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ENHANCING TECHNOLOGY COMPETENCE AMONG PRIMARY STUDENTS THROUGH STEAM LESSONS APPLYING THE DESIGN THINKING PROCESS

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Abstract/Izvleček
This study seeks to evaluate the impact of integrating elements of arts and humanities education into the topic of STEAM on the formation and development of students' competence. The paper suggests a procedure for teaching STEAM subjects using design thinking approaches. Then, technology-related lessons were covered in practical pedagogical activities for grade 3 pupils at three primary schools in Hai Phong, Vietnam. The findings demonstrate that the suggested STEAM subject teaching methodology is workable and helps students develop eight distinctive behavioural markers of technical competence. As a result, this study offers primary school instructors a strategy for implementing STEAM instruction.

Izboljšanje tehnološke kompetence osnovnošolcev s poukom STEAM z uporabo procesa oblikovalskega razmišljanja
Namen študije je ovrednotiti vpliv vključevanja elementov umetnosti in humanistike v okvir izobraževanja STEAM (angl. Science, Technology, Engineering, Arts and Mathematics – znanost, tehnologija, inženiring, umetnost in matematika) ter na oblikovanje in razvoj sposobnosti učencev. V članku predlagamo proces poučevanja predmetov STEAM z uporabo metode oblikovalskega razmišljanja. S tehnologijo povezane lekcije so bile vključene v praktične pedagoške dejavnosti za učence 3. razreda treh osnovnih šol v Hai Phongu v Vietnamu. Ugotovitve kažejo, da je predlagani pristop poučevanja STEAM izvedljiv in pomaga učencem razviti osem značilnih vedenjskih označevalcev tehnične usposobljenosti. Zato ta študija osnovnošolskim učiteljem ponuja strategijo za poučevanje STEAM.

Keywords:
STEAM education, design thinking, technical competence, technology in primary school.

Ključne besede:
izobraževanje izobraževanje STEAM, oblikovalsko razmišljanje, tehnična kompetenca, tehnologija v osnovni šoli.

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Introduction

STEAM education, which combines science, technology, engineering, arts, and mathematics, is a global trend that is gaining attention at all educational levels (Bertrand and Namukasa, 2020; Burnard et al., 2019; Timotheou and Ioannou, 2021). STEAM education encourages students to gain more knowledge in science, technology, engineering, mathematics, and the arts and develop their skills in applying this knowledge to real-world problems. It is regarded as a significant educational strategy for developing and increasing students' capacities (da Silva et al., 2020). By incorporating arts into STEM training, students are pushed to think creatively and develop innovative solutions. This approach also promotes critical thinking, communication, teamwork, and problem-solving skills. Furthermore, students learn digital competence and research ability, both of which are necessary in today's technologically driven environment. Overall, STEAM education educates students, regardless of origin or identity, to be active participants in a complex and rapidly evolving society (Morze and Strutynska, 2021; Perales and Aróstegui, 2021). Numerous academic inquiries have unveiled compelling evidence affirming the applicability of design thinking in facilitating the integration of STEAM education within elementary school curricula (Cook and Bush, 2018; Edelen et al., 2023; Kangas et al., 2013). When combined with a design thinking process that involves empathy elements, STEAM education has been demonstrated to boost students' competence development (Li et al., 2022; Retna, 2016). It fosters creativity and appreciation in students, encouraging them to devise solutions that benefit others (Bush et al., 2020; Cook and Bush, 2018; Edelen et al., 2020). Integrating empathy into the curriculum ensures that students will develop essential problem-solving, critical thinking, and collaboration skills (Cook and Bush, 2018). This approach also helps students appreciate different perspectives and experiences, leading to more inclusive solutions. The outcomes of numerous research endeavours unveil the potential for integrating imagination and design thinking into STEAM education to confer a heightened significance upon the STEAM discipline, advance technical education, and facilitate the cultivation of students' technological competence (Chung et al., 2020; Kant et al., 2018). Additionally, the incorporation of technology education into STEAM instruction will foster the cultivation of students' design thinking acumen, creativity, and social competencies (Cohen, 2017). Design thinking is a valuable tool for educators to address long-term challenges in STEM education (Kangas et al., 2013).

In Vietnam, some educators have applied the design thinking process to implement STEM/STEAM activities in high schools (Do et al., 2021; Ta et al., 2023). However, none of the studies have been applied to primary school students.

