers in parentheses represent adjusted residuals. *p<.05, **p<.01

From Table 8, the χ^2 test for each sex and time period showed significant differences (χ^2 = 52.507, *df* = 12, *p* <.01, *V* = .257). The results of the residual analysis revealed a thought process in which Plan is daily life, Data is scientific experiments, and analysis proceeds with explanations of phenomena. Therefore, after conducting the motor experiment and confirming the existence of batteries, we decided to create a lesson plan to conduct a scientific experiment using a generator that does not require batteries, while tying it in with daily life.

4-3. Practice in the Philippines

Last August 2022, we visited the College of Education, Bulacan State University located in Malolos City, Philippines. In the university, experiments on STEM education were conducted on six university teachers specializing in science education, science and technology education, and early childhood education. The experiments consisted of two types: the simple motor and the hand-waving generator pipe. These two types of experiments were distributed by the OSE Research Institute, and these were brought to the Philippines from Japan.

The researchers introduced first the two experiments to the faculty members of the university. They explained the purpose of the experiment and showed how to assemble and use each material. After, the faculty members tried to assemble the parts. The faculty members were amazed when the simple motor which requires a battery, and the enamel wire rotation were completed as shown in Figure 5. They carefully observed the materials and tried to figure out how they can use the materials in their classrooms.

Figure. 5 Experiencing winding operation **Figure. 6** Experiment using a handmade apparatus

After the first experiment, another experiment was introduced to the faculty of the College of Education, Bulacan State University. This experiment was conducted using the hand-waving generator pipe as shown in Figure 6. While doing the experiment, some of the faculty members commented that they can use the materials in teaching electricity not only at the high school level but also in the primary grades. Also, teachers mentioned that they wanted their students to experience these experiments too. Table 9 showed additional comments from Filipino teachers after the experiments. Due to the positive interest shown by the faculty members, the researcher decided to plan and conduct these experiments for secondary school students and university students in the future.

Table 9.

Post-Experiment Impressions by Filipino University Teachers (partial)

A. Simple Motor	B. Hand-waving Generator
I believe that a simple motor can be used by teachers at both elementary and secondary levels in teaching science even in the Philippine setting. Through the use of the simple motor, learners can easily understand the concept being taught. However, there is a need for the teacher to explain which side would be fully rubbed by sandpaper and which should be half only. Also, the materials used to make the simple motor are easy to find and available here.	I think this practical instructional material can be useful in teaching science concepts at the elementary and secondary levels. It promotes inquiry and critical thinking among learners. Very interactive to use. It can be used even without a battery.

5. Conclusion

In this study, we decided to create a lesson plan to teach students to realize the importance of electricity. After confirming the existence of batteries with a simple motor, we decided to create a science experiment using a generator that does not require batteries, while tying it to our daily lives. Experiential understanding of the content of basic experiments related to electricity is different from learning from textbooks and videos, and is expected to generate new questions and further exploration, ultimately leading to the development of learners with the ability to learn on their own. Students in the present society need to be provided with meaningful and relevant activities like activities related to their daily lives. These activities give them the opportunity to reflect and use their reflection on how to make their world a better place to live in. In addition, the PPDAC cycle used from the perspective of educational data science will be a useful tool for modifying lesson plans. It can help teachers to provide relevant and responsive lessons in their science classrooms. Therefore, focusing on the electrical field and developing lesson plans using the PPDAC cycle will be useful for promoting STEM education not only in Japan but also in Asia.

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Acknowledging the elephant in the room:
Supporting New Zealand teachers and learners with digital addictions

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In the late 1990s, internet addictions were first described as technological addictions that involved human-machine interactions. With the ever-increasing demands to be online and on devices, we need to support and protect our teachers and learners now more than ever. As educators, we expect and are personally expected to spend increasing hours online to source, develop and share work. Although online and digital addictions are common, few know what they look like; therefore, many go undiagnosed. We frequently hear "they are always online", but what is the difference between high usage and addiction? With the increase in addiction rates and the lack of long-term data, parents, teachers and educators need to be aware of the signs and triggers and strategies to prevent, reduce addictions and support those with addictions. This paper focuses on helping inform the reader about the types, signs and support strategies to assist those with digital addictions. There should not be blame associated with these addictions unless something is done to help prevent the steady increase in numbers.

As of January 2023, internet users worldwide have reached 5.16 billion, accounting for 64.4% of the world's population, with social media platforms attracting 4.76 billion active users (59.4% of the world's population) (Statista, 2023a). Mobile phone internet use is also rising, with projections of 7.33 billion by the end of 2023 (Statista, 2023a).

In North America, young people from lower-income homes generally use two hours a day more screen time than those from high-income homes, and as a result of having less access to laptops, they have to spend more time on smartphones to do their homework (Kamenetz, 2019). In 2019, more than half of the children in America owned a smartphone by the age of 11 (Kamenetz, 2019). Between the ages of 8 and 12, these children average six hours a day of screen time, and by the ages of 13 and 18, these children spend about 9 hours a day on entertainment, with their parents averaging 9 ½ hours of screen time each day (Commonsense, 2017). Teens now value texting more than face-to-face contact with their peers, and over 50% of teens feel addicted to their phones (Kline, 2021).

The population of Aotearoa, New Zealand, has grown to 5.21 million in January 2023; 95.9% of the population or 4.99 million, were internet users, with 4.24 million social media users, equating to 81.4% of the total national population (Kemp, 2023). Notably, New Zealanders aged between 16 to 64 spend over 6 hours online daily, which is closely approaching the worldwide average (Statista, 2023b).

Digital Learning and New Zealand Curriculum

Over the last decade, teachers have been encouraged to move from *digital literacy* to *digital fluency* integration in their teaching practice. The Ministry of Education (MoE) describes digital fluency as “supporting teachers, kaiako, ākonga and students to confidently and effectively use digital technologies to enhance teaching and learning outcomes" (MoE, 2023) with the "role of the teacher to harness these tools purposefully and to teach students to benefit from using these ubiquitous tools for learning" (Wright, 2010, p. 46).

With guidance from Netsafe, the MoE defined the term of a digital citizen which included digital fluency skills, and stated the need for all students to become savvy digital citizens, "With the increased use of digital technologies and borderless spaces online, we need to be able to nurture and teach our young people to become discerning, responsible digital citizens able to confidently conduct themselves when connecting to people, resources and information in real-world contexts here in Aotearoa and in the wider global community" (MoE, n.d.). Whilst promoting increased use of digital technology, MoE has set the expectation that teachers (and students) should make suitable choices when online, whether this considers the amount of time online is yet to be seen.

Technology is one of the main learning areas where students and teachers are required to be frequently online and using devices. This is as a result of the 2017 changes to both the English-medium (MoE, 2017a) and Māori-medium curriculum (Te Marautanga o Aotearoa) (MoE, 2017b). The intention of digital technologies' content is to "significantly contribute to students developing the knowledge and skill they need as digital citizens and as users of digital technologies across the curriculum" (MoE, 2017a, p. 3).

Technology education is partially responsible for the growing use of digital tools and devices in New Zealand schools. All technological areas encourage use of creative digital hardware and software. Students work through a design process in which they are expected to use e-learning at many stages of technological practice (Reinsfield, 2019). With the key skills of collaboration, communication and managing-self being developed, many different types of software aid and guide learners in these tasks. The effects of the increasing use of e-learning and digital technologies in education may vary; while holding a promise for better learning outcomes, in some cases, they may also *cause* challenges and issues (Harfield, 2019).

COVID-19 lockdowns in Aotearoa New Zealand exacerbated the use of digital tools, and the time online increased substantially for teachers and students. Not only did this impact learning time online during each lockdown but in two thirds of schools, leaders told ERO that they intended to retain some elements of distance learning (usually online) and they intended to increase the use of digital technology in their curriculum (Te Ihuwaka: Education Evaluation Centre, 2021, p. 20). However, this is at a cost, we are now starting to see the wide-reaching impact of digital addiction and digital anxiety (I'm Enough, 2023). Those required to use digital tools for their job and learning are therefore more at risk (Lee, et al.,2023).

The Ying and Yang of Increasing Time on the Internet and Digital Technologies

Once called "Athens without slaves" the internet was initially seen as a way of ensuring democracy and a voice for all (Rheingold, 1993). However, two and a half decades later people are now trying to curb the beast unleashed (Wong, 2021). Like any issue, the pervasive influence of digital tools and the internet comes with their fair share of advantages and drawbacks. The Aesopian fable of 'blowing hot and cold', as cited by Aboujaoude and Gega (2020), illustrates the dualistic nature of technological advancements and their impacts. With ample potential for uses and misuses, fast-evolving technologies and unregulated, chaotic online environments are ill-suited for an academic inquiry, raising concerns around privacy, mental health and true cost of technologies. Socio-digital tools used by young people provide powerful affordances for connected learning but can also cause many distractions (Kruskopf et al., 2021).

Although devices were seen as a saviour for many during covid, people are now noticing a marked increase in time on devices and the internet (Gupta et al., 2020). Parents commonly complain that their children are dependent on or addicted to their smartphones or devices (Bergert et al., 2020). When considering behaviours related to devices and the internet, the focus should not solely be on screen time but also on the activities a person performs and the motives that drive such behaviours (Vujić et al., 2023). Although academic research customarily targets younger populations, fewer studies involve older users and educators, who may also experience the harmful effects of excessive digital technology use and technology-induced anxieties. "Problematic use and addiction lie on the same continuum, where inappropriate use can turn into addictive use" (Vujić et al., 2023, p.1). "When we hear a ping, buzz, or notification from our smartphone, this activates a reward cue… not dissimilar from seeing lights and hearing sounds on a slot machine. This creates a combination of a classical conditioning response loop along with reward conditioning" (Greenfield, 2021, p. 36), resulting in an elevation of dopamine. Behaviour alters the brain chemistry, brain structure and neurobiology which can induce biological changes in the brain, thus altering behaviour, and the cycle of addiction continues (Greenfield, 2021).

Along with the steadily increasing internet penetration, the demographics of online users are also changing. Younger users such as millennials, Generation Z and iGen are increasingly online due to their digital native upbringing, social media usage, streaming, online shopping and technology integration into education (Reid et al., 2023). Many equate time on a device to increased digital fluency and digital literacy skills. However, a recent study has found this inaccurate (Reid, et al., 2023).

Digital technologies have altered social interactions and our perceptions of 'safety' on various levels. If previously scams, malware, phishing, spyware, clickbaits, spam, hackers, and viruses were commonly mentioned cyberthreats, now the focus is shifting to interpersonal issues associated with negative aspects of online behaviours, such as 'sexting', 'swiping right', grooming, cyberbullying, ghosting, trolling, and blocking. Society is so accustomed to these terms they are now a common part of everyday vernacular. For this reason, it is helpful to discuss some of the common anxieties and issues linked to the excessive use of mobile phones and social media to shed light on how these change the ways we engage with each other.

FoMO, commonly known as the Fear of Missing Out, refers to the feelings of anxiety and discomfort that individuals experience when they believe they are being left out of social events, experiences, or opportunities enjoyed by others (Rautela & Sharma, 2022). It is closely associated with the use of social media, as people often compare their own lives to the carefully curated highlights presented by others, leading to feelings of inadequacy and a fear of missing out (Greenfield, 2021).

In turn, this may lead to behaviours associated with 'flexing online ego', in particular, selective presentations of a persona that showcases success, happiness, and popularity, often combined with demonstrations of overexaggerated achievements, experiences, or possessions on social media platforms in the pursuit of admiration or validation from others and boosting self-esteem (Turkalj, 2021). External validation and social comparisons linked with using social media and digital technologies is a common cause of self-esteem issues and questioning one's worth that may disrupt one's self-perception and overall well-being. Individuals may feel inadequate or develop unrealistic expectations of themselves based on the online personas they encounter online (Greenfield, 2021; Vujić et al., 2023).

Nomophobia, an abbreviation for "no-mobile-phone phobia", is a growing concern due to its adverse impacts on mental health and well-being. The fear of being without a mobile phone or unable to use one's phone due to no network connection or low battery has been identified as a distinct phobia, similar to agoraphobia or social anxiety disorder (Beyazacli et al., 2021). The research suggests that nomophobia is a specific manifestation of increased stress, anxiety, depression and poor emotional regulation related to problematic mobile phone use and smartphone addiction (Elhai et al., 2017).

Phubbing (derived from "phone" and "snubbing”) occurs when individuals are engrossed in their phones, scrolling through social media, texting, or browsing the internet, while disregarding the presence and conversation of those around them (Franchina, et al., 2018). It has become an increasingly prevalent form of problematic behaviour associated with digital technologies, and may have detrimental social consequences, including feelings of disconnection, rudeness, and diminished social compassion (Schneider & Hitzfeld, 2019). The anonymity and distance provided by online interactions tend to erode the human capacity to empathise with and exercise social compassion. The lack of non-verbal cues and face-to-face interactions can impede individuals' ability to understand and respond to the emotions and needs of others, potentially leading to a decrease in empathy and compassion (Franchina, et al., 2018).

Types of digital addictions

Digital addiction tends to be an umbrella term, with some believing online addictions and digital addictions differ, whilst others use the term interchangeably (Cemiloglu, et al., 2022). However, “researchers have agreed consensually that it is a phenomenon which exists in reality” (Yadav, et al., 2022, p. 83). Because smartphones are of limited use without an internet connection and many devices also use the internet, a number of terms have been developed to focus on the nuances of these distinctions (Vujić et al., 2023). Commonly used terms which relate to problematic device use and online behaviours include; Smartphone addiction (SA), Problematice Smartphone Use (PSU) Pathological internet use, Excessive internet use, Compulsive internet use, High internet dependency, Internet addiction disorder (IAD), Social media fatigue (SMF), Internet gaming disorder (IGD), Gaming disorder (IGD) as well as Problematic internet use (PIU) which includes; computing addictions, hacking, cyberspace addictions and virtual relational addictions, and Internet gaming addictions (Meng et al., 2022; Vujić et al., 2023). To gain a deeper understanding of the differences between these notions, we suggest reading a recent article by Fineberg, et al. (2022). For the purposes of this paper, the term digital addiction will encompass both digital and online addictions.

Digital addiction levels vary between countries; Eastern countries report around 8.9%, whilst Western countries only 4.6% (Pan, et al., 2020). However, it is essential to be cognizant that findings depend on measures and the target populations, as levels of digital addiction have ranged from 0.8% to 26.7% (Kuss et al., 2014).

Digital addictions can take multiple forms these are generally grouped according to the following categories:

- *Cyber sexual addiction* (compulsive access to sex and porn websites),
- *Cyber-relationship addiction* (over involvement in online relationships),
- *Net-compulsions* (including online gambling, online gaming, obsessive online shopping, obsessive online day trading, excessive social media use, digital hoarding, and Cyberchondria (compulsive searching of online health information)),
- *Information overload* (excessive web surfing or database searching) and
- *Computer addiction* (obsessive non-online gaming) (Rahayu, et al., 2020; Vujić, et al. 2023).

In 2013, the Diagnostic and Statistical Manual of Mental Disorders, published by the American Psychiatric Association, first listed Internet Gaming Disorder (IGD) as a mental health condition, opening a pathway for better diagnostics and treatment. Subsequently, in 2018, the World Health Organization (WHO) officially included Gaming Disorder (GD) in the International Classification of

Diseases (WHO, 2018). These significant developments acknowledged IGD and GD as mental and addictive disorders, with GD specifically categorised as a disease. This recognition emphasised the urgency of supporting individuals affected by these conditions. It is essential to recognise that IGD and GD, like any other mental disorder or disease, cannot simply be addressed by avoiding the triggers or causes. Various conditions exist along the spectrum of excessive and problematic use of digital devices and online behaviours. Their impact on teaching and learning must be acknowledged, and adequate protocols should be developed to support students and educators.

Impact of digital addictions

The research on digital addictions features a psychological phenomenon of escapism, an avoidance or alleviation negative emotions, stress, or reality by immersing oneself in digital technologies, including excessive use of social media, online gaming, e-sports, streaming, video and binge-watching as a means of distraction or temporary relief. While a tendency to escape real-life responsibilities and challenges, social isolation, and decreased productivity associated with escapism pose mental health and well-being risks, Kosa & Uysal (2020) argue that it may have a positive or negative impact on individuals.

Like all addictions, digital addictions can have a negative impact on a person's life. This can include lowering of students' academic performance (Chaudhury & Tripathy 2018), work performance issues, personal and social problems, family disruption (Yadav, et al., 2022), invasion of other's privacy, dietary-related problems, and harm to self or others, as well as personal and social problems (Cham, et al., 2019), feelings of depression and perceived stress (Elhai et al., 2017), in addition to loneliness, social phobia,and fatigue (Bian & Leung, 2015). Digital addiction has been shown to have a physical impact manifested as hypertension, cardiac dysrhythmia, obesity, metabolic disorders (Greenfield, 2021), back pain, eye strain, carpal tunnel syndrome (Young 1998), and/or ability to sleep (Stanković et al., 2021). Excessive screen time can impact transactive memory, empathy, and even grey matter development in young minds (Ward, 2013).

By including the teaching of digital fluency and digital citizenship we hope to promote digital wellness (the practice of refraining from indulging in the Internet and digital media for reasonable amounts of time). However, social media-addicted youth are showing increasing signs of becoming self-absorbed, isolated with feelings of loneliness, increased personal insecurities and with digital users still not being able to discern online scams and not thinking carefully about the information that they post online just to get their audience's approval (Zook, 2023).

It remains unclear why certain individuals are affected by digital addictions while others are not. Several factors are believed to contribute to digital addiction; these include; personal factors, socio-cultural aspects, environmental variables, psychological predispositions, family and school factors and perceived internet characteristics (Chung, et al., 2019). Others believe some technologies are designed to encourage users to return and use them. These technologies encourage repetitive behaviour and offer a reward system (Alter, 2017; Eyal, 2014). People with anxiety, depression or low self-esteem are more susceptible to digital addictions, whilst aggression and impulsivity are positively associated (Abdul, et al., 2018). Internet addictions have been positively associated with online gaming, chatting, and social networking (Király, et al., 2014). Teachers' support and attitudes towards school life are also associated with adolescents' online addictions (Ko, et al., 2015). "Social isolation appears to be a strong contributing factor to the deleterious impact of the internet" (Greenfield, 2021, p.31). "Stresses related to school closures, social distancing, isolation, and increased screen time as a result of the COVID pandemic have been associated with an increase in online addictions, with the full ramifications yet to be realised (Gjoneska, et al., 2022). While there is an emphasis on developing digital fluency and citizenship, promoting digital wellness as the practice of refraining from the Internet and digital media overuse for reasonable amounts of time is important.

Symptoms and Treatments

As there are many interpretations of ‘digital addiction’, and just as many approaches to its diagnosis. Some focus on time or attachment to a device, others use diagnostic criteria for behavioural addiction and others focus on the harmful consequences as a result of the addictive relationship (Cemiloglu et al., 2022). The characteristics of digital addictions share commonalities with other behavioural addictions, including

- salience (dominates the person’s life),
- mood modification (reaction when engaging in the activity),
- tolerance (increasing amounts of the activity are required to achieve the same effect),
- withdrawal (effects when the activity is discontinued),
- conflict (conflicts involving the activity)
- relapse (tendency to revert to earlier behaviour patterns) (Griffiths, 1999)

The behaviours of a digital addict are often described as impulsive, compulsive, excessive and hasty (Rahayu, et al., 2020).

Treatment is determined by the type and severity of the addiction. Cemiloglu, Almourad, McAlaney, and Ali (2022) suggest four main categories of strategies to combat digital addictions: psycho-social (behavioural), software mediated (limiting or controlling device use), pharmacological (using medication) and a combination of these. Often addiction symptoms are comorbid (go hand-in-hand) with psychiatric symptoms, such as depression and anxiety (Qu, et al., 2021). For these cases, a pharmacological approach is often prioritised over psychological and can include the use of selective serotonin reuptake inhibitors (SSRIs) (Khan, et al., 2022).

A range of common psychological approaches are also used to support digital addictions. These generally focus on self-help coping strategies, such as learning to accept the issue and learning to identify its triggers. Talking and learning about the addiction and its triggers in motivational interviewing; family therapy; reality therapy; cognitive-behavioural therapy (CBT); acceptance & commitment therapy (ACT); and a multimodal approach utilising a number of strategies has also been shown to be beneficial (Lee, et al., 2023). Support groups provide shared experiences and strategies to move forward.

Changing both the body’s physiological and psychological reactions have also been shown to be helpful in tackling digital addictions. Some strategies for monitoring the time online, and on devices include; tracking, scheduling and moderating one’s screen time. Changing habitual patterns of use is complex and requires practising ‘digital detoxing’ and ‘digital dieting’ and reinforcing and rewarding any positive behavioural changes (Radtke et al., 2022). Schell (2022) suggests that abstaining from specific applications, developing a personal log, using reminder prompts of the costs and benefits of behaviour change, and developing a personal log have effectively changed addictive habits (Schell, 2022).

There is a range of other beneficial strategies including following daily routines, and increasing physical exercise, which compensate for the decrease in the dopamine levels due to relaxation techniques, limited online usage, and ensuring both alone and social time are well balanced (Gjoneska, et. al, 2022).

Implications

Recognising the signs of digital addiction is a good starting point for prevention. However, balancing online and real-world interactions is crucial, especially for students and educators. During the pandemic's emergency online mode, we have learned to value our well-being routines, which also apply to managing digital addictions (Doyle, et al., 2022). For instance, regular sleep and exercise, following a healthy diet, practising stress reduction techniques, nurturing relationships, and balancing caregiving or family commitments with one's need for personal space and time are practices to be revisited and adapted for those suffering from online addictions. Taking specific measures like monitoring and controlling screen time, setting an example by reducing device usage, utilising well-being apps and analogue tools, like watches, staying connected with friends, and seeking assistance contributed to maintaining well-being (Király et al., 2014). Prevention can start with simple measures such as turning smartphones to grey scale to reduce the stimulus from colour.

Menon, Mishra, and Padhy (2021) argue that addressing digital addictions in teaching and learning settings requires raising awareness among key stakeholders. Parents, teachers, and students should be able to recognise early warning signs and symptoms of addictions, including excessive irritability, difficulty completing homework, attentional deficits, academic decline, excessive preoccupation with internet use and a simultaneous loss of interest in age-appropriate activities. Parents are encouraged to monitor their children's Internet usage and content access via parental control software, schedule healthy routines and engage in joint activities, such as playing video games with children, which can be a way to establish some control over their internet usage (Menon, et al., 2021). To address the issue of increased screen time, various prevention programmes have been developed for schools (Carbonell et al., 2018; Neverkovich et al., 2018). Ali, Butt, and Warraich (2023) emphasise the importance and impact of digital citizenship on students, teachers, and student teachers. The authors suggest considering personal, psychological, technological, and social factors when designing educational programmes that promote digital citizenship. Educators should take a holistic approach to teaching digital citizenship, including addressing digital wellness and raising awareness of the consequences of digital addiction in today's society.

In a discipline with such a heavy emphasis on devices, all technology teachers, especially digital specialists, need to be aware, and ready to act. Reading about possible consequences of possible overuse of digital technologies, internet and smartphones can help us see cues. Understanding comorbidity, causal linkages, and risk factors, can help teachers, parents and students be cognisant and mindful. An easy to read chapter explaining the influence of smartphones and addiction is by Greenfield (2021).

Providing non-judgmental support is crucial in addressing digital addictions, as individuals affected by this condition should not be blamed or stigmatised. Digital addiction is recognised as a disease, similar to other illnesses, and it is not the fault of the person experiencing it. Simply ceasing device usage does not serve as a "cure" for this condition. In the digital age, complete abstinence from online activities is not feasible, thus suggesting total avoidance of online participation is not a practical solution, comparable to advising against using electricity. However, recommending abstaining from problematic applications or behaviours and promoting controlled and balanced internet usage can be one of many constructive strategies (Petersen et al., 2009).

It is important to recognise the signs and symptoms of addiction and assist affected individuals in seeking help. Students, teachers, and the broader community are all susceptible to digital addiction, and by collectively reducing addiction rates and supporting those affected, we can contribute to our shared well-being and overall quality of life. To progress in addressing digital addictions, we must be attentive and compassionate.

Conclusion:

The official recognition of Internet Gaming Disorder and Gaming Disorder by the American Psychiatric Association and the WHO signalled the seriousness of these mental health conditions, raising pivotal questions about our response to their prevention and mitigation before digital addictions become a widespread pandemic. As a discipline with expectations of high digital device usage, we must be proactive. We must acknowledge the elephant in the room. Technology teachers and learners are working in a potentially hazardous field. We need to engage in the difficult discussions about whether these disorders should be considered learning problems and whether educational institutions should make accommodations accordingly.

Furthermore, it is essential to reflect critically on how our approaches to treating different addictions are inconsistent. The harmful effects of gambling, smoking, and alcohol, for instance, are acknowledged and mitigated by restrictions and regulations, particularly for minors. However, this is not the case with online and digital addictions; instead, we knowingly promote online and digital use in classrooms, sometimes rewarding students with leisure screen time for completing tasks. This situation begs the question of how accountable we are for exposing our students to the risk of digital addictions.

These concerns demand reflecting upon an educators' role in shaping the digital well-being of students. By fostering open discussions and responsible strategies, we can work towards minimising the risks associated with digital addictions and protecting students' mental health while preparing them for the demands of the digital age.

How culpable are we for our children's future digital addictions?

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Curriculum Integration: Principles for Schools and Initial Teacher Education

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Abstract:

Curriculum integration is ‘all the rage’, but it is not being implemented consistently in classroom contexts. The challenge for both the teacher and the student is to reflect on the learning and the process of coming to know, a challenge that is mirrored in Initial Teacher Education, in the tertiary sector. This challenge has been identified in the literature as the curse of knowledge (Russell, 2013), once you have learnt something, it is very difficult to know what it is like to not know it. A case study was selected from within a much larger dataset of teaching artefacts, that had been used in English-medium and Māori-medium teaching contexts for year one to eight students (aged between 5 and 12 years). The selected case study representing ten weeks of learning for composite classes of students was then analysed in relation to the literature on curriculum integration, with a focus on approaches used in teaching these methods in higher education settings.

Emerging principles for integration will be discussed as part of the conference presentation. There are implications for practitioners and for lecturers. Taking a step back, there are wider implications for curriculum development and policy authoring in Aotearoa New Zealand.

HE WHAKATAKINGA: INTRODUCTION

This paper focuses on the primary and intermediate sectors, which in Aotearoa New Zealand includes children aged between 5 and 12 years of age. There are two key curriculum frameworks that are implemented in New Zealand classrooms – The New Zealand Curriculum (Ministry of Education, 2007, 2017c), for English-medium educational contexts, and Te Marautanga o Aotearoa (Ministry of Education, 2008, 2017) for Māori-medium educational contexts. The key questions that guided this paper are:

- How can thematic planning purposefully integrate across the curriculum areas, starting with a Hangarau (Māori-medium Technology) need or opportunity?
- What are some of the ways that the initial teacher education sector can engage with this thematic planning?

This paper will overview intersections in selected literature between curriculum integration, and initial teacher education. The method will be briefly summarised - a pragmatist bricolage approach (Kaushik & Walsh, 2019; Rescher, 2016). Then a specific unit will be laid out and analysed in relation to the literature, in the identification of initial principles for curriculum integration – in the classroom context, and in the initial teacher education sector. This unit was delivered with children in 2004 and has been selected as a unit demonstrating exemplary implementation of purposeful curriculum integration. Although the unit was delivered almost 20 years ago, it was one of the first topics of conversation that was raised by students when we were reminiscing recently about the old school days, as we thought of a few words we may want to share for our school centenary book:

> "Do you remember when we made a toilet?"
>
> "Yeah – and we stayed at school for the night in the whare (house) we made!"

It is valuable taking a closer look at a dataset where the data has not been evaluated but needs to be evaluated. What is it about this unit that made it so memorable for students? What lessons can be learnt by our next generation of teachers in the initial teacher education sector? Tamsin Hanly, as lead teacher and Ruth Lemon, as lead lecturer – reflect on the unit.

LITERATURE: SELECTED INTERSECTIONS

Curriculum integration has evolved in meaning over time. In his focus on curriculum integration within middle schools, Dowden (2010) traced the development of the term, from the 1990s, where curriculum integration tended to refer to thematic units. Beane (1997) began earlier, tracing the role of schools in promoting social integration in the 1800s and the subsequent contributions of the German educator Johann Herbart concerning potential correlations and links between the disciplines that could lead to some integration in students' classroom studies. In reference to suggestions that curriculum integration is ahistorical, Fraser (2013), argued that the concept of curriculum integration emerged in the early 1900s because of the work of educators such as Dewey (1910, 1913) and Kilpatrick (1926). Fraser (2013) discussed the differences between thematic learning and curriculum integration. Fogarty (2009) went a step further and outlined a range of possible lenses that could be applied by teachers who are planning on integrating curriculum in their classrooms.

1. Cellular Model – Focusing on priorities of each course, also known as concept-driven curriculum (Erickson & Lanning, 2014)
2. Connected Model – Making explicit connections with each classroom opportunity
3. Nested Model – Targeting multi-dimensional skills and concepts into one lesson
4. Sequenced Model – Rearranging sequence when a topic is taught to coincide with a parallel topic in another discipline
5. Shared Model – Integrating one subject with another through the learner's conceptual eye
6. Webbed Model – Weaving natural and obvious themes of a subject (such as the work of an artist of writer) into the fabric of a discipline
7. Threaded Model – Integrating what is taught with cognitive tools, strategies, and technical tools that cross disciplines
8. Integrated Model – Involving interdisciplinary team discussions when planning curriculum
9. Immersed Model – Connecting past experiences and prior knowledge with new information
10. Networked model – Building new bonds of interest with other experts through networking (Fogarty, 2009, p. 2)

This definition of curriculum integration as a continuum of practice, involving the application of a series of lenses in the planning and delivery of integrated content in the classroom context, is the definition with which this paper's thinking is aligned.

In Māori-medium contexts, one of the goals for the sector is language revitalisation and regeneration, so language integration is the first consideration (Ellis, 2003; Gibbons, 2015; Ministry of Education, 2009; Nation & Newton, 2008; Ratima & May, 2011; Riwai-Couch, 2022) when looking at curriculum integration. This means that the literature on second language acquisition is vital, particularly material that is focused on the Māori language. A good example of this is Te Aho Arataki Marau (Ministry of Education, 2009), because although these curriculum guidelines are aimed at English-medium schools, the guidelines lay in a foundation of second language acquisition theories, including task-based language learning (Ellis, 2003) and the complementary intercultural communicative language teaching (Newton et al., 2010) that explore learning chunks of language, as does the lexical approach (Thornbury, 2002). Literature reviews have been conducted, focused on second language acquisition in the classroom context (Ellis, 2005), or more broadly on theories of second language acquisition (Broad, 2020) and on the impact of second-language learning (O'Brien et al., 2017). This paper subscribes to notions such as Deliberate Acts of Language Learning (Lowman, 2019) as a pedagogically efficient ways of noticing, collecting and rehearsing language, with the aim of language acquisition within rich learning contexts.

A key consideration when exploring curriculum integration in the Initial Teacher Education sector is that of the curse of knowledge (Russell, 2013). In the Australian context, Berry (2007) extends on this idea through her explorations of the tensions inherent in teaching about teaching, with theories informing her practice as a biology teacher educator. Educators need to consider the importance of the balance between pedagogical content knowledge and discipline or curriculum content knowledge – before it is possible to integrate, there needs to be a thorough knowledge of the separate curriculum areas.

METHODOLOGY

Pragmatism as a research methodology had its foundations in the philosophical approach of the same name and the idea that actions (or outcomes) carry meaning (Rescher, 2016). Pragmatism "embraces plurality of methods" (Kaushik & Walsh, 2019, p. 3), in that the methods chosen should be those that will most efficiently answer the research questions. Being placed in the centre of the continuum between objectivity and subjectivity, pragmatism functions as a bridge between the two, facilitating an abductive approach to research and focusing on the links between knowledge and experience (Kaushik & Walsh, 2019). An abductive approach creates a balance between inductive and deductive approaches and will support the answering of the research questions in this context, which cross between the objective and subjective domains. All the artefacts in the dataset contain aspects of knowledge and experience. Because the dataset has come from a combination of knowledge and experience, pragmatism is the logical methodology.

METHOD

This research utilises a pragmatist perspective to examine a series of teaching resources, including plans, student artefacts, and modelled and shared classroom artefacts. The available dataset represents 25 years of teaching practice across English-medium and Māori-medium contexts with year one to eight students (aged between 5 and 12 years of age). The available dataset consisted of many different document types, as outlined in Table 1. The dataset was scanned for the purpose of this study, this paper being the pilot study to start examining the dataset and to introduce initial principles of best practice, with a focus on Māori-medium educational contexts. The survival unit was selected as a starting point, due to the memorability of the unit to students, and due to the authors' belief, that Hangarau (Māori-medium Technology) is a robust means of planning for integrated learning across the curriculum. These artefacts for the selected unit of learning has also been used with student teachers in the initial teacher education sector, supporting the extrapolation of initial principles for best practice.

Table 1 The Types of Data in the Available Dataset

Plans	*Student artefacts*	*Modelled and shared classroom artefacts*
Unit plans	Exemplars	Brainstorms
Weekly plans	Photographs	Drafted songs
Year overviews	Videos	Writing drafts
Written rationales for classroom delivery	Audio recordings	Exemplars
	Booklets	Models of the day's success criteria

CASE STUDY: NGĀ PAREKURA Ā-TAIAO – NATURAL DISASTERS

This unit was delivered in 2004 in a whānau rumaki reo, a Māori-medium immersion language classroom where 80-100% of the teaching and learning experiences are delivered in te reo Māori (Māori language), with mātauranga Māori (Māori knowledge) as the epistemological and ontological foundation of everything that is being taught. Tamsin Hanly was the lead teacher. There were two composite year level classrooms, the nohinohi or junior primary class of 5-7-year-olds, studying at levels 1-2 of Te Marautanga o Aotearoa; and the tuakana or senior primary class of 8-11-year-olds, studying at levels 3-4 of Te Marautanga o Aotearoa. The nohinohi and tuakana classes worked separately for Te Reo Matatini (Māori-medium literacy) and Pāngarau (Māori-medium numeracy) but worked together in mixed ability groups for all other curriculum areas. The unit's premise was that the class needed to prepare for a natural disaster. They had been divided into four equal sized groups, each group containing an equal number of boys and girls, and an even spread of students between 5-11 years of age.

The unit was introduced using an audio CD. A couple of audio tracks had been included at the beginning of the disc, then, using Audacity, a recording of radio static had 'interrupted' the radio broadcast with an emergency announcement. The teacher's voice had been altered to try and make it less recognisable. The class had been advised that they needed to prepare water, food, shelter, bedding, and a sanitation system to be used while they waited for help to arrive.

The groups were then formed, and each group met together to be introduced to their 'wero' or challenge card. The first group, *Ngā Tangata Tapu* (Precious/Special/Sacred People) was tasked with designing a bedding and sanitation system that could support 50 people overnight. The second group, *Te Korowai Ruruhau* (The Sheltering Cloak) had the task of designing and building a structure on the school grounds that was large enough to hold 50 people, warm, and waterproof. The third group, *Te Wai Oranga* (Living Waters) had the task of collecting, filtering, and purifying water and making the cups from which 50 people would be able to drink over the duration of the survival evening. The last group, *Ringa Raupa* (Hard Workers) had the challenge of designing a menu using only what was available from the school's permaculture garden, cooking the food (enough for 50 people), and ensuring that there was some form of plate on which the food could be served. From these larger Hangarau (Māori-medium Technology) challenges, there were multiple opportunities for Hangarau practice over the term.

Figure 1 The Wero Cards Introducing the Term's Main Challenge and Essential Criteria

(1) Ngā Tangata Tapu	(3) Te Wai Oranga
a) Kua pā mai he aitua taiao i te kura nei. Ā, ko tā koutou nei mahi ko te waihangatia *(create)* me te hangaia ētehi tūmomo moenga **kia takoto ai te tangata ki runga**, me ētehi tūmomo paraikete **<u>mahana</u> kia whakamahia e 50** ngā **tāngata a tētehi pō.** Anei ngā paearu mō a koutou nei tūmomo moenga, tūmomo paraikete hoki - * kia mahana * kia whakatangatanga *(comfortable)* * whakamahia ngā rauemi o te kura, i te kura anahe, arā, ko ngā rauemi māori me ngā rauemi kua hangaia e te tangata e) Ko tā koutou nei mahi tuarua ko te waihangatia me te hanga i tētehi wāhi mimi, wāhi tūtae e āhei ana tātou ki te whakamahi a tētehi pō. Whakamahia ngā rauemi kei te kura nei anahe.	Kua pā mai he aitua taiao i te kura nei. Ā, ko tā koutou nei mahi ki te kura nei ko te: a) whakarite i tētehi huarahi kia hopu i te wai e) whakarite i tētehi huarahi kia tātari/whakamā i te wai i) waihanga *(design)* me te hanga i ētehi ipu hei kapu, me ētehi ipu hei ipu wai **(E 50 ngā tāngata)** * me whakamahi i ngā rauemi anahe o te kura, i te kura, arā, ko ngā rauemi māori me ngā rauemi kua hangaia e te tangata
(2) Korowai Ruruhau	(4) Ringa Raupa
Kua pā mai he aitua taiao i te kura nei. Ā, ko tā koutou nei mahi ko te waihanga *(create)* me te hanga i tētehi tūmomo ruruhau ki waho. Anei ngā paearu mō tā koutou tūmomo ruruhau - * kia mahana * kia karo i te wai * kia nunui kia takoto ai, kia moe ai e 50 ngā tāngata a tētehi pō * kia hanga i te ruruhau ki te kura nei, ki te whīra ki te ngahere rānei * me whakamahi i ngā rauemi o te kura kei te kura nei, arā, ko ngā rauemi māori me ngā rauemi kua hangaia e te tangata	Kua pā mai he aitua taiao i te kura nei. Ā, ko tā koutou nei mahi ko te: a) kimihia kai kei te kura nei, kei te ngahere, kei te māra hoki e) whiriwhiria me pēwhea te kai i ngā momo kai - me pēwhea e kai ai, me pēwhea e tunu ai i) waihanga *(design)* me te whakarite i tētehi huarahi pai kia taea e koutou te whakarite i tētehi ahi ki te kura, kia tuna ai ngā kai o) waihanga me te hanga i ētehi taputapu kia tapahi kai, kia tunu kai, kia kai i te kai me ētehi ipu / peihana mo te kai * me whakamahi i ngā rauemi anahe o te kura, i te kura nei. ***Whakaritea kia nawhe te kai, kia nawhe ngā taputapu mō ngā tāngata e 50.***

The culmination of this unit was the survival evening, which was set to be held at school in the last week of term. The evening started on an area close to the shelter that Korowai Ruruhau (The group named 'The Sheltering Cloak') had designed and built. An area for a fire had been marked off with cones, and a 'stage' area had been prepared for the fashion show and the performances that were set to start off our survival evening. An important concept within the Hangarau (Māori-medium Technology curriculum), is the notion of working on a technological outcome to support someone else. Therefore, it was important for each of the groups to 'gift' their outcomes to the wider whānau (families and community), by performing the song that they had composed to explain their outcome. Subsequently, there would be time for us to eat together (Ringa Raupā, the group named 'Hard Workers'), drink together (Te Wai Oranga, the group named 'Living Waters'), and share stories around the fire, before sleeping under the shelter that had been built (Korowai Ruruhau) and using the sanitation system (Ngā Tangata Tapu, the group named 'Precious/Special/Sacred People'). In the morning, we would eat breakfast and then pack up and go back to class for a de-brief and a developmentally appropriate post-test. Could the 5-year-olds talk about the materials they had chosen and the reasons why specific materials were stronger, warmer, or more waterproof? Could the 11-year-olds finalise their initial briefs, testing fitness for purpose and noting the changes or improvements they would make if they had the opportunity to go through another design cycle?

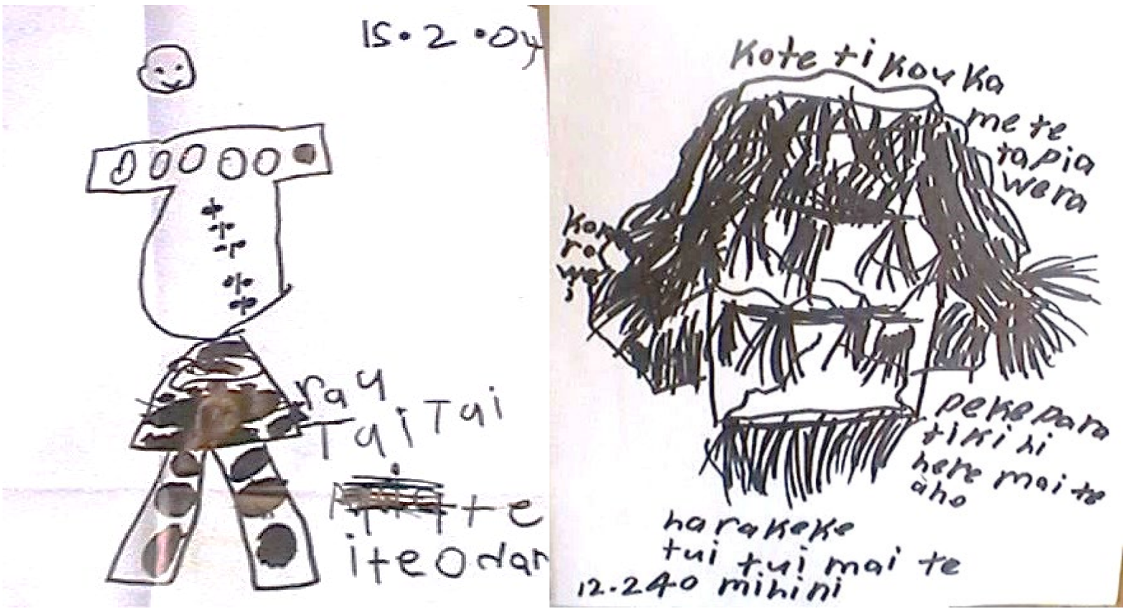
Over the ten weeks of the term, each group researched collaboratively, sharing their findings twice weekly with a whānau member (someone from the wider community who had been identified as having expertise related to their challenge – including a parent who was a plumber; a builder/architect; a parent who worked at the local council in water storage and treatment; and a parent who had regularly catered events). These community experts listened to each group's research and helped them refine their designs using questions and discussion. The teachers had approached the classes' parents and wider community the term prior to this unit, to access appropriate expertise. It is also important to note that the school's principal and Board of Trustees (administrative governing group of parents and staff members for the school) had been notified formally at a Board of Trustees meeting earlier in the year, to ensure that the teachers had Board and Principal support for the learning that had been planned.