Every student possesses a distinct learning style, which significantly influences the calibre of their educational experience. These learning styles are commonly categorized into three groups: visual, auditory, and kinaesthetic (Wulandari and Agustika, 2020). Learning styles will influence students' learning outcomes, reflecting how students understand teachers' materials or self-learning processes (Rasheed and Wahid, 2021). Learning outcomes are also directly proportional to students' motivation to learn (Wallace and Leong, 2020). The above studies show a positive association between students' learning styles, motivation, and learning outcomes. Thus, it becomes evident that students can enhance their educational achievements when educators consistently inspire them while employing teaching methodologies tailored to their individual learning styles (Suciani et al., 2022).

In Vietnamese education, there has been a shift towards competence-based approaches that aim to foster comprehensive development. Forming and developing technological competences for students right from primary school is one of the requirements of this program (Ministry of Education and Training, 2018). This includes the development of technological competences from primary school onwards. The government's Project 146 aims for 80% of schools in Vietnam to incorporate STEM/STEAM education activities by 2030 (Prime Minister of Vietnam, 2022). However, there are currently no specific guidelines for implementing STEAM education in primary schools.

This research project aimed to investigate the following questions:

1. Is the use of the design thinking process appropriate and necessary for organizing and presenting STEAM lessons in elementary school?
2. How does teaching STEAM lessons through the design thinking process affect the development of elementary school students' technological competencies?

Literature review

Forms of teaching STEAM education in primary schools

The findings of several prior studies have indicated that the implementation of STEAM education in elementary schools can encompass the use of project-based teaching, the engineering design process (EDP), and collaborative learning.

To implement STEAM education, Liao (2019) proposes the integration of art, project-based teaching, and the maker movement for the effective execution of STEAM education. Teaching STEAM subjects in conjunction with project-based learning facilitates the application of knowledge from the realms of science, technology, art, and mathematics, enabling students to engage with society and take part in the design process within specific artistic contexts to address challenges encountered during learning activities (Lu et al., 2022). Collaborative learning, a teaching method that allows students to work together to explore, investigate, and solve problems while building knowledge, is often used in STEAM education (Gillies and Nichols, 2015). Cooperative learning within the framework of STEAM education utilizes collective and collaborative learning as a pedagogical approach, enabling students to collectively engage in exploration, investigation, and problem-solving to construct knowledge. This approach is commonly utilized in STEAM education to enhance the understanding of group members in STEAM fields, facilitating research, collaboration, and task completion (Li et al., 2022). Erol et al. (2023) demonstrated the favourable impact of EDP-based STEAM education on student creativity and creative problem-solving skills. Multiple studies suggest that STEAM education underscores the importance of creativity, aesthetics, and individuality through empathetic design for crafting solutions (Bush et al., 2020; Cook and Bush, 2018; Edelen et al., 2020). Cook and Bush (2018) argue that the empathy stage is a unique and essential aspect of design thinking, acting as a driver to inspire students and cultivate their enthusiasm for suggesting problem-solving solutions. Moreover, the design thinking process not only offers elementary school students an opportunity to share their unique viewpoints while designing and creating products but also gives educators a tool to tackle persistent issues like educational reform in STEM disciplines (Kangas et al., 2013). Moreover, findings by Henriksen (2017) posit that design and design-based thinking serve as a conduit between art, science, and other disciplines, thereby rendering design thinking a fitting approach for implementing STEAM education in elementary schools.

Teaching STEAM topics in elementary school according to the design thinking process

Design thinking is an approach to problem-solving that emphasizes empathy, creativity, and logic. It entails analysing specific contexts and devising context-specific solutions. In the context of education, design thinking can be applied to interdisciplinary STEAM instruction.

By incorporating design thinking into STEAM education, we can enhance secondary school students' technical and technological education (Edelen et al., 2023; Wrigley and Straker, 2017). Maria Montessori understood the close connection between student-centred knowledge exploration and design thinking methodology (Kant et al., 2018).