Te Reo Matatini (Māori-medium Literacy) involved a combination of recount and procedural writing with accompanying photographs, diagrams, and illustrations, as we documented what we were doing in our groups. Pāngarau (Māori-medium Numeracy) included measurement and geometry that supported us in our design processes. The whole term was spent in the build-up to the culminating survival evening.

There were related challenges that were introduced to the group over other curriculum areas – for Ngā Toi Ataata and Hauora (Māori-medium Visual Arts and Health curricula), the whole group was challenged to design warm and waterproof clothing that they could wear. See Figure 2. For Pūtaiao (Māori-medium Science), we had tug of wars on the field, as we tested the strength of the fibres that we were thinking of using for our warm and waterproof clothing. We ran a battery of tests – which fibres were the most waterproof, the strongest, the warmest? Through Puoro and Ngā Mahi a te Rēhia (Māori-medium Music and Dance/Drama), each group composed and choreographed a musical item that they performed for whānau who attended our survival evening at the end of term.

This unit has been used to develop student teachers' approaches to planning in the initial teacher education sector, which is discussed in the next section.

Figure 2 Initial Design Sketches in Vivid by Students Working at Levels 1 and 2 of Te Marautanga o Aotearoa



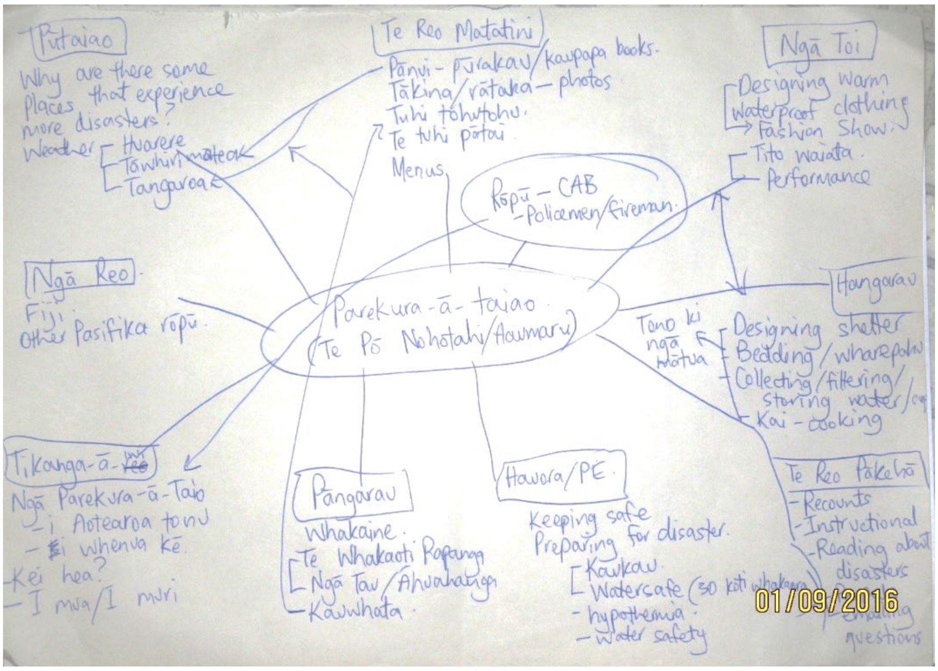
INTEGRATION IN INITIAL TEACHER EDUCATION

Ruth Lemon started as a part-time lecturer in semester two 2015, with full responsibility for EDCURRM 107: Hangarau He Whakatakinga (An Introduction to the Māori-medium Technology curriculum for student teachers) a second year paper that was part of the Bachelor of Education (Teaching) Huarahi Māori specialisation, where te reo Māori, ngā tikanga Māori me te mātauranga Māori (Māori language, practices, and Māori knowledge) functioned as the vehicle through which the student teachers were prepared to teach. The course was delivered over nine weeks between July and the beginning of October, with two weekly sessions of two hours each. The course learning outcomes were ambitious. At the completion of this course, it was intended that students would be able to:

1. Te whakamārama i te āhua me te pūtake o te hangarau i roto i Te Marautanga o Aotearoa. *Explain the nature and purpose of hangarau as reflected in Te Marautanga o Aotearoa.*
2. Te wetewete i ētahi o ngā huarahi ako e whakamahia ana hei whakatinana i te matatini hangarau me te whakaharatau hangarau i roto i ngā kura. *Critique a range of approaches to implementing Te Matatini Hangarau (Technological Literacy) and practice in educational settings.*
3. Te whakaatu i tōna mōhio me tōna āhei ki te whakarite, te whakaako me te aromatawai tōtika i te hangarau. *Demonstrate knowledge and ability to effectively plan, teach, and assess hangarau education.*
4. Te whakamahi tōtika i te reo hangarau. *Communicate using te reo Māori discourse, specific to hangarau.*

Changes to this course were made regularly in response to student and lecturer evaluations, reflection, and feedback. After the first delivery Ruth noticed that the students wanted more opportunities to practice their planning. Ruth has always believed that Hangarau lends itself to curriculum integration, and so wanted to support the students using a case study of cross-curricula teaching as a starting point. We explored some of the artefacts – listened to the karere ohotata (emergency broadcast), looked at the challenge cards and a slideshow of some of the work. We started by brainstorming this integrated unit together – what correlations, what connections, what shared skills did we see across the curriculum areas? We completed a shared brainstorm, see Figure 3 for the brainstorm completed in 2016. The idea was not to force connections between the theme and all curriculum areas, but to see what connections we identified that were logical and that would strengthen connections we had already identified. We also looked for the potential for EOTC (Education Outside the Classroom) experiences. Could we work with a local Citizen's Advice Bureau? What could be an appropriate culminating activity that we could work on together?

Figure 3 Brainstorming the Connections Across Te Marautanga o Aotearoa and our Theme



Then the class split into groups, with each group choosing one of the challenges to focus on writing up formally as part of a unit plan. I did not want the students to have to sit and plan in isolation, for a couple of reasons. I did not want to race towards expecting students to plan independently (Cormack, 1997; Pohatu, 2013). I wanted to scaffold the group by working on a component together, then allowing small groups to work collaboratively, before the students chose another context to explore, either in pairs or individually.

In the next sections, we outline some principles for curriculum integration that have been identified from this teaching, both in schools and in the initial teacher education context. It is highly recommended that systematic research is conducted in the initial teacher education setting into how effective these approaches are and as a means of refining the principles outlines below.

PRINCIPLES OF INTEGRATION

These principles have been grouped by focus – with the first set of principles focusing on planning for curriculum integration in schools, and the second set focusing on engaging with the concept of curriculum integration with student teachers in the initial education sector.

Principles for curriculum integration in schools

- The integration must be meaningful, not forced, with designated times for different curricula to become the focus of the learning. The designated times need to be explicit, so that children are learning the distinctions between the different disciplines they are engaging with.

- Establishing mixed-ability groups allows for the Māori pedagogical approach of tuakana-teina to be implemented in the classroom (Pere, 1982; Tangaere, 1997; Winitana, 2012). This is referring to scaffolded learning, a more experienced tuakana guiding the novice teina in developing their learning.
- To ensure that the research skills were explicitly taught, there was time spent modelling how to take notes, or how to talk about what you had just been discussing (for the more junior pre-literate and students with an emerging literacy).
- Whānau or wider community involvement was essential. If there is the opportunity to invite community members into the classroom context to contribute to the teaching and learning that has been planned, seize it.
- Establishing a 'point' for the learning, a survival evening or culminating activity that we would be building towards, where we would both test and share what we had learned over the term with whānau (families and wider community) – increased engagement across the board.

Principles for curriculum integration in initial teacher education

- The integration must be meaningful, not forced, with designated times for different curricula to become the focus of the learning. The separate disciplines need to be taught explicitly, so that the student teacher can look for correlations and connections in learning, using their pedagogical content knowledge and their knowledge of the curriculum areas.
- Allowing time for whole group and self-selected mixed-ability groups facilitates both the Māori pedagogical approach of tuakana-teina to be implemented with your student teachers (Pere, 1982; Tangaere, 1997; Winitana, 2012), but also allows the time that Cormack (1997) argues is vital in building a community of learners and providing sufficient supports for cognitively demanding work.
- To ensure that the skills for curriculum integration are explicitly taught, allow time for the exploration of a case study together, then spend time producing a shared brainstorm and writing up sections of that brainstorm into the relevant parts of a unit plan (which also models the collaborative approach to unit planning that can be seen in most New Zealand schools).

CONCLUSION AND RECOMMENDATIONS FOR FURTHER RESEARCH

There are implications for practitioners and for lecturers with regards to this first case study. Taking a step back, there are wider implications for curriculum development and policy authoring in Aotearoa New Zealand. We need to study how we teach curriculum integration in the initial teacher educator sector.

We need to study how we develop our thinking as a professional community of practitioners in a sustained and ongoing manner – We need more case studies. We need the opportunity to co-plan and co-teach with identified experts (such as the Mātanga project – see Reinsfield & Fox-Turnbull, 2021).

We need to share more case studies of best practice and conduct systematic research to measure the impact on our students. How can we improve students' experience of curriculum integration, ensuring that we are developing their knowledge at the same time in terms of the distinctions between the different Wāhanga Ako (Learning Areas or subjects/disciplines)?

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The Actual State of Creative Attitudes in Engineering Learning through Text Mining Analysis

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Abstract

The purpose of this study was to grasp the actual situation of creativity attitudes among junior high school students to verify the possibility of developing creativity in education through design process. In Japanese junior high school technology classes, the development of creative attitudes is attempted through engineering education. It can be pointed out that the creativity scales developed in previous studies did not consider the actual conditions of junior high school students because they were developed from the viewpoints of teachers and literature. If we could grasp the actual situation of junior high school students when they engage in creative activities, it would be possible to create a creativity scale that is more appropriate for them. In September 2022, we conducted a survey of 432 junior high school students on their attitudes toward thinking about new things and creating new things. Text data obtained from the survey were analyzed using text mining. As a result, 6 groups were identified. In particular, we can also analyze them in two directions: creative attitudes with autonomous orientation; Groups A, C, D, and E, and creative attitudes with other-oriented orientation; Groups B and F.

Keywords: Creative Attitude; Design Process; Engineering education; Text Mining

Introduction

For learners living today, the developing of creativity is not only fundamental, but also expected by society. In mature markets, which are common in Japan and other developed countries with a high level of development of capitalism, it is considered necessary to innovate in order to differentiate oneself from others and gain an advantage in the economic market (Tana, Ishioka, 2019; Kubo, 2018). Innovation and creativity are fundamental to all academic disciplines and educational activities, not just the arts (Vygotsky, 2011). Innovation should be a new thing or partial new one that is created by a systematic approach and then improved research, and it is not appeared in a daily working system (Songkhram, 2013).

Therefore, this study focused on learners' creativity in the design process of engineering education, believing that the initial stage of the engineering process is the great opportunity to foster creativity (Kiita, Hamada, 2003; Fujimoto, 2006; Green, 1979). Howard et al (2008) describes six phases of the engineering design process, including the Establishing a need phase, in order to model the engineering design process and determine which phases need to be focused on. Since the target population of this study is middle school students, six phases are too many here, so we chose to use one of the following phases: Establishing about the concept or needs, Embodying, and Testing and Evaluating. These three stages include the problem-solving process, or design thinking process. (Ito, 2019; Brown, 2014).

In this study, creativity is defined as the ability and attitude to "create new value". Since creative attitudes support creative thinking and creative skills, and have also been identified as an important aspect of creativity (Onda,1994), we focused on creative attitudes in particular. The category of creativity was set at Kaufman's little-c and mini-c levels of creativity (Kaufman, Beghetto, 2009) at the junior high school level. Mini-c level is creativity through subjective perception, while little-c level is creativity exhibited in the domain of life.

Currently, Japanese school education has set the development of creativity as a goal (MEXT, 2017), but in reality, it has not been realized to a great extent, and it has been pointed out that the reason is that the definition of creativity is unclear (Titige, Yumino, 2010). It is expected that creativity development will become more realized if the definition of creativity is clarified and it becomes easier to understand whether creativity has been developed or not.

Prior research in technology education (Miyakawa, Nakashima, 1996) compared creativity with the goals and content of the Courses of Study and the process of instruction, and defined the components involved in fostering creativity. However, constructs such as "independence" and "curiosity" were selected by the authors with reference to previous studies and may not reflect the actual conditions of the students. In addition, since this study emphasizes the creative process in the testing phase of problem solving, it is believed that there is a lack of consideration of creativity in the early stages of the design process.

From the above, it is recognized that the clarification of creativity reflecting the reality of learners in technology education is an important challenge. Therefore, in this study, we paid particular attention to the design process as an opportunity to foster creativity, and aimed to clarify the actual situation of creative attitudes and to obtain knowledge for fostering creativity. In particular, we will clarify whether students' creative attitudes emerge in the design process as a matter of fact, and where the potential for fostering creative attitudes lies.

Methodology

In order to clarify the actual situation of creative attitudes of junior high school students during the design process, this study conducted text mining of free descriptions that recalled their experiences in the design process to read the tendency of their creative attitudes.

In September 2022, students (432 students) in grades 1 through 3 at one Japanese junior high school were asked to respond to the study's definition of creativity, "thinking of new things and creating new things," using Google Forms in an open-ended format. Subjects had 10 minutes to respond. The question item was "Please feel free to write about a time when you came up with a new idea or created something new. The collected text data were analyzed using the text mining tool, KHCoderVer.3 (Higuchi, 2017). Words with 12 or more occurrences were then chosen to create a co-occurrence network. A co-occurrence network is a graphical representation of the relationship between word occurrences (Higuchi, 2017). The creation of a co-occurrence network involved the authors engaging in discussions to establish groups ranging from 3 to 9, in order to interpret the essence of creativity. Ultimately, the authors reached a final decision through their discussions.

Findings and discussion

In the free-text descriptions of "thinking of new ideas and creating new things," the total number of extracted words was 10,833, with a vocabulary size of 1,118 distinct words. Among these, there were 38 words that occurred 12 times over of more (Table 1). From these extracted 38 words, a co-occurrence network related to "thinking of new ideas and creating new things" was constructed. The co-occurrence network revealed six groupings of words that were relatively strongly interconnected, and each group was labelled from A to F (Figure 1).

Table 1: The 38 frequently-used words

rank	extracted word	the frequency of used words	rank	extracted word	the frequency of used words
1	glad	130	20	excited	25
2	make	118	21	feel	23
3	fun	93	22	friends	20
4	myself	90	23	see	16
5	accomplish	72	24	draw	16
6	say	65	25	like	15
7	think	57	26	difficult	15
8	surroundings	52	27	concentration	14
9	people	51	28	little	14
10	feeling	43	29	other	14
11	work	38	30	improvement	13
12	praise	37	31	picture	13
13	new	35	32	be absorbed	13
14	idea	34	33	family	12
15	complete	31	34	use	12
16	interesting	27	35	occurs	12
17	conceive	26	36	write	12
18	failure	26	37	parent	12
19	good	26	38	satisfaction	12

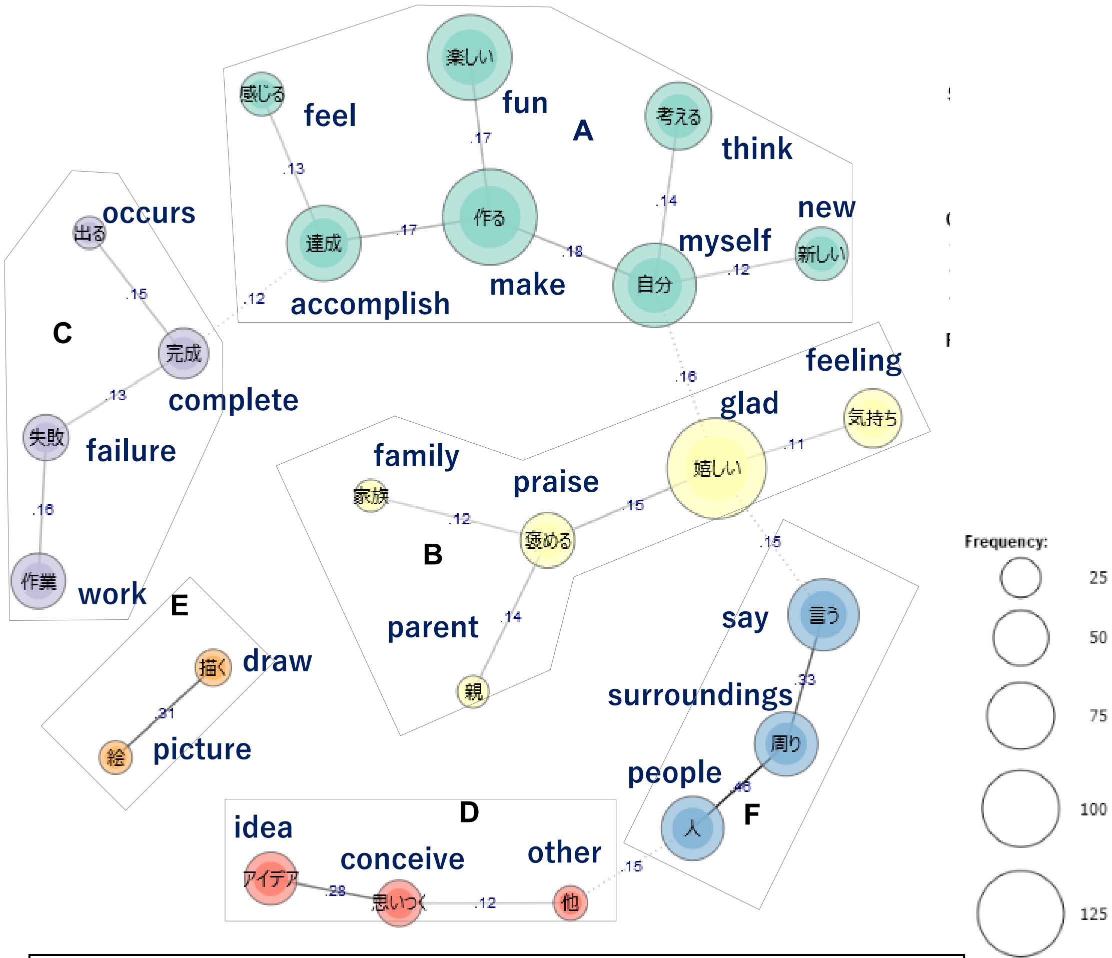

Figure 1: The co-occurrence network revealed six groups of words

Based on the interpretation of the six groups identified in the co-occurrence network, we will discuss the findings for the developing of creativity as well as the actual situation of creative attitudes.

In Group A, a co-occurrence network was formed from words such as "myself" "think" "make" and "fun". Looking at the students' free descriptions, they described their proactive interest and enjoyment by saying, "The reason I decided to arrange and make something handmade was because I thought I could be satisfied by making something a little prettier and something I liked. Based on this, Group A was designated as "fulfillment through subjective creation. This is an attitude that could be voiced in the early stages of the design process.

Group A "Proactive creative attitude" is a creative attitude of enjoying creative activities and being able to act spontaneously, which can be an important element of the learner's own problem finding.

A strong awareness of a problem is a driving force for creation (Onda, 1994), and in order for people to be motivated to act, they must "truly feel that they are acting by their own choice" (Deci, Richard, 1999). It is therefore suitable in the early stages of the design process to inspire a creative attitude. This type of creative attitude can be an opportunity to develop if the learner is able to determine the task and the product to be worked on. In learning the design process to foster creativity, it is important to incorporate questions such as "Why do we need to work on this task?" and "What is new about this product?

In Group B, co-occurrence networks were formed from words such as "happy" "feeling" "praise" and "parents". Looking at the students' free descriptions, they described evaluations by others, saying, "I was happy when everyone praised me for creating something new and amazing," and "I remember being happy when my parents praised me. This led us to label Group B as the "Creative Attitude through Evaluation by Others." Although this attitude is not early in the design process, this creative attitude related to little-c is important.

Since children's emotions and achievement motivation are enhanced when they receive positive evaluations of praise from their mothers (Nakayama, 1994), positive peer evaluations may influence learners' creative attitudes in the design process. This attitude is expressed later in the design process and can be taught when implementing a curriculum that incorporates multiple design processes. For example, in a classroom situation, positive evaluation of the learner's finished work will stimulate a creative attitude in the early stages of the next project. The creative attitude of being aware of others is also a trigger for moving up the stage from mini-c to little-c.