Design thinking is a blend of analytical and creative processes that relies on human competence to formulate emotionally and functionally significant ideas and to convey concepts through non-verbal means (Razzouk and Shute, 2012). Mastery of the design thinking process requires designers to adeptly amalgamate empathy, creativity, and rationality to scrutinize and devise suitable solutions for each unique context (Wrigley and Straker, 2017). Research from the Hasso Platner Institute of Design at Stanford University delineates the use of a human-centred approach in the design thinking process to generate inventive problem-solving strategies, encompassing five key steps: empathy, identification, ideation, prototype, and testing (Aflatoony et al., 2018). These steps are iteratively employed to yield a multitude of solutions. Throughout this iterative process, designers identify issues, test prototype solutions, engage with users to gather feedback, and subsequently refine the design based on the received or observed feedback. The present study utilizes the five steps of the design thinking process to structure STEAM lessons in elementary schools, as presented in Table 1.

Table 1. Process of teaching STEAM topics according to design thinking methodology.

Activity name	Teacher activities	Student activities
Empathy	- Teachers use practical situations associated with lesson tasks.	- Be aware of the problem to be solved and voluntarily think of ways to solve it.
	- The teacher develops a scenario to put students in problem situations, causing students to seek to solve problems based on empathy voluntarily.	- Solve problems with empathy through the experience of using the product and interviewing the users' needs. This empathy helps students answer questions: + What do users want about the characteristics and uses of the product? + What requirements do users have when using the product? + Do users like to send any messages to the product?
Identify the problem	- The teacher asks questions about the given situation and guides students Find out the users' needs for the product.	The student analyses and concretizes the needs and desires of users into requirements and criteria of products. The information collected and aggregated includes:

Activity name	Teacher activities	Student activities
		+ Requirements of users about the characteristics and functions of the product + User activities that have been performed for the product + Users' thoughts, beliefs, desires, and needs for products + The feelings of users when using the product
Idea Formation	The teacher organizes students to come up with product implementation plans. With details that are difficult to describe in words, teachers call for students to perform with image sketches.	Students form groups and share their thoughts and subjective experiences to support product design. Identify feasible ideas to prepare for the next stage.
Fabrication of prototypes	The teacher organizes students to build product prototypes and explore product manufacturing solutions.	Students build product prototypes. Students can improve product design through feedback from team members and product users.
Trial	The teacher organizes students to evaluate activities with prototypes.	Students conduct hands-on activities combined with personal knowledge and experience to evaluate prototypes. Students record feedback on prototypes from their own experiences and user feedback.

Assessing the technological competence of primary students in STEAM topics

According to Falloon (2020), technological competence in learners is the ability to use and evaluate digital resources, tools, and services accurately and to apply them to lifelong learning. These competencies allow students to act effectively and ethically in the learning environment.

In this study, the concept of students' technological competence is considered in implementing STEAM education in primary school to help students become technology aware, communicate and use technology appropriately and evaluate technology and design techniques.

These are the technological competence components mentioned in Vietnam's 2018 general education curriculum (Ministry of Education and Training, 2018). The study aims to document the development of technological competence in primary students by applying design thinking methodology to STEAM teaching in technology. By identifying the respective levels of technological competence components, the study seeks to provide insights into how these skills can be improved through STEAM education in primary schools.

Table 2. Assessment of the technological competence of students through teaching STEAM topics in primary school.

Element name	Code	Expression
Technology awareness	Ta1	Describe the application and importance of technology in family and educational settings.
	Ta2	Identify the purpose and meaning of individual actions when creating technology products.
	Ta3	Keep safe and eco-friendly while using tools to create products and preserve technological products.
	Ta4	State the structure and function of the technology product when viewing the sketch of the idea of making that product.
	Ta5	Recognize the size and know how to form technology products.
Technology communication	Tc1	Discuss and share about the product-making process and make adjustments to suit your team's conditions.
	Tc2	Discuss and share perceptions of technology products with others while performing activities: reading, manipulating, designing, manufacturing, testing, etc.
	Tc3	Through the sharing of others, learn about products. Respond to information sharers by gathering, analysing, and evaluating the data.
Use of technology	Ut1	Use tools to design, fabricate, and test products properly and safely.
	Ut2	Make safe and appropriate use of the prototype.
Technology Review	Tr1	Reviews of technology items' usage, functionality, and form.
	Tr2	Compare the product with its criteria.
	Tr3	Find out the pros/cons of the product creation process.
	Tr4	Suggest product improvements (if any).
Engineering design	Ed1	Presenting the task of shaping and decorating products based on understanding and empathy about the product's purpose, meaning, and uses.
	Ed2	Design object properties are analysed.
	Ed3	Sketch product design (shape, structure, decoration plan etc.)
	Ed4	Fabricate product prototypes according to the design.
	Ed5	Test and adjust products in actual conditions. Document the testing process and adjustments (if any).

Research Methodology

The study employed a pre-experimental approach to assessing the viability and efficacy of teaching STEAM subjects using design thinking approaches. Pre-experimental methods are experiments done on an experimental group without a control group but with adequate pre- and post-experimental test conditions (Voxco, 2021). We conducted research in three classes at two different primary schools in Hai Phong City, Vietnam, with seventy-six experimental subjects. In addition, to accurately describe the development of students' technological competence, we observed five students per class and recorded their performance using Table 2, as suggested above. To facilitate data recording and analysis, we conduct student name encoding in experimental layers, assessing the behaviour of that student according to three levels: (1) not clearly showing behavioural competence; (2) some manifestation of behavioural competence; (3) demonstrating behavioural competence.

To examine how the STEAM lesson in Grade 3 technology has impacted the development of technology competencies for primary students, we developed a lesson plan with two themes: Topic 1: Making school supplies (1 week/2 lessons); Topic 2: Making toys (2 weeks / 4 lessons) – 3rd-grade technology book and applying the design thinking process to STEAM topic teaching to guide students to solve lesson tasks. The content of the two experimental teaching topics is as follows:

Table 3. Summary of a STEAM lesson as a school item - making a ruler.

Learning tasks		Design and build school supplies from materials that are easy to obtain and recycle.
Main student activities		Learn the structure, uses, and ways to make school supplies.
STEAM Field Content	Science	Structure and use of the ruler
	Technology	How to make a ruler from materials that are easy to find and recycle.
	Engineering	Outline and demonstrate the steps for creating your team's ruler.
	Art	Understand what it means to store and use the ruler properly; Appreciate the item you create.
	Math	The calculation and selection of materials and utensils necessary for making rulers.

Table 4. Summary of STEAM lesson on making toys - making a kite.

Learning tasks		Design and build school supplies from materials that are easy to obtain and recycle.
Main activities of students		Learn the structure, uses, and ways to make simple toys.
STEAM Field Content	Science	Structure and use of kite parts
	Technology	How to make a kite from easy-to-find materials.
	Engineering	Outline and demonstrate the steps of creating your team's kite.
	Art	Understand the meaning of the gift given; Use toys correctly. Appreciate the item you create.

Math	Calculations, selection of materials, and utensils necessary for making the kite.

Students will perform steps two and three of the design thinking process on the idea circle (Figure 1). Idea circles are typically drawn on paper, a calendar cover, or glued as decals onto plexiglass boards for repeated reuse. The idea circle can have three or more layers, divided into separate cells depending on the lesson content and the purpose of the student. Class B is where the characteristics of the product are recorded, while Class C states the plan for making such products. Class A is where students sketch the finished product after completing the content in Class B and Class C. If you go clockwise to perform steps 1 to 4 in Class C, this is the process of creating the product by the student. After product testing, students can draw an additional layer D (concentric with layers A, B, and C) to record or redraw product adjustments. Each edit by students can be separated from the other by one cell.

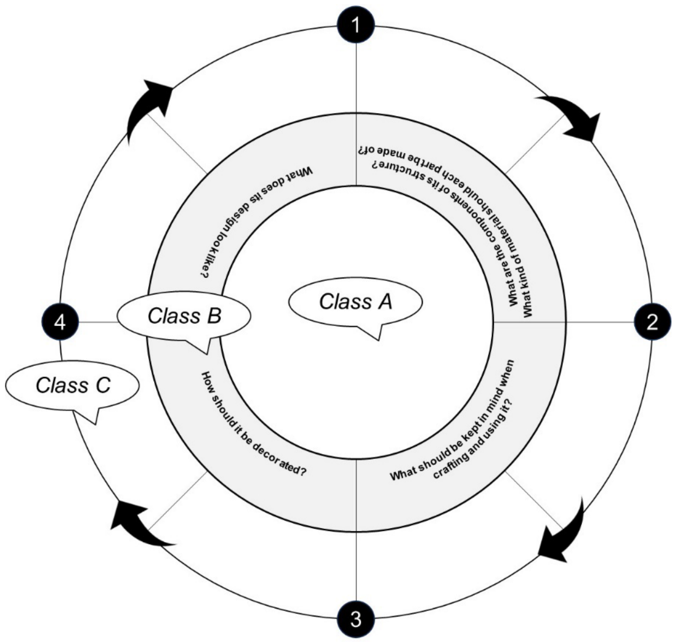

Figure 1. The circle of ideas.