In Group C, co-occurrence networks are formed from words such as "work" "failure" "complete" and "occurs". In the student's free writing, we find statements about problem solving such as "I thought I had completed the project, but when I reviewed it, I found mistakes and areas that I was not satisfied with. I investigated ways to make it work and repeated the challenge. Therefore, Group C was labeled "Creative Attitude through Problem Solving". However, this creative attitude does not appear in the early stages of the design process. It has been argued that the process of problem solving stimulates creative attitudes. For example, psychological resilience is a mental attitude. The groups involved in the creative attitudes derived from the students' descriptions above are incorporated into the design process, as shown in Table 2, characteristic that enables people to cope with problems even when faced with difficulties, and one of its factors is "novelty seeking" (Oshio, *et al*, 2002).

In Group D, a co-occurrence network is formed from the words, "idea", "conceive" and "other". In the student's free writing, statements regarding new ideas are recognized: "I came up with a new idea when I thought about other ways to solve the problem," and "I like to have a different point of view from others. Therefore, Group D was labeled as "Basic Creative Attitudes". This creative attitude is the great description for this study's definition, and is the scene where the learner is demonstrating creativity in the early stages of the design process.

The need for a receptive atmosphere has been pointed out as a condition for fostering creativity (Onda, 1994). Therefore, it is important how ideas generated in the early stages of the design process can be generated in a receptive atmosphere. It is confirmed that methods such as brainstorming are also effective in the design process.

In Group E, a co-occurrence network is formed from the words, "draw" and "picture". In their free descriptions, students described how they came up with ideas, saying, "I was excited to come up with new ideas while drawing various pictures," and "When I tried drawing the pictures I thought of, various ideas came to mind, and I really enjoyed drawing pictures of my own world". Therefore, Group E was labeled "Creative Attitude through Methods". This attitude can also be said to be expressed in the creation of new ideas and things in the early stages of the design process.

The process of adding various lines and dots also includes the desire to encounter lines that exceed the image created in the brain (Iwata, Hirono, 2009). Even simply starting a sketch has the potential to generate new ideas. or some learners, it is more effective to let them sketch freely and think of new ideas than to let them set up tasks with a "proactive creative attitude" as in Group A.

In Group F, a co-occurrence network is formed from the words " surroundings" "people" and "say". Looking at the students' free descriptions, statements related to expression to others are recognized, such as "I was concerned about what the people around me would think of my new product" and "I was happy, so I was proud of it and asked for praise from the people around me". Therefore, Group F was designated as "Creative Attitude Toward Expression". The attitude of wanting to express one's new ideas and things to others is an attitude that can be expressed in the early stages of the design process. This attitude is important when creating a curriculum that incorporates the developmental stages of creativity, because creativity with awareness of others is a trigger for moving up from mini-c to little-c.

One of the creative attitude scales developed by Kimura (1970) is "showy," which includes the desire to proudly show others what one has thought about or produced. This attitude may be stimulated by building into the design process opportunities for learners to generate and communicate ideas and objects to others. This study focuses on the early stages of the design process as an opportunity to foster creativity and the developmental stage of creativity.

In the initial stage of the design process, the following instructional methods are suggested in order to develop the creative attitude of the group ADEF: setting up situations where students can set their own tasks independently, conducting brainstorming sessions to generate ideas freely, allowing students to sketch freely, and creating opportunities for them to communicate their ideas to others. Considering the developmental stage of creativity, it is also important for students to express themselves with an awareness of others and to receive evaluations from others, as in Groups B and F. The opportunity to express themselves to others and to receive positive evaluations of their finished products will encourage the learners' interest in the next project, which will lead them to move up from mini-c to little-c.

We believe that these findings will be useful enough for the development of teaching materials and programs in the future. In addition, the groups of creative attitudes in the design process that we have constructed in this study are consistent with many previous studies on creativity in general. Therefore, we plan to promote further research on learners' creative attitudes in the design process using this framework.

Conclusion

Focusing on "creative attitudes," this study aimed to gain insight into the developing of creativity through clarifying the actual conditions of creative attitudes in the design process among junior high school students. We asked junior high school students to respond to an open-ended question about "thinking of new things and creating new things," and conducted a text mining analysis using the obtained text data, which resulted in the generation of a co-occurrence network.

The creative attitudes of junior high school students were summarized into six categories: "proactive creative attitude," "creative attitude through evaluation of others," "creative attitude through problem solving," "basic creative attitude," "creative attitude through methods," and "creative attitude toward expression.

The following contents were obtained as findings for the development of creativity. In the early stages of the design process, specific instructional situations could be envisioned, such as setting up situations in which students themselves could set their own tasks independently in order to stimulate the creative attitude of the group ADEF. In consideration of the developmental stage of creativity, we were also able to envision instructional situations such as group BF, in which the students are conscious of others and receive evaluation from others.

In the future, we will use the findings obtained to develop a creativity scale to assess creative attitudes in order to further validate the design process as a learning opportunity to foster creativity.

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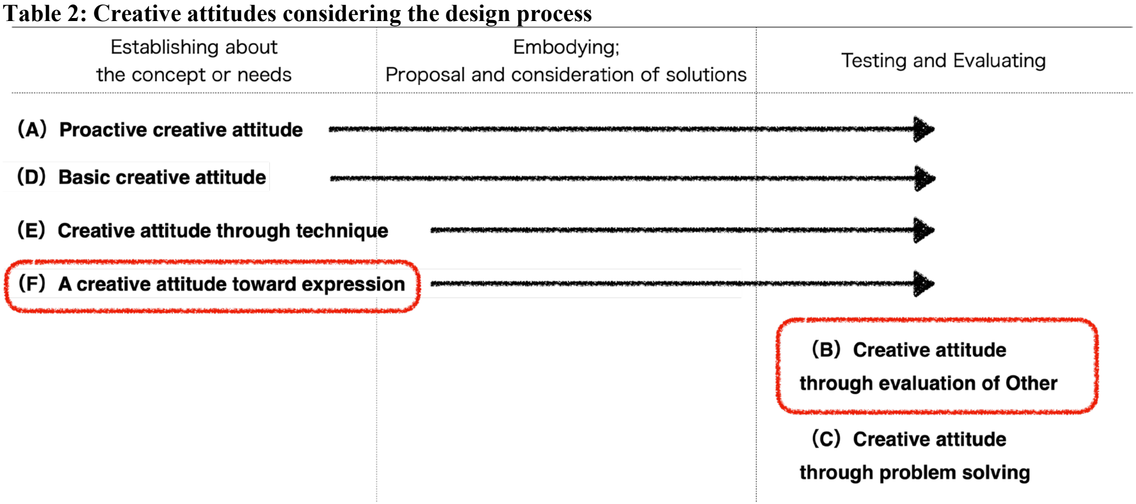
Table 2: Creative attitudes considering the design process



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Development of a framework for a Japanese AI curriculum to build AI literacy in junior high school students

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Abstract

In recent years, AI technology has developed rapidly, and more and more people are using AI on a daily basis. In response, the Cabinet Office in Japan has formulated an "AI Strategy" for 2019. The "AI Strategy" sets forth educational reforms to develop human resources capable of utilizing AI, with the goal of having all high school graduates acquire basic literacy in "mathematics, data science, and AI. Meanwhile, around the world, in 2019, UNESCO released the Beijing Consensus on Artificial Intelligence and Education, which made recommendations regarding education in the age of AI. UNESCO also released "K-12 AI curricula: a mapping of government-endorsed AI curricula" to guide the development of a "curriculum for learning AI" for kindergarten through grade 12 in 2022, and "a of AI curricula" and the need for their development and implementation.

In Japan, however, education for acquiring AI literacy at the compulsory education stage has not been sufficiently implemented. In addition, although Japan aims at AI literacy acquisition, the only places to learn AI literacy are in mathematics and science at the compulsory education stage, which is not sufficient to provide the AI-related learning required in many countries. Therefore, in order to acquire AI literacy in the field of technology and home economics, which is responsible for technology education at the compulsory education level in Japan, this study analyzes and organizes AI literacy and AI curriculum frameworks that have been organized ahead of other countries, and compares them with the learning content in the field of technology, in order to develop a Japanese version of the framework. The aim of the project was to develop an AI curriculum framework, and actual development was conducted.

Keywords: Technology Education, AI Education, Information Education, Curriculum, Framework

Introduction

In recent years, artificial intelligence technology has been developing at an accelerating pace, and its application in fields throughout the world has had a significant impact on a wide range of industrial domains and social infrastructure. Specifically, image recognition, speech recognition, and character recognition are now in daily use. In addition, with the advent of ChatGPT in November 2022, it is feared that the structure of society will change, as it will be able to process more than what natural language processing AI has been able to do so far (Open AI, 2023). This is an issue that has been recognized around the world and was discussed at the G7 Digital and Technology Ministerial Meeting in April 2023, where a joint statement entitled "Action Plan to Promote Interoperability of AI Governance, etc." was issued (Ministry of Internal Affairs and Communications-Japan, 2023).

UNESCO, even before the recent rapid development of AI technology, was concerned about the impact of future AI on society and held the "International Conference on Artificial Intelligence and Education" in Beijing in 2019 to discuss the need for education to foster individuals who can effectively engage with AI (UNESCO, 2019). The conference also resulted in the adoption of the Beijing Consensus on Artificial Intelligence and Education, the first document to provide guidance on how best to utilize AI technologies (UNESCO, 2019). This guide was developed in consideration of Goal 4: Provide inclusive, equitable, and quality education for all and promote lifelong learning opportunities" in "Transforming Our World: The 2030 Agenda for Sustainable Development" adopted by the United Nations, and provides recommendations for enabling all people to learn about and use AI (UN, 2015).

In Japan, rapid social changes are anticipated, and the concept of "Society 5.0" has been proposed in the Fifth Science and Technology Basic Plan (2022), outlining a vision for a future society effectively utilizing technologies such as AI (Cabinet Office-Japan, 2016). The concept of "Society 5.0" has been recognized as a pioneering initiative in international AI strategies and was also presented at UNESCO's " International Conference on Artificial Intelligence and Education". Furthermore, in pursuit of realizing "Society 5.0" and addressing Japan's unique social challenges, Japan formulated the "AI Strategy 2019," outlining measures and establishing an environment for the effective utilization of AI (Cabinet Office-Japan, 2019). This strategy includes proposals related to education and sets a significant goal centred on "educational reform." It aims to ensure that all citizens acquire foundational knowledge and skills related to "mathematics, data science, and AI," as well as the competencies required to design a new society, thus contributing to a sustainable society. To achieve this goal, it is necessary for students to learn the basics of "mathematics, data science, and AI" from elementary school through university. Specifically, starting from the 2022 academic year, the high school curriculum guidelines introduced a new mandatory subject, "Information I," which covers fundamental concepts like databases, and the elective subject "Information II" includes learning topics related to AI (Ministry of Education, Culture, Sports, Science and

Technology-Japan, 2019). Additionally, at the university level, opportunities for learning about AI and data science have been increasing, with numerous faculties in Japan offering programs in these fields (Shinro Navi.,2023). However, there is a notable deficiency in specific opportunities for learning about AI at the elementary and middle school levels. Although the elementary school curriculum guidelines announced in the 2017 academic year mention AI, they do not provide specific instructional content (Ministry of Education, Culture, Sports, Science and Technology-Japan,2017). Similarly, the middle school curriculum guidelines for subjects such as social studies, science, and technology and home economics briefly touch on some AI-related content but do not encompass AI-focused learning experiences (Ministry of Education, Culture, Sports, Science and Technology-Japan, 2018). Consequently, there are challenges in defining the role of AI within compulsory education. Furthermore, the revised "AI Strategy 2022" sets a goal for 2025, aiming for "all high school graduates to acquire a basic literacy in 'mathematics, data science, and AI' and to foster creativity through problem discovery and solving." However, considering that Japan's education system mandates nine years of elementary and middle school education, applying this goal to all citizens is deemed a challenging endeavour (Cabinet Office-Japan, 2022).

The above points confirm that measures are being formulated at the national level to utilize AI technology in the world. It was also confirmed that in countries with advanced AI technologies, efforts are also being made in education for human resource development. In Japan, a similar direction is observed in terms of measures, but in reality, only students who have higher education and above are allowed to learn, and they are not given opportunities to learn so that "all people" can know and utilize the mechanisms of AI, which UNESCO and Japan are aiming for. Therefore, in order to enable students to learn AI from the compulsory education stage in Japan, this study purpose to create a curriculum framework for AI education suitable for Japanese school education by investigating AI curricula and frameworks in the United States, an advanced country in AI education.

In this study, we will focus on AI education in the field of technology in junior high school technology and home economics, which mainly deals with mechanisms and the use of technology, considering that ethical aspects of AI education are implemented in the civics area of junior high school social studies (Ministry of Education, Culture, Sports, Science and Technology-Japan, 2018) and data science aspects are implemented in the mathematics area (Ministry of Education, Culture, Sports, Science and Technology-Japan, 2018) of junior high school. The focus of this project will be on curriculum development in the technology field of junior high school technology and home economics, which deals mainly with mechanisms and the use of technology.

Current Literacy and Curriculum Research on AI Education Worldwide

This chapter provides an overview of AI education curriculum and the perception of AI literacy in the world, and summarizes the basic findings of curriculum development in Japan.

Section1: Five Big ideas and K-12 AI Curriculum Guidelines

The Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA) have organized the AI4K12 Initiative, a working group of scholars, researchers, and teachers to develop national guidelines for teaching AI to students taking K-12. Among its activities, the Initiative is introducing national guidelines for K-12 AI instruction as well as other online resources to facilitate AI instruction, and providing a community of AI-focused practitioners, researchers, and developers.

AI4K12 has developed AI guidelines for K-12 based on the "5 Big Ideas in AI" (**Figure 1**). The "5 Big Ideas in AI" are used by artificial intelligence researchers to better understand AI and develop AI more effectively, and are classified into five categories: 1. Perception, 2. Representation & Reasoning, 3. Learning, 4. Natural Interaction," and "5. Social Impact. "(Touretzky & McCune & Seehorn, 2020) AI4K12 divides K-12 into four clusters of K-2, 3-5, 6-8, and 9-12, respectively, creating a framework for learning about each of the five ideas at each developmental stage (AI4K12, 2023). The fifth framework, "Impact on Society," was presented in December 2022, and all frameworks are currently presented. **Figure 2** shows the Big Idea 1 framework.

This framework has two items, "LO," what the learner will be able to do, and "EU," what the learner will permanently understand; based on the K-1 through K-12 allocations, these two items can be included in the learning content to create a curriculum for AI learning. In addition, the five ideas are interrelated. Therefore, by using this framework while learning, students can learn about AI concepts, essential knowledge, and grade-specific skills from each study. Currently (2023), public comments are being solicited on the framework that has been created, and a trial and error process is underway to make the framework that has now been created more practical and feasible. In this regard, it can be said that the framework is not yet complete and that challenges remain, as it is necessary to continue to accumulate practices in the future.

Section 2: What is AI Literacy? Competencies and Design Considerations (Long & Magerko, 2020)

Long and Magerko point out that the public has a misguided understanding of AI by design and education. They state that AI literacy is necessary to remove such misperceptions of AI. AI literacy in this study is defined as the ability to live with AI in the future.

Figure 1
Five Big Ideas in AI

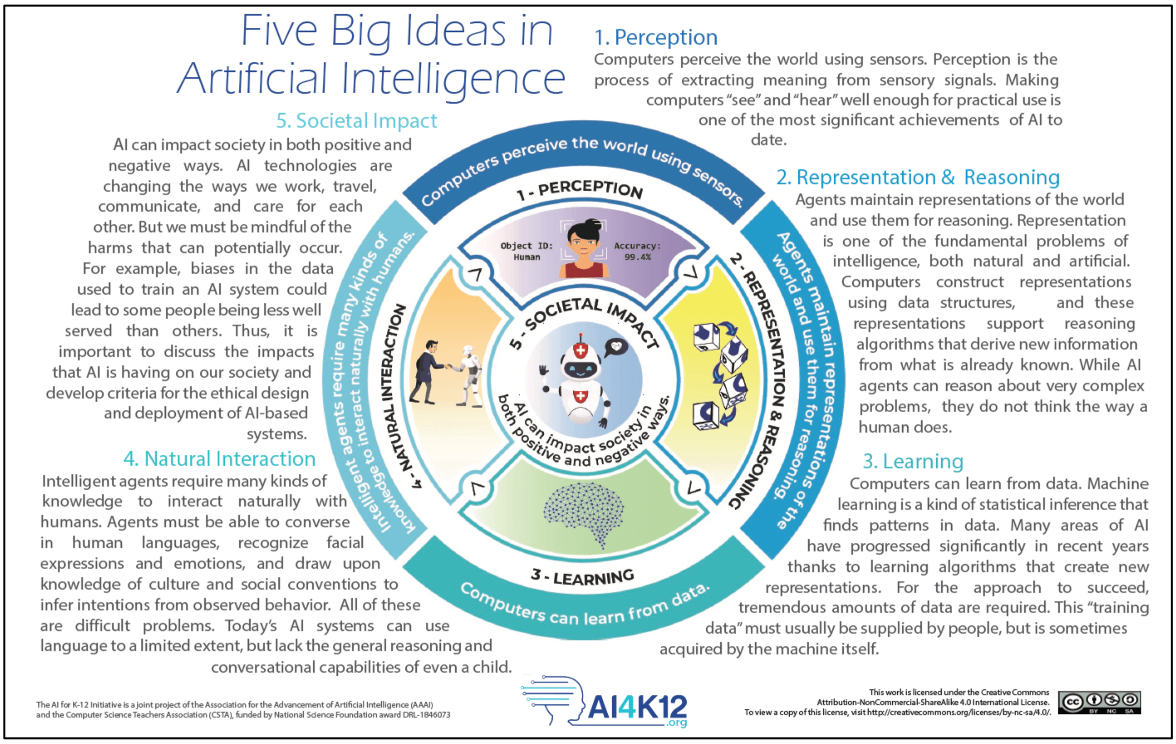

Figure 2
Progression Chart

AI4K12.org — Draft Big Idea 1 - Progression Chart — www.AI4K12.org

Big Idea #1: Perception	*Computers perceive the world using sensors.*	**Perception is the extraction of meaning from sensory information using knowledge.**	**The transformation from signal to meaning takes place in stages, with increasingly abstract features and higher level knowledge applied at each stage.**	LO = Learning Objective: what students should be able to do. EU = Enduring Understanding: what students should know.
Concept	**K-2**	**3-5**	**6-8**	**9-12**
Sensing (Living Things) **1-A-i**	**LO:** Identify human senses and sensory organs. **EU:** People experience the world through sight, hearing, touch, taste, and smell.	**LO:** Compare human and animal perception. **EU:** Some animals experience the world differently than people do. **Unpacked:** Bats and dolphins use sonar. Bees can see ultraviolet. Rats are have no color vision; dogs are red-green colorblind. Dogs and rats can hear higher frequences than humans.	**LO:** Give examples of how humans combine information from muliple modalities. **EU:** People can exploit correlations between senses, such as sight and sound, to make sense of ambiguous signals. **Unpacked:** In a noisy environment, speech is more understandable when the speaker's mouth is visible. People learn the sounds associated with various actions (such as dropping an object) and can recognize when the sound doesn't match their expectation.	N/A -- for AI purposes, this topic has already been adequately addressed in the lower grade bands. *Other courses, such as biology or an elective on sensory psychology, could go into more detail about topics such as taste, smell, proprioception, and vestibular organs.* *Possible enrichment material: look at optical illusions (Muller-Lyer illusion, Kanizsa triangle) and ask which ones are computer vision systems also subject to.*
Sensing (Computer Sensors) **1-A-ii**	**LO:** Locate and identify sensors (camera, microphone) on computers, phones, robots, and other devices. **EU:** Computers "see" through video cameras and "hear" through microphones.	**LO:** Illustrate how computer sensing differs from human sensing. **EU:** Most computers have no sense of taste, smell, or touch, but they can sense some things that humans can't, such as infrared emissions, extremely low or high frequency sounds, or magnetism.	**LO:** Give examples of how intelligent agents combine information from multiple sensors. **EU:** Self driving cars combine computer vision with radar or lidar imaging. GPS measurement, and accelerometer data to form a detailed representation of the environment and their motion through it.	**LO:** Describe the limitations and advantages of various types of computer sensors. **EU:** Sensors are devices that measure physical phenomena such as light, sound, temperature, or pressure. **Unpacked:** Cameras have limited resolution, dynamic range, and spectral sensitivity. Microphones have limited sensitivity and frequency response. Signals may be degraded by noise, such as a microphone in a noisy environment. Some sensors can detect things that people cannot, such as infrared or ultraviolet imagery, or ultrasonic sounds.
Sensing (Digital Encoding) **1-A-iii**	N/A	**LO:** Explain how images are represented digitally in a computer. **EU:** Images are encoded as 2D arrays of pixels, where each pixel is a number indicating the brightness of that piece of the image, or an RGB value indicating the brightness of the red, green, and blue components of that piece.	**LO:** Explain how sounds are represented digitally in a computer. **EU:** Sounds are digitally encoded by sampling the waveform at discrete points (typically several thousand samples per second), yielding a series of numbers.	**LO:** Explain how radar, lidar, GPS, and accelerometer data are represented. **EU:** Radar and lidar do depth imaging: each pixel is a depth value. GPS triangulates position using satellite signals and gives a location as longitude and lattitude. Accelerometers measure accleration in 3 orthogonal dimensions. **Unpacked:** Radar and lidar measure distance as the time for a reflected signal to return to the transceiver. GPS determines position by triangulating precisely timed signals from three or more satellites. Accelerometers use orthogonally oriented strain gauges to measure acceleration in three dimensions.