Teachers at the host school will implement this lesson plan after fully understanding the lesson idea and assessment methodology. To collect data on the development of students' technological competencies by applying design thinking methodologies to

STEAM topic teaching, we follow the following process:

Phase 1: Experimental preparation
In this step, teachers assign specific tasks to ensure effective teaching and assessment in group discussions. One teacher is responsible for teaching the class, while another records the lesson. Another teacher evaluates the classroom atmosphere, checking for engagement and participation. Finally, two teachers evaluate the case of five students in the class, recording their development of technological competence over two lessons. This approach helps ensure that all aspects of teaching and assessment are covered, leading to a more comprehensive evaluation of student progress.

Phase 2: Conducting experiments
Participating teachers divide the class into groups of 4 or 6 students so that the students who intend to be assessed will be in groups. The data collected will be recorded and saved. Then, the data is analysed using the content analysis method. The analysis assessed behavioural indicators corresponding to the technological competence of the students participating in the lesson.

Phase 3: Processing experimental results
After gaining information about the student's performance in the learning process for STEAM topics, the information obtained will be reproduced and used to plot the technological competence curve of the student. The spider schema shows the curves representing the technological competence of students.

Results and discussion

The results of the study shed light on the following issues:
Appropriate and feasible design thinking process for teaching STEAM topics in primary school
In two trial implementations, we discovered that most instructors in these primary schools supported the design thinking approach in two trial deployments. The teachers taking part in the project had no prior experience teaching with the design thinking methodology. Particularly in subject topic 1, teachers struggled to perform empathy exercises since they were still unfamiliar with the design thinking methodology. Students in experimental classrooms, meanwhile, are eager to try out novel teaching methods. However, at first, children had a tough time expressing

their thoughts while suggesting ideas to design and produce school supplies since they were unused to utilizing the idea circle. In topic 2, expressing ideas for designing and creating toys is more complex than expressing ideas for designing and producing school supplies, but students do an excellent job of developing and presenting ideas for making items because they are used to the learning style of design thinking (Figure 2).

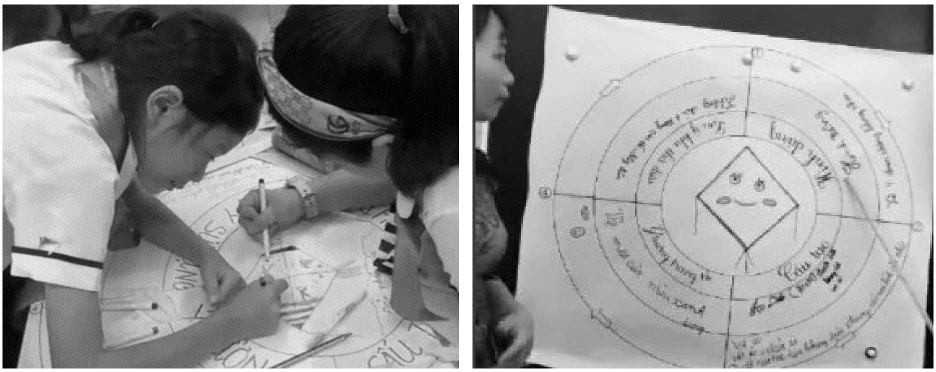

Figure 2. Students take part in activities related to the second STEAM subject, such as creating product blueprints and presenting designs.

Teaching STEAM topics helps students foster and develop technology competencies.

To evaluate the behavioural development of the components of technological competence, we compute the average score for each behavioural expression by the fifteen students chosen for evaluation, corresponding to three levels to assess the behavioural growth of the technological competence components. The proficiency level that results is then converted to a percentage (Figure 3). The degree of technological competence is not reflected in the average score, which measures how students behaved across two themes.

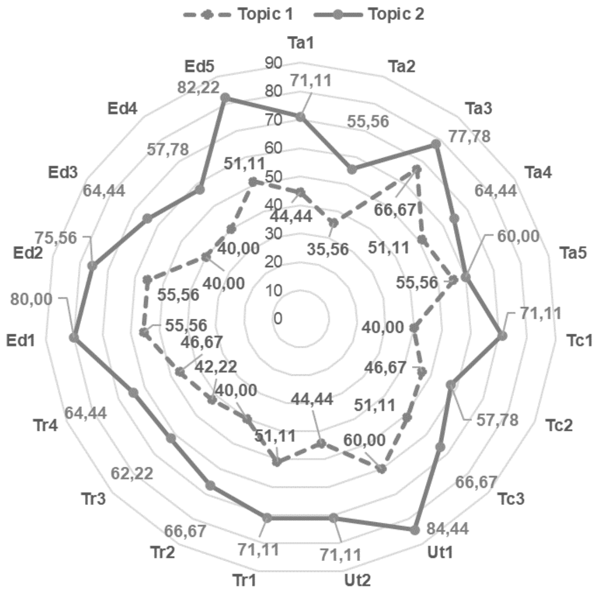

Figure 3. The average score for 15 students' behaviour through two experimental topics.

Observing and evaluating student behaviour across two experimental topics revealed that students developed components of technological competence. To further confirm this statement, we perform a T-Test for each component of technological competence as follows:

Table 6. Paired sample T-Test for components of technological competence.

Composition	Assessments	Average value	S.D.	Difference	p-value	Conclusion
Ta	Pre-test	50.67	6.57	-13.78	< 0.001	Supported
	Post-test	64.44	12.51			
Tc	Pre-test	27.55	7.10	-11.56	< 0.001	Supported
	Post-test	39.11	10.04			
Ut	Pre-test	20.89	2.34	-10.22	< 0.001	Supported
	Post-test	31.11	6.51			
Tr	Pre-test	36.00	7.89	-16.89	< 0.001	Supported
	Post-test	52.89	14.13			
Ed	Pre-test	48.44	7.33	-23.55	< 0.001	Supported
	Post-test	72.00	12.13			

Based on the results of the T-Test, it can be concluded that there are statistically significant differences in the development of students' technological competence in the two topics.

The development of students' technological competence increased unevenly

This uneven increase is related to students' learning styles and motivations. Based on the results of studies on students' learning styles and motivation (Rasheed and Wahid, 2021; Wallace and Leong, 2020). From the sharing of the classroom teacher, through observing behaviour, interests, and work performance, fifteen students were divided into three groups.

(1) For the students, the learning style is more practical, shown by actions such as Learning products in practice, remembering knowledge through experience, actively sharing product insights, working hard to create products, and loving to play assembly games. Teachers find it challenging to maintain classroom discipline with this group of children since students frequently lose attention. However, when this group of students recognized their learning goals and was willing to study, the outcomes of their behaviour aimed at increasing their technical ability over two experimental subjects were typically relatively constant, with steady growth in topic two compared to topic 1. This observation applies to all the NK3, M2, and MK5 learning outcomes.

(2) For students with observational learning styles (NK2, NK4, MĐ1, MĐ4, MĐ5, MK1, MK2, MK4), which are shown by actions such as remembering what they see, if teachers only give presentations without visual aids to illustrate, students will have difficulty acquiring new knowledge. As a result, the items produced by this group of pupils frequently lacked innovation since they witnessed teachers modelling or observing other groups and mimicking their methods. However, with the drive to achieve learning objectives, this group of students finished the product and demonstrated behaviour in two very comparable subjects; there was a development of technical ability in topic 2, but the level was not noticeable compared to the group of students (1). Teachers must entirely and diversely create visual aids, models, and tangible things to leverage this group of students' aptitude to remember via observation to assist pupils in learning knowledge.

(3) For a group of students whose learning style through listening, reading, and writing is manifested through behaviours such as enjoying listening to lectures, discussing, remembering what students hear or read, liking to read and write down personal thoughts, having difficulty memorizing images, and the rest, these characteristics coincide with the behavioural expression of students NK1, NK5, M3, MK3. Because they have trouble comprehending issues via observation and using technology to make goods, the items created by this group of pupils frequently do not match product standards or user needs. Teachers can help this set of pupils with challenging motions during the product-making process and prepare all visual aids.