Until now, the subject of AI education to cultivate such AI literacy has been to increase diversity in the workforce. However, some of the AI education targets announced around 2019 to develop AI literacy are now being targeted to those without a technical background. Therefore, the authors decided to extract key aspects from the literature in various fields to create a framework on which to base the design of learning to cultivate AI literacy.

First, AI literacy in this study was defined as "a set of skills that enable individuals to critically evaluate AI technology, communicate and collaborate effectively with AI, and use it as an AI tool online, at home, and at work." AI literacy is also defined by the authors as the skill to understand "AI without knowing how to code," in view of the fact that most of the AI we interact with in our daily lives does not require us to know how to program. This confirms that the authors aim to develop a set of capabilities to evaluate and utilize AI without having to understand how to program.

To cultivate AI literacy, the authors present five conceptual frameworks. These are "What is AI?", "What can AI do?", "How does AI work?", "How should AI be used?",” How do people perceive AI?” . Within each of these frameworks, competencies and design considerations are provided. Long and Magerko? analyzed more than 150 articles on AI education from a variety of fields to determine: 1. what do AI experts believe non-technical learners should know about AI, and 2. what are the existing knowledge and misconceptions that non-technical learners have when interacting with AI. This analysis was conducted from the perspective of "What do non-technical learners see as important to know about AI?
The study concludes by indicating that it encourages this research to guide future empirical and design research on AI literacy, but challenges the need for further empirical research and the need to expand it to accommodate new knowledge, technologies, and rapidly changing social norms.

Section 3: K-12 AI curricula (UNESCO, 2022)
UNESCO has conducted a survey and analysis to capture the current status of what kind of AI education K-12 students are receiving to prepare them for life and work in the AI age, and compiled the results in a report. Specifically, UNESCO has conducted a survey on AI curriculum recommended by each government, its contents, and its implementation. In addition, the report aims to help guide the development of support tools and frameworks with a view to developing a framework for teaching AI literacy in each country.

The "Five Big ideas and K-12 AI Curriculum Guidelines" and "What is AI Literacy? Competencies and Design Considerations" are also cited as examples in this report. The report also summarizes the actual status of AI education in each country.

At the end of the report, nine findings and thirteen recommendations are presented, based on the survey and analysis of the actual situation. Among these are: "There is still a paucity of research on the evaluation of AI curricula," "Most AI curricula tend to be integrated into existing academic subjects," "The goals of AI curricula should focus on the development of values and skills necessary for work and life in the AI age," and "Developmentally appropriate The "need to develop a curriculum that is developmentally appropriate," and "the PBL method, which is a real-life problem-solving activity, is often used as a suitable and effective educational method for an AI curriculum.

Section 4: Summary of Literacy and Curriculum Research on AI Education Worldwide

Summarizing the findings from the survey of the three previous studies, two common points were observed.

1. that AI education is required to enable people to adapt to the future society

2. In AI education, it is necessary to provide literacy education for AI concepts and other competencies and AI applications.

3. That it is necessary to provide learning that is appropriate to the developmental stage of learners.

4. Many practices of AI curriculum have not been reported and need to be demonstrated in the future.

Based on these results and issues, we will aim to create a Japanese version of the AI curriculum framework.

The Reality of Information Education in Japan

In this chapter, we organize information education in Japan and aim to find points of contact that can be applied to AI education.

Section 1: Historical Background of Information Education in Japan
According to Sumi, the "information society" in Japan began to arrive in the 1960s, and at that time it was "intensive informatization" in which specialists aimed to process information efficiently (Sumi, 2018). In the midst of this informatization of society, the response of education was indicated in the "Promotion of Information Processing Education in High Schools" in the "Council on Science Education and Industrial Education (1969)". From this time until the early 1980s, a vocational education approach was used to develop information processing skills.

However, major changes began to occur in computers after the 1970s, and personal computers spread rapidly from 1984, when the Internet began operations. In 1986, the second report of the Provisional Council on Education proposed the term "information use ability," and the term "reading, writing, and computer literacy" was used to refer to the ability to use information. In 1986, the second report of the Provisional Council on Education proposed the term "information literacy" and positioned it as one of the basic literacy skills along with "reading, writing, and abacus. Since then, information education in Japan has been conducted as shown in **Table 1**, with the aim of fostering the ability to utilize information.

The "ability to utilize information" is defined as "the qualities and abilities necessary to perceive various events in the world as information and its connections, and to use information and information technology appropriately and effectively to discover and solve problems and form one's own ideas". Specifically, it is defined as "the ability to use computers and other information tools appropriately in learning activities as needed to obtain information, organize and compare information, transmit and communicate the obtained information in an easy-to-understand manner, and store and share the information as needed" and "the ability to use information tools necessary for carrying out learning activities, such as basic operation and the ability to use information technology in an appropriate manner. It also includes "the ability to acquire the basic operations of information means necessary to carry out learning activities, as well as qualities and abilities related to programming thinking, information morality, etc."

From the above, it was confirmed that in Japan, "information" has been taught as a "means" to solve problems, and that learning of skills has been the main focus of information education. This is different from other countries that have promoted computer literacy education, which is not limited to computer learning but also includes methods of communicating to others, and thus handles information in a consultative manner.

Table 1: Transition of Information Education

period	event
1985	Administrative action is taken for information education as general education.
1986	The term "information use ability" first appeared in the second report of the Provisional Education Council.
1989	Information education is included in the curriculum guidelines at elementary, junior high, and high schools.
1997	Three perspectives and eight elements of information use ability were established in the "Toward the Implementation of Systematic Information Education (First Report).
1998	Courses of study are presented with an awareness of systematic information education. The aim is to cultivate the ability to use information in "comprehensive study time" in elementary through high schools, "Information and Computers" in the technology field of technology and home economics in junior high schools, and the new "Information" course in high schools.
2007	Fundamental Law of Education Reform
2011	Revised Courses of Study for Elementary Schools
2012	Revised Courses of Study for Junior High Schools. Information and Computers" is reorganized into "Information Technology.
2013	Revised Courses of Study for Senior High Schools. Revised to "Common Subject Information Science" and "Information" as a specialized subject.

Section 2: **Current information utilization skills (Ministry of Education, Culture, Sports, Science and Technology-Japan (2019)**

The Courses of Study for elementary and junior high schools were published in March 2017, and the Courses of Study for elementary and junior high schools for special-needs children were published in April of the same year, positioning "information use ability" as a "quality and ability that forms the basis of learning" as well as language ability and others. In order to cultivate these abilities, it was decided that "curricula should be organized from a cross-curricular perspective, taking advantage of the characteristics of each subject area," and that ICT environments should be developed at each school to enhance learning activities that make appropriate use of these abilities. This is a significant change, since the "qualities and abilities" had not been positioned as such until now.

In addition, in the Courses of Study for elementary schools and special-needs schools, learning activities and programming education for mastering basic ICT operations are to be implemented systematically according to the characteristics of each subject, and in each Courses of Study, various improvements have been made in both information education and the use of ICT in subject guidance. In the Courses of Study for Senior High Schools published in March 2018 and Courses of Study for Senior High Schools of Special Needs Schools published in February 2019, "development of ability to utilize information" and maintenance of ICT environment are described as in elementary and junior high schools, and "Information I" is newly established as a required subject in senior high schools. In addition, various enhancements were made to the use of ICT in information education and subject guidance, such as the establishment of "Information I" as a required subject in high schools.

In the handbook prepared in December 2019, the "three perspectives and eight elements" previously presented were reorganized into three pillars of qualities and abilities in order to cultivate the ability to use information. The reorganized contents are summarized in **Table 2**.

In this section, we will check the contents related to AI education. Programming learning is included from Step 2 of the middle elementary school stage. In addition, learning about networks, which will be the basis for AI learning, is included from Step 4, the junior high school stage. However, we could not confirm any other descriptions of learning that might be related to AI.

From the above, it was confirmed that the current information use ability, as well as the previous information use ability, does not have a strong computer literacy aspect and, therefore, does not sufficiently mention AI education.

Table 2: Three perspectives and eight elements of information use ability

point of view	Element
Practical ability to use information	Appropriate use of information tools according to the task and purpose
	Independent collection, judgment, expression, processing, and creation of necessary information
	Transmitting and communicating information in consideration of the situation of the recipient, etc.
Scientific understanding of information	Understanding of the characteristics of the information tools that form the basis of information use
	Understanding of basic theories and methods to handle information appropriately and to evaluate and improve one's own information use
Attitude to participate in the information society	Understanding of the role and impact of information and information technology in our social life
	Necessity of information morality and responsibility for information
	Attitude to participate in the creation of a desirable information society

Section 3: Information education in the field of technology at junior high schools (Ministry of Education, Culture, Sports, Science and Technology-Japan, 2020)

We explored the relationship between AI education and the technology field of junior high school technology and home economics (hereinafter referred to as "junior high school technology") in the Courses of Study published in 2017.

First, we looked for descriptions related to AI in the study guidebooks for the technology field. In the summary of the study of information technology, there are examples of studies in which the use of artificial intelligence is examined from various perspectives. However, we could not find any descriptions of the use of artificial intelligence as a matter of instruction.

In the current Courses of Study, the qualities and abilities to be fostered in all subjects are organized into three categories: "knowledge and skills," "ability to think, judge, and express," and "ability to learn and human nature. The qualities and abilities listed here are those that Japanese children need to "carve out a future society," and it is clear that they are abilities that must be acquired at the compulsory education stage. This, in other words, can be seen as the general education necessary for children who will live in the future.

The same is true for junior high school technology education. Information education in junior high school technology is organized into the four qualities and abilities shown in **Table 3**.

Table 3: Handling of information education in the field of technology

Guidance Matters	Study Contents
(1) Activities to investigate information technology that supports our daily life and society	・Understanding of principles and laws of information representation, recording, computation, communication, etc., digitalization of information, automation and systemization of information processing, and information security ・Understanding of information morality
(2) Activities to solve problems in daily life and society by programming interactive contents using networks	・Understanding of the structure of information and telecommunications networks and the mechanisms for using information ・Acquire skills to create safe and appropriate programs, check their operation, and debug them. ・To solve problems by programming interactive contents.
(3) Activities to solve problems in daily life and society by programming measurement and control	・Understand the mechanism of measurement and control systems ・Acquire skills to create safe and appropriate programs, check their operation, and debug them. ・To solve problems by programming measurement and control systems
(4) Activities to consider the future development of society and the state of information technology	・Understanding the concept of technology in relation to daily life, society, and the environment ・Evaluate technology and consider appropriate selection, management, and operation, as well as improvement and application based on new ideas.

Reading Table 3, the study of networks is the content of the middle school technology course. This is the foundation for learning AI. It was also confirmed that problem solving through programming is being implemented.

Considering that the Courses of Study aim to provide children with the general education they need, it was confirmed that the junior high school technology course considers these contents to be necessary skills for today's children.

In addition, although junior high school technology and home economics technology is a subject that deals with technology education, it was found that technology is taught as a "general education" rather than as a specialized education.

Section 4: Informatics Education in Information Studies, a Common Subject in Senior High Schools (Ministry of Education, Culture, Sports, Science and Technology -Japan, 2019)

In the 2018 high school curriculum guidelines in Japan, a new subject, 'Information Science,' was introduced, and its connection to information and AI education was explicitly outlined. Specifically, in the curriculum for Information I and Information II, elements of AI education are incorporated into the topics of 'Problem Solving in the Information Society' and 'Computers and Programming,' with corresponding learning examples provided. This confirms a clear commitment within high school education to integrate AI, aligning with the national AI strategy's goal of equipping high school graduates with AI literacy.

Section 5: Organizing Prior Research on AI Education in Japan

We explored papers on AI education in Japan from a database operated by the National Institute of Informatics and categorized them by category.

A survey of papers containing the word AI education from 2000 to 2023 identified 107 papers.

Of these, 103 papers targeted at universities were found to include the development of teaching materials, practices, and surveys for university students. Four papers were targeted at high schools, one for research, two for practice, and one for implementation. One paper was targeted at middle schools, and only one was a survey. Note that this one paper was the same as the one targeting upper secondary schools. There were zero cases for elementary schools.

From the above points, it was confirmed that most of the papers on AI education in Japan are related to the "Mathematics, Data Science, and AI Education Program Accreditation System at the Literacy Level (MDASH)" under the AI Strategy issued earlier by the Cabinet Office, and that most of them are targeted at universities. Some papers were also found targeting some upper secondary schools, but almost no papers at the compulsory education level could be identified.

Section 6: Organize the requirements for the development of a Japanese AI curriculum framework

In organizing the previous studies up to this point, the following three things have been confirmed.

1) Information education in Japan has treated "information" as a "means" for problem solving and has focused on skill-based learning. Information here includes elements other than computers, and to date, a different approach has been taken than in other countries where computer literacy education has been promoted. Among these, information utilization skills are currently organized into three perspectives as qualities and abilities to be cultivated. In terms of content, some of the studies are common to computer literacy education. Among them, network learning was found to be related to AI education.

2. Japanese compulsory elementary and junior high schools aim to nurture children with "the skills necessary to pioneer the society of the future. This means that Japanese elementary and junior high schools are the places where children learn the skills necessary for living in the future society, i.e., the general education required for the future. In addition, as for information education in their respective schools, "programming thinking" is fostered in elementary schools, and computer literacy education is provided in junior high school technology courses. However, we could only confirm network learning as a study related to AI education.

3. It was confirmed that AI education is implemented in higher education and beyond.

Based on the above points, we set three requirements for the creation of an AI curriculum framework for technology education at the compulsory education level in Japan.

1. to effectively utilize the current learning in the acquisition of information application skills, since computer literacy education is not sufficiently implemented in Japan

2. Since information use ability is organized into three qualities and abilities, the framework should also be organized into three qualities and abilities.

3. Of the instructional content related to AI education at the upper secondary school level and above, the content of general education should be handled.

With regard to 3, it has been confirmed that the content of instruction at upper secondary school is set based on the study of junior high school technology subjects. Therefore, it was assumed that the content of upper secondary school instruction would be selected that could be carried over to the junior high school stage.

Based on these requirements, the development of an AI curriculum framework in Japan will be implemented.

Development of a Japanese AI Curriculum Framework

In this chapter, we will develop a Japanese AI curriculum framework based on the previous research survey in Chapters 2 and 3. As indicated in "1. Introduction," this study aims to develop a framework

focusing on "technology education" at the compulsory education stage.

The procedure for developing the framework is to first organize the AI literacy to be fostered, consider considerations for fostering AI literacy, and then create a framework that incorporates specific learning items.

Section 1: Organizing AI literacy to be developed through technology education

The requirements for the development of the Japanese AI Curriculum Framework, which were set up to provide instructional content at the level of general education 3, the "AI literacy" proposed by Long and Magerko is consistent with the needs of this framework.

In addition, since this AI literacy also takes into account the "5 Big Ideas in AI," we considered that it fully satisfies the UNESCO recommendation for curriculum development to check whether or not it is based on evidence.

Therefore, we decided to extract only those competencies proposed by Long and Magerko that are consistent with the qualities and abilities in the field of technology and home economics technology. The following eight competencies were selected: 1. Recognizing AI, 4. General vs. Narrow, 5. AI's Strengths & Weaknesses, 6. Imagine Future AI, 12. Learning from Data, 15. Sensors, 16. Ethics, and 17. Programmability. Competencies 8 " Decision-Making)" and 13 " Critically Interpreting Data" are technical contents, but were excluded from the junior high school version of AI literacy because they should be covered in the common subject of information science in upper secondary schools, considering the actual state of learning in Japan.

Next, we organized the relationship between each competency and the content of study in the technical field of technology and home economics (hereinafter referred to as "technology studies"), and prepared to make use of them in curriculum development after the creation of AI literacy. In organizing the content, based on the current content of technology studies, we categorized the relationships with the competencies into three categories: (1) those that can be adapted from the current content, (2) those that can be adapted from the current content, and (3) those that are new and not covered in the current content.

The first category, "1) items that can be adapted from the current study content," includes "15. sensors. Sensors have been studied in the Measurement and Control Systems course in the Technology Department, so we believe that the content can be used as it is in the current course.

Next, "2) Items that should be adapted from current studies" include "1. recognition of AI," "5. advantages and disadvantages of AI," "6. imagining future AI," and "16. ethics. First, for "AI awareness," we have been studying "understanding of principles, laws, and mechanisms" in order to acquire knowledge and skills in the technology course. Although AI technology is a new technology, we thought that the study of its advantages and disadvantages could be transferred to other areas of study in the technology class. We thought that we could transfer the study of AI technology from our previous technology courses to the study of its pros and cons. In the past, we have also worked on "Imagining Future AI," in which students evaluate and utilize technology to think about the future of the technology they have learned about in the summaries of the subject matter. Imagining AI of the future will lead to being able to "evaluate and utilize AI technology," and we thought that we could transfer this learning development. As for "ethics," the technology department has been studying "information morality" in its information studies. We thought that the content of this study could be adapted by including AI technology in the study content.

Lastly, "3) New content not covered in the current curriculum" includes "4. wide and narrow AI," "12. learning from data," and "17. programmability. In "Broad and narrow AI," students will learn the difference between specialized AI and general-purpose AI, which is the AI of the future era, by comparing them based on their social applications and mechanisms. As for "learning from data," although it is not possible to transfer the content from the technology course, it is possible to transfer the content from the information science course, a common subject in high schools. In this context, we will take a technological approach to how to collect data and how to utilize data. For "programmability," we will incorporate new learning content such as AI programming. In doing so, we will take into consideration the fact that this is a general education technology, so that students will be able to solve problems with a minimum of programming, rather than complicated programming.

Based on these organized contents, AI literacy was organized based on the three qualities and abilities in the current Courses of Study. **Table 4** shows the organization.

Section 2: Curriculum Development Considerations for Fostering AI Literacy

In developing the curriculum for teaching AI literacy described above, we examined considerations Long and Magerko each have a set of design considerations in their proposed AI literacy instruction. Based on this, we organized the considerations for competency development.

First, as a prerequisite, we will implement AI education in the context of general education technology, so that even learners who do not have mathematical or computer knowledge can learn AI concepts.

Table 4: Organization of the relationship between the Japanese version of AI literacy and the three pillars of qualities and abilities

Competency	Knowledge and Skills	Thinking, Judgment, Expression, etc.	Ability to Learn, Human Nature, etc.
Recognizing AI	Understanding how to identify the presence of AI		
General vs. Narrow	Understanding of the differences between humans and AI.		
AI's Strengths & Weaknesses	Understanding the pros and cons of AI	Ability to understand the advantages and disadvantages of AI and use AI to solve problems	
Imagine Future AI		Ability to use AI technology to solve problems to build a better society	Attitude to devise and create AI technologies to build a better society
Learning from Data	Understanding that AI learns from data	Ability to use data to solve problems	
Sensor	Understanding of how AI collects data	Ability to collect necessary data to solve a problem	
Ethics	Understanding the relationship between AI and data that raises ethical issues		Attitude to use AI ethically, with consideration for bias and user privacy
Programmability	Proficiency in programming AI		

Next, regarding the considerations in each competency, in the competency "5. advantages and disadvantages of AI," students should be able to treat AI technology critically by understanding it correctly while doubting its intelligence and reliability. It also introduces viewpoints that are not generally introduced so that participants can look at AI from new perspectives.

Competency "6. Imagine AI of the future" enables students to solve problems with an awareness of society and to experience AI learning that interacts with society.

Competency "12. Learning from Data" will enable students who utilize the system to understand the process for AI to reason through experiments. In addition, by preparing data sets for learning applications, students will be able to better understand the limitations and deadlines of the data. Furthermore, they should be able to collect data with preconceived notions so that there is no bias in the source of the data set.

In Competency "16. Ethics," in order to increase the transparency of the design in problem-solving situations where AI is utilized, the design intent and the data, etc. being utilized should be presented in a manner that is clear to the other party.

Finally, in competency "17. Programmability," care should be taken to ensure that coding skills are not harmed by the issue. In addition, consideration should be given to the fact that biased AI can be created by personal values, so that the impact of such bias can be understood.

The above points will be taken into consideration when discussing the content of instruction.

Section 3: Curriculum to foster AI literacy

After organizing the previous contents, curriculum development for fostering AI literacy will be conducted. Here, we will organize the contents of instruction for fostering AI literacy with reference to the "Progression Chart" in AI4K12, and conduct curriculum development. As shown in Japan's information use skills and elementary school programming studies, programming has been studied since elementary school, but unlike K-12, Japanese schools do not practice AI education from elementary school. Therefore, the content of instruction will be organized in relation to what Japanese junior high school students are learning. In addition, as with literacy, we decided to organize it in relation to the three pillars of qualities and abilities.

Of the eight competencies, the items that fall under Big Idea 1 are "15. sensors," those under Big Idea 2 are "1. recognition of AI" and "17. programmability," and those under Big Idea 3 are "1. recognition of AI," "5. strengths and weaknesses of AI," "12. learning from data Learning," "17. Programmability," items that fall under Big Idea 4 are "4. Wide and Narrow AI," "5. Advantages and Disadvantages of AI," and items that fall under Big Idea 5 are "1. Recognizing AI," "6. Imagining AI in the Future," and "16. Ethics," and the content of instruction was organized accordingly. **Table 5** shows the organized instructional content. The items adopted as instructional content were selected and discarded according to the developmental stage of Japanese junior high school students.

Table 5: Japanese AI Curriculum - For Junior High School Technology

	Competency	Knowkedge and Skills	Thinking,Judgment,Expression,etc	Abikity to Learn,Human nature,etc
BigIdea 1	Sensor	・Know what computer sensors recognize. ・Know how images are recognized through features and be able to explain how image detection works.		
BigIdea 2	Recognizing AI	・Be able to explain the difference between algorithms and AI for classifying things.		
	Programmability	・To be able to explain how to make decisions on algorithms to solve problems by using decision trees, etc.		
BigIdea 3	Recognizing AI	・Understand the difference between how people learn and how AI learns.		
	AI's Strengths & Weaknesses	・It can also detect potential biases in the training data and their causes.		
	Learning from Data	・Know how supervised and unsupervised learning recognizes. ・A dataset can be created and a classifier can be trained. ・Understand that large amounts of data are needed to understand broad concepts.		
	Programmability	・The accuracy of the AI model can be verified.		
BigIdea 4	General vs. Narrow	・Understand the difference between narrow and broad AI systems.		
	AI's Strengths & Weaknesses	・Know that there are questions that AI can answer and questions that it cannot answer.		
BigIdea 5	Recognizing AI	・Explain how AI-based services are used on a daily basis.		
	Imagine Future AI		・The daily life that will be changed by AI technology can be examined. ・Design and produce AI that solves social problems.	・It attempts to examine daily life as it is changed by AI technology. ・Trying to design and produce AI that solves social problems
	Ethics	・Understand that AI technology can have different effects on different human input resources. ・Deepfake defects can be identified.	・Evaluate the impact of AI on various goals and values. ・Evaluate whether transparency and accountability are met in the design of AI systems. ・AI can be used to design the system in such a way that privacy is not violated.	・Tries to consider the impact of AI on various goals and values.

In this study, we investigated curricula and frameworks for creating curricula in countries where AI education is practiced ahead of other countries in Japan, in order to enable students to learn about AI from the compulsory education stage in Japan. We aimed to create a curriculum framework in AI education suitable for the technology field of junior high school technology and home economics, which focuses on the use of mechanisms and technology in Japanese school education.

The following is a summary of the findings of this study.

(1) We were able to explore the trend of AI education in the world and confirm "AI literacy" as a general education, "AI curriculum frame" and considerations.

(2) We were able to confirm the actual situation of AI education in Japanese education, and the contents of information education to date, in an organized manner.

(3) We were able to develop a frame for an AI curriculum for junior high school technology courses, drawing on past Japanese information education while referring to global trends.

These findings have enabled us to develop a framework for learning to acquire some AI literacy in Japanese junior high school students through the study of junior high school technology courses.

Curriculum development and classroom practice based on this framework in Japanese junior high school technology classes will be the subject of future work.

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Development of video teaching materials and self-monitoring system to support skill acquisition

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Abstract

Technology education in Japan is offered only in junior high school technology and home economics classes, and it is necessary for students to efficiently acquire the skills that form the basic content of technology education in a limited amount of time. In addition, because of recent technological innovations, the use of tablets is recommended in school education. The purpose of this study is to develop a multi-viewpoint system using tablets that can be easily introduced in the classroom for skill acquisition in technology education, and to develop video materials to support skill acquisition. In this study, we focused on the skill acquisition scene of sawing, and developed a system that can easily monitor sawing from three directions and created a video to support the acquisition of sawing skills. As a result of using the system, the participants were able to identify problems in their movements by themselves and tried to correct them, and their sawing skills improved.

Keywords: Skill acquisition; Sawing; Technology education; Self-monitoring system; video teaching materials; multichannel input device

Introduction

In this study, we believe that skill acquisition, which is the foundation of engineering and technology education, has advantages that cannot be learned in other subjects. However, for the following reasons, for example it takes time to acquire the skills (Yamamoto, 2023; Okuno *et al.*, 2003), the direction of technology education has changed due to the diffusion of ICT in schools (MEXT, 20219, 2020b; Yamamoto, 2010), and teachers' teaching skills (Mukouyama, 1987), opportunities for that learning and teaching have been reduced (MEXT, 2020a; Mastumoto *et al.*, 2013). Therefore, this study aims to develop a skill acquisition system using ICT equipment for sawing to improve the efficiency of skill acquisition for learners and teachers, and to respond to the new direction of technology education.

To improve the efficiency of skill acquisition, audio-visual materials have been developed (Uzawa *et al.*, 2011; Ando *et al.*, 2012), a system using sensors and applications has been developed (Itagaki *et al.*, 2021), and a self-monitoring system using multiple viewpoints has been developed (Fukuda *et al.*, 2021). In order to use the systems and teaching materials presented in the previous studies in schools, knowledge and costs are required to implement them, and there are challenges in utilizing them in general schools.

As a new direction of technological education, ICT-based technological education is expected to be developed along with innovations in information equipment (MEXT, 2021a; Kimura *et al.*, 2023). On the other hand, looking at the average of OECD member countries, the ratio of ICT utilization reached 51.3%, while the ratio of ICT utilization in Japan was only 24.4% in elementary schools and 17.9% in junior high schools (MEXT, 2021b).

Based on the above, the effective use of ICT equipment to improve the efficiency of skill acquisition has the potential to fully complement the challenges of providing learning opportunities for skill acquisition and the use of ICT. If these issues could be solved, it would be possible to guarantee skill acquisition as a basis for engineering and technology education, while fully responding to the new direction of technology education.

Therefore, the purpose of this study was to treat sawing as a skill acquisition scene and to develop video teaching materials using a system that displays video data from three directions on a single screen in real time using a tablet, which is widely used in general. We also attempted to verify the efficiency of skill acquisition by using the developed system.

Methodology

In this study, we created video teaching materials using ICT equipment in the acquisition of sawing skills, and conducted a verification experiment with college students as subjects in order to verify the learning effects. Also, we approached the video material from two perspectives: to allow the learner to observe the sawing operation from multiple viewpoints by using the equipment with multi-view input, and to create multiple examples of the sawing operation.

Developed multi-view input system; In this study, we utilized a multi-channel input device from Company I and used the camera function of a tablet device for filming. This system uses three tablets to capture images of the saw being used from three directions: front, side, and flat. Each tablet and multi-channel input device can be connected via HDMI for input to a single screen and synchronized (Figure 1, 2). Figure 3 shows an example of video recording.

Figure 1: System structure and connections

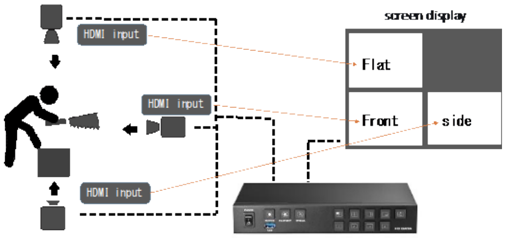
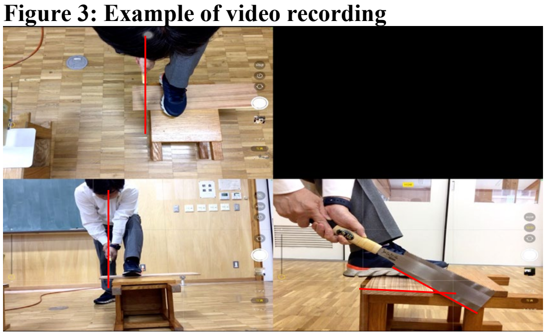


Figure 2: System structure and connections

Figure 3: Example of video recording



Developed video materials: Based on the authors' previous teaching experience, four videos were created by intentionally reproducing errors that students are likely to stumble upon.

Video #1: Proper sawing, the appropriate sawing video material describes material fixation (chair orientation, foot position, and material position), posture and eye awareness, selection of saw tooth type, beginning cutting procedure, saw angle, stroke, and end of cut.

Video #2: Problems with saw angle, in this video, the material is firmly fixed, but the angle of the saw is large, and the material is lifted upward with a force greater than the force exerted by the foot. In this video, you can learn about adjusting the proper saw angle and balancing the applied force.

Video #3: Problems with posture and line of sight, this video shows that there are problems with the posture and leg position for fixing the material and the line of sight during cutting, and that the misalignment increases as the saw is pulled. For correct posture and eye contact, the position of the legs can be checked, and the state of the cut can be checked with both eyes.

Video #4: Problems with the stroke, in this movie, the stroke of the saw is short and only a part of the saw blade is utilized.

Figure 4: Problems with saw angle

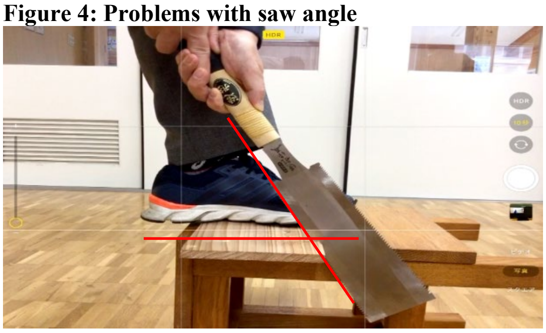


Figure 5: Problems with posture and line of sight

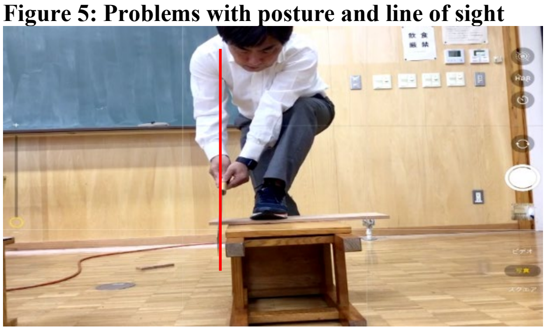
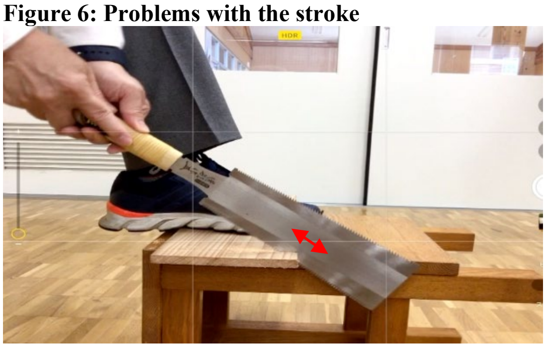


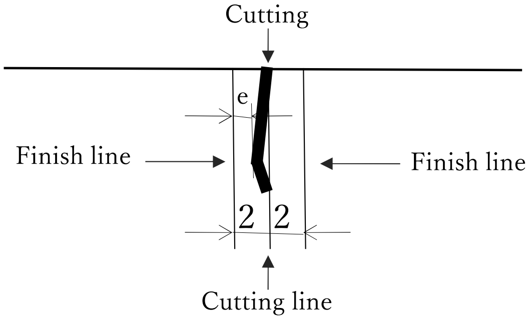
Figure 6: Problems with the stroke



The experiment was conducted in May 2023. Forty college students (22 males and 18 females) were divided into a control and an experimental group, and then the effect of skill acquisition in sawing was verified through regular explanations and explanations using the video materials developed. The measurements taken were deviation from the cut line, cutting time, and sawing awareness survey. Data for 36 students were included in the analysis, excluding students whose cutting times, misalignments, etc. were significantly larger than those of others.

In the experiment, a double-edged saw (210 mm blade length), a woodworking chair for the material fixing stand, and thinned cedar wood (600 mm long, 150 mm wide, and 10 mm thick) as the material to be cut were provided, assuming that the experiment would be conducted at a junior high school. Finish lines were marked on four sides of the material; cutting lines were marked 2 mm from the finish lines (Figure 7). These lines were prepared before the experiment. Subjects cut the material by sawing with both hands.

Figure 7: Finish and cutting line, deviation



The " deviation: e" of the sawing was measured as the deviation from the finish lines. In the measurement, the maximum deviation of both the front and back surfaces was measured in units of 0.1 mm by utilizing a digital caliper. Based on the fact that this experimental saw produces a 1.4 mm shaving allowance, the deviation was measured based on the distance of the finishing line from 0.7 mm, which is half of the 1.4 mm allowance.

The procedure consisted of the first cutting, explanation (video viewing), second cutting, and third cutting. After the first cutting, the participants were divided into two groups (control group and experimental group) so that the cutting time and displacement were equal among the groups.

Explanations were given on the names of each part of the saw, characteristics of the blade, and safety instructions. The cutting method was explained for about 10 minutes, including instruction on fixing the material, how to hold the saw, how to start cutting, the angle of the saw when cutting, how to apply force, the cutting posture, eye contact, and the end of the cut. The control group then received approximately 6 minutes of explanation by general demonstration, and the experimental group received 6 minutes of explanation while watching four videos.

The second cutting was intended to relax the students by explaining that time measurements and errors would not be figured. A third cut was then made for measurement. For educational considerations, the control group received a video explanation of the sawing, and the experimental group received a demonstration of the sawing, and the experiment was completed.

Findings

The results of the sawing tasks are shown in Table 1 and Table 2. Also, no significant differences were observed in both the first cutting time and the misalignment, confirming the two groups as the same quality group. Furthermore, both groups showed significant differences in both cutting time (Control Group: t (34) = 2.99, P<0.01, Experiment group: t (34) = 5.35, p<0.01), and deviation (Control Group: t (34) = 2.11, P<0.01, Experiment group: t (34) = 3.50, p<0.01) from the pre-experiment levels, confirming the improvement in skill.

Table 1: The results of the cutting time

	Cutting time (t)			
measurement	Control Group	Experiment group	t-test	
1st	44.1	45.4	0.30	n.s.
2nd	32.4	31.0	0.61	n.s.

Table 2: The results of the deviation

	Deviation (mm)			
measurement	Control Group	Experiment group	t-test	
1st	1.53	1.56	0.05	n.s.
2nd	0.98	0.62	2.07	*

:* p<0.05

To confirm the usefulness of the video teaching materials developed in this study, we checked the significance of cutting time and deviation and found no significant difference in cutting time. However, a significant difference was confirmed for deviation (t(34)=2.07, p<.05), indicating that the deviation was smaller in the experimental group. In other words, we were able to confirm the usefulness of the video teaching materials developed in this study in terms of a smaller deviation range.

In addition, a five-item questionnaire was conducted on awareness during the sawing task, which is not easily expressed in the results of the task. The results of the survey, showing the mean values of the control and experimental groups for awareness during the sawing task, are shown in Table 3. The results of the significance difference test showed that there were two items that were significantly different between the control and experimental group. The two items that showed significant differences were "awareness of posture" (t(34)=2.14, p<.05) and "awareness of line of sight" (t(34)=2.17, p<.05). In other words, the video materials were able to make the subjects more aware of their posture and line of sight, especially during the sawing task. Video #1 illustrates appropriate sawing with respect to posture and line of sight, and video #3 shows some posture and line of sight issues, suggesting that these materials produce a more adequate learning effect than explanations through general demonstration.

Table 3: Awareness during the Sawing task

	Control Group	Experiment group	t-test	
Direction of the workbench	3.9	4.0	1.46	n.s.
Angle of the saw	3.7	3.9	1.26	n.s.
Fixing materials firmly in place	3.6	3.6	0.33	n.s.
Lengthening the stroke	3.7	3.7	0.35	n.s.
Posture during work	2.8	3.3	2.14	*
Sound of work	2.3	2.4	0.40	n.s.
Line of sight	3.2	3.6	2.17	*
End of work cut-off	3.8	3.9	0.47	n.s.
Types of saw teeth	4.0	4.0	-	n.s.
Enations and videos	3.6	3.6	0.33	n.s.
Beginning of work	3.9	3.9	0.00	n.s.

*: p<0.05

Conclusion

The purpose of this study was to develop a video teaching material using a system that displays video data from three directions on a single screen in real time, treating sawing as a skill-learning scene using tablets, which are widely used in general. We also attempted to verify the efficiency of skill acquisition **by** using the developed system. The results are summarized below.

The first outcome of this study was the development of four video teaching materials of successful and unsuccessful cases of sawing from three viewpoints on a single screen. The second outcome is that the usefulness of the created video teaching materials was confirmed by the experimental results, which showed that the sawing deviation was reduced. The final outcome confirms the awareness during the sawing task, which could not be clarified in the experiment, and confirms the usefulness of the video materials developed in this study regarding the sawing posture and line of sight.

In summary, as discussed in the introduction, we were able to verify that the effective use of ICT equipment to improve the efficiency of skill acquisition has the potential to fully complement the challenges of providing learning opportunities for skill acquisition and the use of ICT.

The remaining issue is the development of a self-monitoring system. By using multi-channel input devices to monitor their own skills, the learners can check their individual problems. If the self-monitoring system can be effectively utilized in conjunction with the developed video teaching materials, it will be possible to provide learning opportunities for further skill acquisition and fully complement the issues of ICT utilization.

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An Exploratory Study into the Impact of Professional Learning and Development on Teachers' Digital Technologies Implementation

Lynley Stringer, Dr Kerry Lee, Dr Sean Sturm, and Nasser Giacaman

Abstract

Consistent with global trends towards education that promotes the skills and dispositions students will need to actively engage in the society of their future, the New Zealand National Curriculum was updated in 2017 to include Digital Technologies-focussed technological areas. The content was named "Hangarau Matihiko" in the indigenous Māori-medium curriculum and "Digital Technologies" in the English-medium curriculum. This exploratory study investigated the long-term impact of three different models of professional learning and development on 48 primary and intermediate school teachers' implementation of the Digital Technologies and Hangarau Matihiko curricula. The findings showed Professional Learning and Development has a positive influence on teachers' Hangarau Matihiko/Digital Technologies implementation, Professional Learning and Development reduced internal barriers to implementation, and Professional Learning and Development needs to support teachers to create their own lessons and resources.

Keywords:

21st-century capabilities, elementary education, improving classroom teaching, secondary education

Introduction

The growing sophistication of digital technologies (e.g., artificial intelligence and big data) has already triggered a shift in the labour market away from highly repetitive and uncomplicated tasks to those that demand more complex aptitudes (OECD, 2018), with exponential growth predicted within our lifetime (Keep & Brown, 2018). Adding further complexity is the reliance placed on these technologies to solve a growing range of complex societal problems such as climate change (Benade, 2017), growing inequality and natural resource depletion (OECD, 2016). Although the extent to which these developments will play out is argued by many, one thing that is agreed upon is the role that education plays in promoting the skills and dispositions students will need to actively engage in the society of their future (Keep & Brown, 2018; World Economic Forum, 2018).

Consistent with global trends, the New Zealand Ministry of Education (MOE) updated the existing Te Marautanga o Aotearoa (Indigenous Māori medium) curriculum and the New Zealand Technology curriculum (English medium) in 2017 to include two new Digital Technology areas. The content was named "Hangarau Matihiko" (HM) in the Māori-medium curriculum and "Digital Technologies" (DT) in the English-medium curriculum.

Falling under the wider Computer Science (CS) subject, DT extends students past the eLearning/digital fluency focus of learning *with* technology to learning *about* technology (MOE, 2018). A critical component of DT is student development of computational thinking (CT) skills (e.g., algorithmic thinking, decomposing problems, representing data) and the ability to apply these skills both digitally and non-digitally to solve a range of problems (Dong et al., 2019). Unique to this curriculum area, teachers are expected to adopt 21st-century pedagogies to promote students' development of DT dispositions such as creativity and critical thinking (Battelle for Kids, 2019; Relkin et al., 2021).

The need for this transition to prepare young people for an increasingly complex and volatile world is evident (World Economic Forum, 2018), yet, globally, implementation of DT curricula has been slow (Larke, 2019) and inconsistent (Mertala et al., 2021). In response, a range of CS Professional Learning and Development (PLD) models have been created to increase teachers' understanding of DT curricula and required pedagogy (Lim et al., 2020; Reinsfield, 2016).

The purpose of this article was to explore how different PLD models affected New Zealand primary school teachers' experiences implementing the HM|DT curricula. The research questions guiding this study were as follows:

- How does participation in Professional Learning and Development models influence teachers' Hangarau Matihiko and Digital Technologies implementation?
    - How do different Professional Learning and Development models influence teachers' Hangarau Matihiko and Digital Technologies implementation?
- How does Professional Learning and Development impact the challenges teachers face when implementing the Hangarau Matihiko and Digital Technologies curricula?

Through this research, we gained an empirical understanding of the impact of HM|DT PLD on teachers' implementation, which can be used to inform decisions to support teachers' HM|DT implementation, ultimately leading to better outcomes for students and societies.

Literature Review

The benefits of DT education are wide and can be seen at a student, school and society level (European Commission/EACEA/Eurydice, 2019; OECD, 2019; Rich et al., 2020; Webb et al., 2017).