Discussion

The study's findings addressed the research question of whether the design thinking process is suitable and essential for structuring the teaching of STEAM subjects in elementary schools. The utilization of the design thinking process in teaching STEAM topics yields a favourable impact on the enhancement of elementary students' technological competencies. This aligns with the insights from prior studies outlined in the introduction, emphasizing the advantages of incorporating design thinking in implementing STEAM education in elementary schools. It creates an environment for students to engage in learning activities actively, fostering creativity, problem-solving skills, and nurturing technological competencies (Chung et al., 2020; Edelen et al., 2023; Kant et al., 2018). The advancement of technological proficiency relies on the learning style and motivation of individual students, consistent with the findings of Wallace and Leong (2020) regarding the positive correlation between performance, learning style, motivation, and student outcomes. This outcome demonstrates that students can conduct procedures comparable to how designers think and work if there is a suitable teaching methodology and instructor supervision. Students learn how to conceptualize, reflect on, and express their design and fabrication ideas by performing various design activities on a range of materials. From this, it can be concluded that design thinking sets the stage for an enriching learning experience through which primary school students can perform learning tasks actively, meaningfully, and intentionally, solving practical problems based on empathy for others. These study results are consistent with other studies on design thinking in STEAM education in elementary schools (Cook and Bush, 2018; Kangas et al., 2013).

Throughout the pedagogical experiment, we closely observed the behaviour of students to draw inferences about the development of various competencies within technological proficiency. As a result, we observed that competencies, such as technology communication and technology utilization, showed lower average values in comparison to other areas. This led us to surmise that elementary school students may not have accrued adequate knowledge, skills, and experience in these domains. Therefore, they might encounter challenges when called upon to share knowledge pertaining to technological products. Additionally, there may be an objective reason: in Vietnam, the promotion of STEAM education in elementary schools has been a recent development, resulting in Vietnamese elementary teachers lacking proper training in design thinking and STEAM education. Consequently, they may face challenges in selecting teaching methods that align with students' learning styles while organizing activities in line with STEAM education. This finding correlates with the research outcomes of Duong et al. (2024) regarding the factors influencing the readiness of Vietnamese elementary school teachers to implement STEAM education.

After the pedagogical experiment, we found that primary instructors typically teach most of the courses in the classroom, except for specialist subjects, making integration across subjects more feasible than at higher levels. Teachers can easily arrange a time between subjects to implement the topic. Products for primary school students to make are usually handmade from recycled materials or materials that are easy to find. Therefore, teaching STEAM topics in the design thinking process can be advantageous to implement in primary schools. However, the increased workload as teachers implement STEAM topics is an obstacle to implementing STEAM education in schools. For more effective implementation of the design thinking process in primary school, the learning activities provided to students should stem from real-world situations, addressing practical problems through the perspective and experiences of primary children. Teachers should be provided with materials or participate in training sessions on design thinking methodology to understand the difference between design thinking and technical design processes as an empathetic organization. Teachers need to receive the support of education managers and colleagues when they need professional support regarding increasing workload.

Conclusion

The study's findings have provided preliminary validation that implementing STEAM-themed teaching activities utilizing the design thinking process at the elementary school level is suitable and viable. This endeavour by educators will aid in nurturing and cultivating the technological acumen of elementary school students. Nevertheless, the progression of technological competence is contingent upon the learning style of each student. Furthermore, the study's outcomes serve as valuable points of reference for educational administrators seeking to implement STEAM education in elementary schools adeptly. The meaningful results suggest further research and expansion with more students and a more comprehensive range of topics; it is valuable information for primary STEAM teachers and elementary school administrators to consult when implementing STEAM in primary school.

However, this study has certain limitations: because of the classroom setting and the issue of facilities, teachers frequently divided groups of students in the process of their practising product manufacture. As a result, some students were not paying attention to problem resolution, and the behavioural manifestations of technological competence components were not demonstrated. In the process of students offering ideas about and solutions to manufacturing research goods while developing a set of scales to evaluate students' behavioural manifestations via observation, researchers should also analyse students' competence growth through other manifestations. As a result, the following study direction will continue to implement new STEAM themes on experimental subjects and various alternatives for assessing the influence of STEAM education on the development of students' technological competence.

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