Digital Technologies in Aotearoa/New Zealand

Covering students in Years 1-13 (ages 5-18), the HM|DT curricula address similar principles but are not direct translations of each other (Kellow, 2018). Rather than prescribe one-size-fits-all guidelines and exemplars, the New Zealand HM|DT curriculum content is written in general terms to allow schools to develop their own unique implementation of the content and empower teachers as decision-makers (Crow et al., 2019). From 2017, the MOE funded a range of PLD support packages to increase teachers' digital fluency and knowledge of the HM|DT curriculum areas. Funding is no longer available for HM|DT PLD.

Challenges to Digital Technology Implementation

While updating/adopting curricula is seen as one of the first steps required to transform education and drive reform, there is a multitude of "very powerful barriers in place that prevent digital technologies [curricula] from reaching their potential in educational institutions and teaching and learning practices" (OECD, 2016, p. 3).

External barriers

The evolution of technology from its vocational beginnings has led to confusion around the importance and purpose of DT and its role in education (Kellow, 2018; Reinsfield & Fox-Turnbull, 2020). Misconceptions are further widened due to a lack of global agreement on (1) basic concepts in this learning area, (2) the best methods to deliver the content (Fowler & Vegas, 2021) and (3) even the name of the subject area itself (McGarr & Johnston, 2020; Varoy et al., 2021).

Given the technical component of DT, it is unsurprising that teachers working in schools that are well-resourced in terms of DT infrastructure (e.g., bandwidth, networking and appropriate digital devices) find it easier to effectively implement DT (Lindberg et al., 2017; Vrasidas, 2015). Yet due to the evolving nature of this learning area, schools are challenged to find funds both initially to purchase ICTs and on an ongoing basis to maintain upgrades and licenses, etc. (Bolstad, 2017; Johnson et al., 2017). Research has also highlighted teachers can face additional challenges if DT is not a priority of the school community in terms of funding provision for ICTs (Yadav et al., 2016), PLD and a supportive environment to encourage implementation (Sentence & Csizmadia, 2017).

Internal barriers

DT requires teachers and students to be digitally competent (Garneli et al., 2015), and, while there has been an emphasis on teachers' ICT capabilities within education systems for many years now (European Commission/EACEA/Eurydice, 2019), a lack of teacher and student familiarity with ICTs was highlighted prior to the Coronavirus pandemic (Bower & Falkner, 2015) and again after the pandemic (van der Vlies, 2020).

DT, in its redeveloped form, is a reasonably new learning area for both primary and secondary schools (Geldreich & Hubwieser, 2020; Heintz & Mannila, 2018), requiring teachers to develop new knowledge and understandings of technical concepts, often with little prior knowledge to base this on (Vivian et al., 2020). The multifaceted aspect of DT (e.g., principles, ICTs, hardware/software) and evolving nature of each requires teachers to continually upskill to ensure they stay aware of new developments (Johnson et al., 2017; Munasinghe et al., 2021). Developing a 21st-century pedagogical approach has also been seen to challenge some teachers (Lindberg et al., 2017).

Professional Learning and Development

To respond to changes in education and ensure a high standard of teaching, teachers are expected to be life-long learners and regularly undertake PLD activities to develop their "skills, knowledge, expertise and other characteristics as a teacher" (OECD, 2009, p. 49). DT PLD has been shown to significantly influence teachers' DT understanding (including jargon), DT self-efficacy, DT implementation (Kong et al., 2020; Munasinghe et al., 2021), address misconceptions (Bower & Falkner., 2015; Reinsfield, 2016) and promote adoption of 21st-century pedagogical approaches (Lim et al., 2020).

Yet there are still areas for improvement, with Buss and Gamboa (2017) and Rich et al. (2021) finding teachers felt anxious when teaching more complicated concepts even after completing a PLD programme. Additionally, Heintz & Mannila (2018) found teachers were confident teaching the lessons provided in the PLD, but they did not develop the confidence to create their own lessons or support other teachers within their schools.

The many factors impacting DT implementation have led researchers to claim that new kinds of PLD are needed to ensure teachers feel confident in their DT knowledge, understanding of the purpose of DT and connections to their own classroom setting, are comfortable adopting 21st-century pedagogies and are ICT literate (Pargman et al., 2020; Vivian et al., 2020).

Current study

CS research shows PLD has a positive impact on teachers' CS implementation (e.g., Kong et al., 2020; Rich et al., 2021) and perceptions of barriers to implementation (Celepkolu et al., 2020), yet there is a multitude of differences between each PLD model (e.g., content, facilitation method, follow up support, length of sessions) (Love et al., 2022) limiting the generalisability of the findings. There are gaps in research that compares the long-term impact of in-person and online PLD (Love et al., 2022) and longitudinal research that measures changes between internal and external order barriers to CS implementation (Schmitz et al., 2022). Furthermore, the researchers could not uncover any CS research that examined the impact of different DT PLD models on teachers' implementation.

To help fill these gaps and support DT implementation, this study analysed the long-term impact of three distinctly different PLD models (including in-person and online) on primary school teachers' implementation of the HM|DT curricula and tracked how the PLD influenced barriers to teachers' implementation.

Methodology

This research followed a mixed-method design, with data collected through a descriptive longitudinal survey design methodology (Hofer & Piccinin, 2010). Ethical approval was granted from the University of Auckland Human Participants Ethics Committee on 18 March 2022, reference number UAHPEC23875.

Participants

Due to the mix of online and in-person PLD models, both convenience and clustered sampling practices were used to recruit participants. In July 2022, educational entities (e.g., DTTA and TENZ), social media DT support groups and all pertinent school principals listed in the MOE school directory were emailed details of the research and invited to forward the research information to their members/teaching staff.

Teachers signed up directly with the researcher and were invited to complete the first questionnaire through the secure Qualtrics platform two weeks prior to beginning their chosen PLD model (July/August 2022), then again within two weeks of finishing the PLD (September/October 2022) and finally approximately six months after completing the PLD (February/March 2023). For each questionnaire participants completed, they were provided with a $20 gift card. To ensure a range of perspectives were gathered, participants were encouraged to complete all three questionnaires even if they had not completed all the allocated PLD or had missed a previous questionnaire.

47 participants completed the initial questionnaire, 40 the second, and 37 the final questionnaire. Representing about 0.05% of the overall New Zealand teaching workforce (MOE, n.d.), 33 participants completed all three questionnaires. Appendix A shows the background data of these 33 participants.

PLD models

Participants were given the choice of completing one of three HM|DT PLD models.

Online Self-Led

From 2018 to 2020, the Kia Takatū ā-Matihiko\Digital Readiness Programme consisted of self-directed online pīkau (short online lessons), and online and in-person workshops were designed to upskill teachers to imbed HM|DT in their teaching. In 2020, this programme was officially closed, yet many of the online resources were transferred to an open platform. Participants were able to access these remaining resources and work independently through the pīkau.

In Person

Delivered by a MOE Accredited Facilitator, this PLD option consisted of two 1-hour workshops delivered at a primary school in New Plymouth, New Zealand. This PLD introduced participants to the HM|DT curricula and involved hands-on activities (both non-digital and digital) that participants could implement within their own classrooms. It included reflection and discussion time with the other participants. Teachers were given access to a range of online activities to adapt within their own teaching programme.

Online Facilitated

Delivered by the same accredited facilitator as the in-person workshops, these two 1-hour workshops were delivered online through Google Classrooms. Again, this PLD introduced participants to the HM|DT curriculum and included reflection and discussion time between participants. Teachers were asked to gather a range of objects prior to the session so that they could follow along with the hands-on activities. Again, participants were given access to a range of online activities to adapt in their own planning.

Instrument

The implementation and challenges constructs within the questionnaire were created based on the findings of Dong et al. (2023), Rich et al. (2020), Sentance and Czismadia (2017) and Shin et al. (2021). Open-ended questions regarding areas participants felt confident in, areas they were less confident in, goals they had set themselves and any challenges they and their school face with implementing DT were also included to gather detailed information to support the quantitative questions. Pre-testing of the instrument was conducted with a group of educators. The DT version of the first questionnaire is provided in Appendix B.

Analysis

Quantitative Analysis

Numerical values were applied to answers from the 33 participants that completed all three of the questionnaires to create two constructs to measure changes in implementation and challenges over the research period. Descriptive statistical analysis was undertaken on both these constructs, and statistical analysis was conducted on the implementation construct. A two-way repeated measures Analysis of Variance (ANOVA) was conducted using the SPSS software to make comparisons between the dependent variable (implementation) and the between-subjects factor (PLD models: in-person, online facilitated and online self-led) and the within-subjects factor (time: pre-, mid- and post-).

Qualitative Analysis

The qualitative dataset was made up of participants' responses to the open-ended questions. Inductive style reflexive analysis following Braun & Clarke's (2022) guidelines was undertaken on all participants' qualitative data (including participants that only completed one or two questionnaires), meaning the dataset was made up of 125 responses from 48 individual teachers. The main researcher first conducted this analysis using the NVivo software prior to review by the other researchers.

Triangulation

The initial findings from the statistical analysis and the thematic analysis were then integrated following a concurrent convergence triangulation model (Plano Clark & Creswell, 2018).

Results

This section begins with a focus on the number of PLD hours participants completed before presenting the triangulated qualitative and quantitative analysis in relation to each of the research questions.

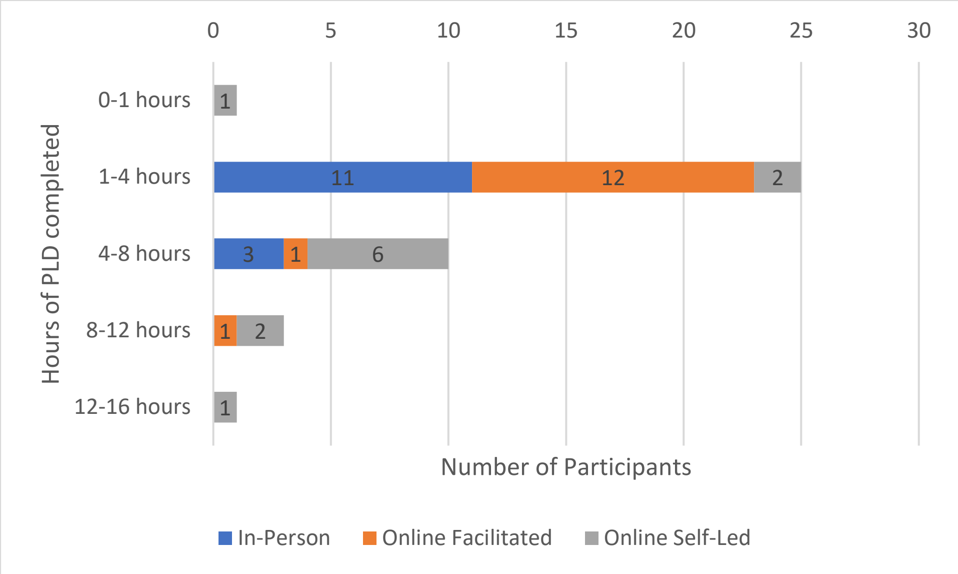
While the thematic analysis was conducted in an inductive way, after the initial review of the dataset, the themes were found to correspond to the categories within Knezek & Christensen's (2016) will, skill, tool pedagogy (WSTP) model, which predicts teachers' technology integration. The 'will' category represented teachers' attitudes towards HM|DT; 'skill' referred to teachers' HM|DT knowledge and understanding; 'tool' represented external factors; and 'pedagogy' related to how teachers teach (Woltran et al., 2022). Appendix C shows how the qualitative data was organised around the WSTP model.

PLD hours

The number of hours of PLD associated with this research that the participants of each PLD group completed is shown in Figure 1.

Figure 1

Number of Hours of PLD Participants Completed as Part of Research Project

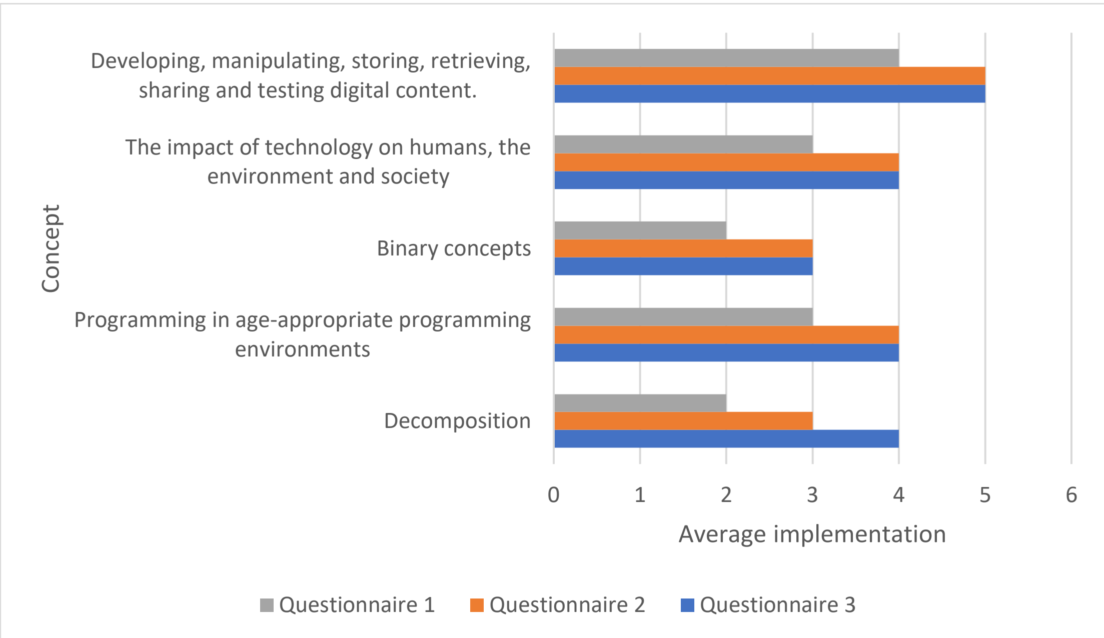


How does participation in different Professional Learning and Development models influence teachers' Hangarau Matihiko and Digital Technologies implementation?

Figure 2 shows how the average implementation of five key HM|DT skills changed over the research period.

Figure 2

Average Implementation of Hangarau Matihiko/Digital Technologies Key Skills Over Research Period



Note: The following scale was used: (1) I'm unsure of the task, (2) Never, (3) Less than once a term, (4) About once a term, (5) About once a month, (6) About once a week, (7) Almost daily.

Implementation was seen to increase in all five key areas from beginning the PLD to directly after the PLD. Binary was shown to be the skill implemented least at the 6-month post-PLD mark, with qualitative data suggesting teachers were less confident with this skill.

The mean and standard deviations for teachers' value beliefs for each PLD group over the three data collection periods are shown in Table 1. The highest possible cumulative score a teacher could have was 35.

Table 1

Mean and Standard Deviation for Hangarau Matihiko/Digital Technologies Implementation Over Research Period

Time	PLD model	Mean	Std Deviation	N
Pre-	In-person	12.27	3.88	11
	Online facilitated	16.62	5.44	13
	Online self-led	15.67	4.69	9
	Total	**14.91**	**5.00**	**33**
Mid-	In-person	17.09	4.11	11
	Online facilitated	21.23	5.51	13
	Online self-led	20.33	3.32	9
	Total	**19.61**	**4.78**	**33**
Post-	In-person	19.91	6.53	11
	Online facilitated	22.00	6.11	13
	Online self-led	22.22	2.54	9
	Total	**21.36**	**5.48**	**33**

Increases between the pre- and mid-data collection points on average rose approximately 5-points with small increases between the mid- and 6-month post-PLD point.

Appendix D outlines how the assumptions of ANOVA were applied to the two-way repeated measures analysis. Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the two-way interaction (x2(2) 9.35, $p = .009$). The Greenhouse–Geisser method was used to correct for this. There was no statistically significant interaction between the PLD model and time on implementation, $F(3.14, 47.03) = .36$, $p = .790$, partial $\eta 2 = .02$. The main effect of time showed a statistically significant difference in mean implementation between the pre- to mid- and pre- to post-data collection periods. There was no statistically significant difference in implementation beliefs between PLD groups. Further main effects are reported in Appendix E.

The qualitative data described the positive impact of the PLD on teachers' HM|DT implementation.

> Having now learnt how easy it is to use the vocabulary throughout other curriculum subjects, it feels easier to take lessons using the expected curriculum framework for digital

technologies. Q2P32

Yet other participants described how conflicting school priorities and changes in teaching circumstances meant their HM|DT implementation had not changed after completing the PLD.

> I have not yet had a chance to implement this learning this term as the release component I was teaching has changed, and my team is loaded with three major school-wide PLD. Q2P20

While a few participants had not been able to overcome challenges to begin implementing the DT at the 6-month post-PLD mark, the majority of the analysis suggested the PLD increased teachers' understanding of the curriculum resulting in improved implementation through more explicit planning, teaching and discussion of key HM|DT skills.

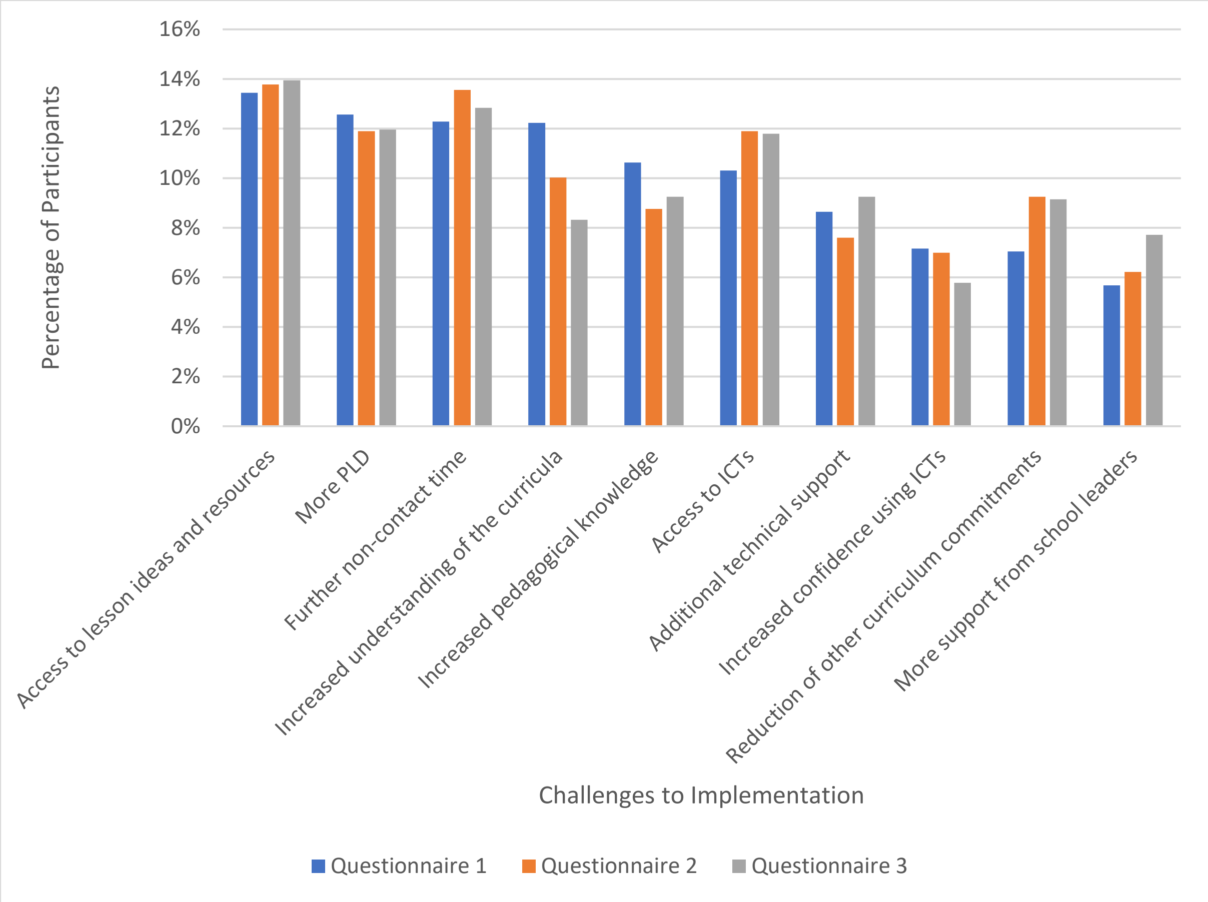
How does Professional Learning and Development impact the challenges teachers face when implementing the Hangarau Matihiko and Digital Technologies curricula?

The most frequent factor that the qualitative data was coded to related to 'skill' (34%), followed by 'tool' (25%), 'pedagogy' (24%) and 'will' (18%). This shows the importance both internal factors (skill) and external barriers (tool) have in supporting teachers' HM|DT implementation.

Participants were asked to rank the ten common challenges to DT implementation factors (shown in Figure 3) from those that supported their implementation the most to those that supported their implementation the least. Values from 1 (least support) to 10 (most support) were given to participants' ranking of each of the factors, and these were summed at each data collection point. Figure 3 shows how participants' rankings of these challenges changed over the research period.

Figure 3

Challenges to Participants' Hangarau Matihiko/Digital Technologies Implementation Over Research Period



The quantitative data showed each of the internal challenges (increases understanding of the curricula, increased pedagogical knowledge and increased confidence using ICTs) reduced over the research period and all remaining external challenges except more PLD grew. Although the greatest barrier identified throughout all three data collection periods was access to lesson ideas and resources (13%, 14%, 14% retrospectively), only 2% of the qualitative data was coded to a lack of lesson ideas and resources.

> I find it difficult to find age-appropriate activities that are both plugged and unplugged, which are engaging and immerse all the students into digital technologies throughout the other core curriculum subject areas. Q1P32

Initially, participants ranked more PLD (13%) as the factor that would next support their implementation the most, but, after they had conducted the PLD, unsurprisingly, this factor was replaced by access to further non-contact time (14%). The qualitative data, alongside many other studies (e.g., Love et al., 2022; Rich et al., 2021), claimed a lack of planning and classroom time to be a substantial barrier to teachers' implementation, so it was surprising to find that this was not highlighted as a more significant barrier within the quantitative data.

> A challenge is the time it takes to find resources and plan for things that aren't second nature. Q3P30

> Time is usually the problem even when trying to integrate through other curriculum areas. (Q3P4)

Pre- PLD participants found their lack of understanding of the HM|DT curriculum was a barrier to their implementation (12%), but, after the PLD (10%) and again six months post-PLD (8%), participants did not rate this challenge as high. Many participants attributed increases in their understanding of the curricula to experiences implementing HM|DT.

> I am much clearer about what is expected at my level. I can see now how it can be incorporated across the curriculum. Q2P30

> I am really enjoying trying new things and investigating how I can improve. The more confidence I have, the more I am exploring. (Q3P11)

Similarly to Shin et al. (2021), it was encouraging to see that more support from school leaders was not seen to be a major challenge to teachers' HM|DT implementation (6%, 6%, 8% retrospectively), although interestingly it did become more important to participants after conducting the PLD.

> Getting our curriculum document updated is my first goal. This will help to ensure myself and all the staff understand how to incorporate digital technologies into all our teaching and learning programmes. Q2P47

Over the research period, access to lesson ideas and more support from school leaders became more of a barrier to teachers' implementation.

Teachers were shown to face many common challenges to their implementation, with the quantitative data showing the PLD reduced internal challenges by increasing teachers' HM|DT knowledge. Access to lessons and resources was seen to be the greatest barrier to teachers' HM|DT implementation throughout the whole research period.

Discussion

Finding One: PLD has a positive influence on teachers' HM|DT implementation.

While this study did not find that one PLD model was more effective at raising teachers' HM|DT implementation, statistically significant improvements in implementation were found after participants completed the PLD. Collectively, HM|DT implementation was seen to rise at all three data collection periods, yet the number of teachers contributing to this rise in implementation dropped off at the 6-month post-PLD mark. Hamamsy et al. (2021) found a similar effect where collectively more CS lessons were being implemented in the second-year teachers who undertook PLD, but these were being taught by fewer teachers than in the first year.

The qualitative analysis reiterated the findings of Cutumisu and Guo (2019) by showing that the PLD helped teachers form positive beliefs about DT and gave them the confidence to trial implementing these skills. Most participants' HM|DT implementation increased immediately after the PLD and then again at the six-month mark after having the opportunity to implement HM|DT lessons and cement their new knowledge. This connects to the responses of Rich et al.'s (2021) participants that their confidence in teaching coding increased after implementing coding lessons.

Teachers' implementation of lessons that introduced students to binary concepts increased over the research period, yet it was the skill least implemented, and the qualitative data suggested it is an area teachers are less confident implementing.

Finding Two: PLD reduced internal barriers to implementation

Due to the relatively recent introduction of DT curricula and teachers' lack of familiarity with ICTs (van der Vlies, 2020), there is a multitude of internal factors impacting teachers' DT implementation (Celepkolu et al., 2020; Shin et al., 2021). While teachers' CS understanding and pedagogical knowledge are known to be a barrier to implementation (Love et al., 2022; Rich et al., 2021), this research extends current understanding by highlighting the positive impact of PLD on internal challenges to teachers' HM|DT implementation. This finding raises questions about how PLD can be further strengthened to also reduce the impact of external barriers.

Finding Three: PLD needs to support teachers to create their own lessons and resources

Access to lesson ideas and resources was found to be the highest barrier to teachers' HM|DT implementation at all three data collection periods. While Crow et al. (2019) discovered an excess of relevant and easily accessible online and offline lesson support materials, the qualitative data reiterated the findings of Mellegard & Pettersen (2016) and Vrasidas (2015) that teachers lacked the time to search and apply these resources to their own classroom setting.

The qualitative data supported the findings of Hamamsy et al. (2021) and Saxen and Chiu (2022) in that participants found the PLD provided them with basic lesson ideas and resources that could easily be used in the classroom to get them started. Yet participants in this research and that of Shin et al. (2021) raised concerns about a lack of knowledge in developing lessons that targeted students with diverse needs, varied skills and behavioural difficulties.

Limitations

Limitations of this research include the non-randomisation of participants to PLD groups, attrition of participants throughout the research period, the lack of a control group and the fact most participants from the in-person PLD were from the same school. The research was limited to New Zealand primary teachers, and there was a relatively small sample size with a slight underrepresentation of male teachers. Only one type of data was collected (say what it is), and there was a reliance on recruiting participants through electronic means (email and social media). While these limitations are not uncommon within complex education systems, acknowledging them helps to contextualise and validate the research findings.

Conclusions and Future Work

Recognising teachers' and students' low ICT skills (van der Vlies, 2020), teachers' limited exposure to DT (Yadav et al., 2016) and the many factors impacting teachers' DT implementation (OECD, 2016), it is not surprising we have seen a trend of offering CS PLD to primary school teachers. Research such as this has shown PLD, in general, has a positive influence on teachers' self-efficacy (Love et al., Rich et al., 2021) and implementation (Hamamsy et al., 2021). Filling identified research gaps, this study found PLD had a positive long-term impact on 48 primary school teachers' HM|DT implementation, but no one type of PLD model (in-person, online facilitated, online self-led) was more effective at raising implementation than the other.

The research found no statistical difference between in-person, online-facilitated and online self-led PLD on teachers' HM|DT implementation, yet long-term growth in implementation was seen in 80% of participants. This growth was promising, given the challenges teachers described at the beginning of a new school year with upskilling a new group of students. Teachers found having the time to cement their knowledge and reflect on experiences teaching the curricula (Rich et al., 2021; Saxena & Chiu, 2022) gave them more confidence to implement further. This raises questions about the differences between PLD models in terms of the duration of the PLD and available follow-up support.

The study uncovered the ways PLD influences the challenges teachers face implementing HM|DT and revealed ways in which CS PLD can be strengthened to minimise these challenges. Participants' responses suggested PLD would benefit from building on DT concepts they already know (Bartholomew et al., 2022), placing more emphasis on skills they are less confident with (Rich et al., 2021), and supporting teachers to develop their own lesson plans and resources (Shin et al., 2021).

While Redmond et al. (2021) claim internal barriers are more difficult to overcome than external barriers, participants within this research claimed internal factors were not such a barrier to their implementation post-PLD. Like teachers in Celepkolu et al.'s (2020) research, many participants claimed that, after the PLD, they felt less intimidated by the HM|DT curricula. Furthermore, participants in this study had revelations post-PLD on how much of the curricula they were already inadvertently teaching within other curriculum areas. This highlights how even short introductory PLD can upskill teachers' understanding and have a significant effect on both the quality and quantity of their HM|DT implementation.

The vagueness, pedagogical freedom and need to integrate DT within other curriculum areas are all new approaches for New Zealand teachers that saw participants seeking access to lesson materials to support their implementation (Mellegard & Pettersen, 2016). This barrier can be addressed through PLD to ensure teachers are provided opportunities to upskill in adapting existing and creating appropriate resources based on the curricula that are appropriate for; students' interests/skills, teachers' abilities, available ICTs and their unique setting (Celepkolu et al., 2020). This is of particular importance in ensuring planning caters to all students, including those with diverse learning and behavioural needs (Shin et al., 2021).

The study highlighted a multitude of areas of future research such as the relationship between teachers' DT knowledge and implementation, the difference between short-term and ongoing PLD and the impact of providing pre-developed lessons and resources on teachers' DT self-efficacy and implementation.

This article reports the findings around teachers' HM|DT implementation that forms part of a larger research project. The authors plan to publish a second article around the impact of the PLD on efficacy beliefs in the near future.

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Appendix A

Descriptive statistics of demographic variables

Demographic variable categories	Frequency *(n = 33)*	Percentage
Gender		
Female	29	88%
Male	4	12%
Age		
20-29 years	5	15%
30-39 years	6	18%
40-49 years	14	43%
50-59 years	5	15%
60-69 years	3	9%
Year level taught*		
Year 0	7	
Year 1	7	
Year 2	7	
Year 3	7	
Year 4	9	
Year 5	12	
Year 6	9	
Year 7	6	
Year 8	7	
Non-classroom role	2	
Highest level of qualification		
Graduate diploma	7	21%
Degree	21	64%
Master's degree	4	12%
Other post-graduate qualifications	1	3%
CS qualifications		
Formal CS qualification	2	6%
None	31	94%
CS support groups*		
DT Facebook groups	6	
Technology Education New Zealand	1	

Digital Technologies Teachers Aotearoa	4
Other	2
None	21
DT PLD completed within the year prior to research*	
School-based	7
Personal learning	2
None	22

*Note: This does not total to 33 as some teachers taught a range of year levels, were members of multiple CS support groups or had completed more than one type of DT PLD.

Appendix B

Questionnaire One:

After collecting background information, each questionnaire was split into two branches based on the curriculum (HM or DT) that participants were implementing. While the questions were identical in each branch, key terminology in the HM version was written in Te Reo Māori to replicate the terminology used in the HM curriculum. Only the DT branch of the first questionnaire is provided here. The questionnaire includes additional questions related to the wider research project that are not relevant to this article.

UNIVERSITY OF AUCKLAND
Waipapa Taumata Rau
NEW ZEALAND

Kia ora,

This confidential questionnaire is part of a PhD research project investigating the effectiveness of different models of Professional Learning and Development (PLD) on promoting primary and intermediate school teachers' implementation of the Digital Technologies component of the New Zealand Technology Curriculum (English-medium curriculum) and the Hangarau Matihiko component of Te Marautanga o Aotearoa (Māori-medium curriculum).

As a participant of this research, you have agreed to take part in a Digital Technologies/Hangarau Matihiko PLD program and complete a questionnaire at three distinct points in time:
(1) prior to undertaking the PLD
(2) within two weeks of finishing the PLD
(3) approximately six months after undertaking the PLD.

This questionnaire is to be completed prior to undertaking your first PLD session. It will take approximately 10 minutes to complete.

More information can be found on the Participant Information Sheet. Thank you very much for your time and help in making this study possible. If you have any queries please feel free to contact me on the email address below.

The $20 gift voucher will be sent by text message to you within 5 working days as a small acknowledgement of your contribution towards this research.

Kia ora rawa atu
Lynley Stringer

Researcher: Lynley Stringer: e-mail lstr769@aucklanduni.ac.nz
Lead supervisor: Dr Kerry Lee: e-mail k.lee@auckland.ac.nz or phone 09 623 8899 ext 48529

Approved by the University of Auckland Human Participants Ethics Committee on 18.3.22 for three years. Reference Number UAHPEC23875.

The focus of this study is on New Zealand primary and intermediate teachers' implementation of the Hangarau Matihiko and Digital Technologies curricular. This means only those teachers currently employed (either part-time or full-time) in a New Zealand primary or intermediate school setting are eligible to undertake this research.

Which of the following categories best describes your employment status?

- ○ Currently employed in a New Zealand primary or intermediate school
- ○ Other (please specify)

Which year level/s are you currently teaching?
More than one option can be selected.

- ☐ Year 0/New entrants
- ☐ Year 1
- ☐ Year 2
- ☐ Year 3
- ☐ Year 4
- ☐ Year 5
- ☐ Year 6
- ☐ Year 7
- ☐ Year 8
- ☐ Other (please provide details)

First and last name:

Email:

Please enter your mobile number.
Note this is used only to send you the gift voucher.

Which category below includes your age?

- ◯ 20-29 years
- ◯ 30-39 years
- ◯ 40-49 years
- ◯ 50-59 years
- ◯ 60-69 years
- ◯ 70+ years

To which gender do you most identify?

- ◯ Female
- ◯ Male
- ◯ Gender diverse
- ◯ Prefer not to say

What is the highest level of qualification you have completed?

- ◯ Graduate diploma
- ◯ Degree
- ◯ Master's Degree
- ◯ Doctorate Degree
- ◯ Other (please list)

Do you hold any formal computer science qualifications?

- ◯ No
- ◯ Yes (please list)

Are you a member of any Hangarau Matihiko or Digital Technologies support groups eg: DTTA, TENZ, Community of Learning, Facebook groups?
If yes please list the group/s

- ◯ No
- ◯ Yes (please list)

Have you completed any Hangarau Matihiko or Digital Technologies PLD in the last year? If so, please list the type of PLD and approximate number of hours completed.

- ◯ No
- ◯ Yes (please list)

Hangarau Matihiko (Māori-medium curriculum) and Digital Technologies (English-medium curriculum) address similar principles for each respective context yet they are not direct translations of each other.

Which of the following curricula do you implement OR do you intend to implement within your teaching?

- ◯ Hangarau Matihiko (Māori-medium curriculum)
- ◯ Digital Technologies (English-medium curriculum)

Questionnaire splits into HM|DT branches here. Only the DT branch is shown here.

Please note this research focuses specifically on teaching ABOUT technology rather than the eLearning/ICT subject of teaching WITH digital devices and computers.

Please do not be discouraged by the questions as they are designed to measure changes in your implementation and confidence teaching the Digital Technologies technological area. All responses are confidential so please answer accurately and honestly.

The Raranga Matihiko Kaiako framework outlines the progress we make as we move from little or no understanding of teaching the Digital Technology curriculum content to mastery of this learning area. Please select the category from the framework below that you feel you best fit into.

Only one can be selected.

- ◯ I am unaware or have limited awareness of the Digital Technology curriculum content including how and why it can be integrated across the curriculum.
- ◯ I understand or have an awareness of the Digital Technology curriculum content. I tend to focus on teaching the content in isolation rather than integrating across the curriculum.
- ◯ I am confident in my understanding of the 'big picture' of the Digital Technology curriculum content including how and why Digital Technology can be integrated across the curriculum. I am beginning to focus on integrating Digital Technology across the curriculum.
- ◯ I am confident in my understanding of the Digital Technology content, and it naturally occurs in my practice.

Please indicate approximately how often you implicitly or explicitly teach each of the following concepts and skills including as cross-curricular learning opportunities:

	I'm unsure of the concept	Never	Less than once a term	About once a term	About once a month	About once a week	Almost daily
Decomposition	◯	◯	◯	◯	◯	◯	◯
Programming in age-appropriate programming environments	◯	◯	◯	◯	◯	◯	◯
Binary concepts	◯	◯	◯	◯	◯	◯	◯
The impact of technology on humans, the environment and society.	◯	◯	◯	◯	◯	◯	◯
Developing, manipulating, storing, retrieving, sharing and testing digital content.	◯	◯	◯	◯	◯	◯	◯

Please indicate your agreement with each of the following statements.

	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree
Digital Technologies concepts should be taught in primary and intermediate schools.	○	○	○	○	○	○
Learning Digital Technologies concepts can help primary and intermediate students become more engaged in school.	○	○	○	○	○	○
My current teaching situation does NOT lend itself to teaching Digital Technologies concepts to my students.	○	○	○	○	○	○
Digital Technologies is an important 21st century literacy.	○	○	○	○	○	○
My current students are going to need to have Digital Technologies knowledge to remain competitive for jobs by the time they are adults.	○	○	○	○	○	○

Please indicate your agreement with each of the following statements.

	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree
I can describe fundamental computer concepts (eg: loops, algorithms).	○	○	○	○	○	○
When I'm presented with a problem, I have difficulty breaking it down into smaller steps.	○	○	○	○	○	○
I can suggest different algorithms to solve the same problem.	○	○	○	○	○	○
I can look at a simple computer program and understand the purpose of each command (eg: input, output, sequences, loops).	○	○	○	○	○	○
I can identify, select, and use a range of digital devices, applications, and file types for a particular purpose.	○	○	○	○	○	○

Please indicate your agreement with each of the following statements.

	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree
I struggle to know where to find resources to support my Digital Technologies implementation.	○	○	○	○	○	○
I can explain concepts from the Digital Technologies curriculum well enough to be effective in teaching Digital Technologies.	○	○	○	○	○	○
I can develop and plan effective computerised and non-computerised (unplugged) Digital Technologies curriculum lessons.	○	○	○	○	○	○
I believe I have the requisite skills to support students to manipulate, store and retrieve digital content.	○	○	○	○	○	○
I find it hard to help students identify the components in a simple input-process-output system and describe how they work together.	○	○	○	○	○	○

Reflecting on your current ability to teach the Digital Technologies curriculum content, do you have any areas that you are more/less confident in? Have you set yourself any goals within this technological area?

Drag and drop the following items to show those that you feel would support your implementation of the Digital Technologies curriculum content the most (top) to those that would support your implementation the least (bottom).

Further non-contact time (eg: planning, testing digital devices)

Access to additional digital devices (eg: laptops, iPads, robotics)

Access to lesson ideas and resources

Additional technical support

More support from school leaders

More PLD

Reduction of other curriculum commitments

Increased understanding of the Digital Technologies curriculum content

Increased confidence using ICTs and digital devices

Increased pedagogical knowledge in relation to teaching Digital Technologies

Please describe any challenges/problems (if any) you and your school face/have faced with implementing Digital Technologies.

Appendix C

Inductive Thematic Analysis Themes and Categories

The number of participants that mentioned each theme is given alongside the number of transcript excerpts that were coded to each theme as well as this figure as a percentage of the total coded comments.

Theme / Sub-Theme Category	**n of participants contributing**	**n of transcript excerpts assigned**	**% of transcript excerpts assigned**
SKILL			
Positive connotations			
Impact of PLD on understanding	21	30	7%
ICT skills	24	27	6%
Impact of PLD on implementation	18	24	6%
HM|DT confidence	12	16	4%
HM|DT curriculum knowledge	13	13	3%
Use of terminology	9	10	2%
Negative connotations			
No change to implementation after PLD	8	8	2%
Limited HM|DT curriculum knowledge	5	5	1%
Terminology	3	3	1%
HM|DT Confidence	2	2	0%
Limited ICT skills	1	2	0%
TOTAL SKILL	**116**	**140**	**34%**
TOOL			
Positive connotations			
Supportive school environment	9	16	4%
Teaching resources	6	7	2%
Student skills & behaviour	2	2	0%
ICT availability	1	1	0%
Negative connotations			
Lack of appropriate ICTs	12	16	4%
Limited planning time	13	15	4%
Lack of classroom teaching time	13	14	3%
Limited student skills & range of behavioural needs	9	13	3%
Lack of school support	11	12	3%
Availability of teaching resources	5	7	2%
TOTAL TOOL	**81**	**103**	**25%**
PEDAGOGY			
Positive connotations			
Cross-curricular approach to implementation	22	35	8%
HM|DT goals	17	24	6%
Implement HM|DT using unplugged approach	15	22	5%

Authenticity of implementation	12	15	4%
Learning alongside students	3	3	1%
TOTAL PEDAGOGY	**69**	**99**	**24%**
WILL			
Positive connotations			
Commitment to further learning	26	36	9%
Already teaching HM|DT	9	10	2%
Positive beliefs towards HM|DT	6	6	1%
Negative connotations			
Lack of HM|DT confidence	14	16	4%
Negative beliefs towards HM|DT	4	6	1%
TOTAL WILL	**59**	**74**	**18%**

Appendix D

Overview of ANOVA Assumptions for Implementation Construct

Assumption (Assessment method)	**Outliers** (Studentized residuals for values greater than +/- 3.)	**Normality** (Shapiro-Wilk's test of normality p > .05)	**Homogeneity of variances** (Levene's test of Homogeneity of variances p > .05)	**Homogeneity of covariances** (Box's test of equality of covariance matrices)	**Sphericity** (Mauchly's test of sphericity)	**Details**
Implementation	Met	Met	Met	Met	Violated	Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the two-way interaction (x2(2) 9.354, p = .009). The Greenhouse–Geisser method was used to correct for this violation.

Appendix E

Main Effects of Implementation ANOVA Analysis

The main effect of time showed a statistically significant difference in implementation at the different time points, $F(1.57, 47.03) = 28.43$, $p < .001$, partial $\eta 2 = .49$, with implementation increasing from pre- ($M = 14.91$, $SD = 5.00$) to mid- ($M = 19.61$, $SD = 4.78$) and post- ($M = 21.36$, $SD = 5.48$). Post hoc analysis with a Bonferroni adjustment revealed that there was a statistically significant increase in implementation from pre- to mid- ($M = 4.7$, 95% CI [2.80, 6.60], $p <.001$) and from pre- to post- ($M = 6.53$, 95% CI [3.73, 9.32], $p <.001$), but not from mid- to post- ($M = 1.83$, 95% CI [-0.17, 3.82], $p = .081$).

The main effect of the group did not show a statistically significant difference in implementation between the PLD groups, $F(2,30) = 2.52$, $p = .097$, partial $\eta 2 = .14$.