Empowering Teachers' Learning to Develop Students' Design Thinking Skills

Supat Srikongpan[1,*], Phrakhrusutheejariyawattana[1] & Akchatree Suksen[1]

[1]Mahamakut Buddhist University, Isan Campus, Khon Kaen Province, Thailand

*Correspondence: Mahamakut Buddhist University, Isan Campus, Khon Kaen Province, Thailand. Tel: 66-896-182-784

Received: March 12, 2024 Accepted: April 26, 2024 Online Published: June 16, 2024

doi:10.5430/wje.v14n2p151 URL: https://doi.org/10.5430/wje.v14n2p151

Abstract

The purpose of this research was to employ the Research and Development (R&D) methodology to produce an educational innovation, called "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills", expected to be widely used among the schools that are the target population in disseminating the research results. This online self-training program consisted of two projects: 1) the development project for teachers' learning, consisting of seven self-training modules for teachers' learning, and 2) the project for teachers using learning outcomes for student development, consisting of a self-training module used as teachers' practice guideline. The experimental results of the first project revealed that the post-test scores of 16 teachers met the standard criteria of 90/90 and their post-test scores were significantly higher than the pre-test scores. The experimental results of the second project pointed out that the post-test scores of 300 students were significantly higher than their pre-test scores. The research results were, therefore, by the established research hypotheses, indicating that the effectiveness of the educational innovation was confirmed. As a result, it can be used to benefit teachers and students in schools that are the target population for disseminating research results.

Keywords: online self-training program, teachers' learning, design thinking skills

1. Introduction

Stobierski (2022) stated that design thinking is an approach to problem-solving in which the practitioner seeks to understand a potential product or service's end user, including their goals, challenges, and aspirations. They then use that knowledge to conceive solutions. In addition, Matter (n.d.) stated that design thinking is identified as one of Matter's top soft skills that is linked to performance, development, and career success. Similarly, Dam & Siang (2022) discussed that design thinking is not an exclusive property of designers—all great innovators in literature, art, music, science, engineering, and business have practiced it. So, why call it Design Thinking? What is special about Design Thinking is that designers' work processes can help us systematically extract, teach, learn, and apply these human-centered techniques to solve problems creatively and innovatively—in our designs, in our businesses, in our countries, and in our lives. It aligns with the concept of Han (2022), stating that in an age when innovation is key to business success and growth, you have likely come across the term "design thinking." Perhaps you have heard it mentioned by a senior leader as something that needs to be utilized more, or maybe you have seen it on a prospective employee's resume.

Because design thinking is important, many academics have presented concepts and ideas to enhance design thinking skills for individuals in various industries, whether in the public, private, or public sectors, regardless of gender, age, or status. The main target group for enhancing design thinking skills in any society is "students" who will be an important force in the development of the country in the future.

World of Insights (n.d.) presented the following 8 design thinking skills for leadership development: 1) empathy, 2) systems thinking, 3) feedback and continuous improvement, 4) questioning mindset, 5) collaboration and facilitation, 6) customer centricity, 7) coaching, and 8) change management. Moreover,

Stobierski (2022) suggested 5 steps to enhance design thinking skills as follows. 1. Clarify: the practitioner narrows

down the focus of the design thinking process. They identify the problem that will be explored to ensure the best possible outcome. 2. Ideate: the practitioner generates ideas for solutions. They should regularly challenge their assumptions to overcome biases and think of truly unique and innovative ideas. 3. Develop: the practitioner experiments with the solutions they conceived in the ideate phase. Prototypes should not be expensive or considered "final," but rather as tools to test and learn from. 4. Implement: the practitioner must test each prototype. The goal is to learn and collect as much data as possible and use it to further iterate on potential solutions.

According to the aforementioned information, the importance of design thinking skills is presented. Moreover, many suggestions for enhancing design thinking skills have also been provided. Especially when searching for information on the internet, a variety of viewpoints of knowledgeable people from various regions across the world addressing the following issues: definitions, importance, characteristics, development guidelines, development steps, obstacles, and challenges in development and evaluation have been found.

The researchers have recognized various aforementioned viewpoints on design thinking skills as valuable and useful knowledge that can used for enhancing design thinking skills for students in secondary schools under the Office of the Basic Education Commission, Thailand. Therefore, the R&D methodology was utilized to produce an educational innovation, called "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills".

This educational innovation was developed based on the concept of "knowledge and action are power". Various perspectives on design thinking skills in a variety of issues were used as a guideline for teacher development. Teachers would learn first. Then they would use the learning outcomes to enhance students ' design thinking skills according to the determined indicators.

The researchers believed that the R&D methodology with the steps described in the "Research Methodology" topic would yield an "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills" that was effective and could be disseminated to secondary schools under the Office of the Basic Education Commission which were the target population in disseminating the results of this research throughout the country. According to the principles of research and development, the developed innovation must be tested in the area considered as the representative of the population. When the findings indicate that the innovation is effective and meets the specified criteria, it can be disseminated and applied for the learning benefit of the research population.

1.1 The Purpose of Research

The research aimed to use the R&D methodology to produce an educational innovation, called "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills", which effectively meets the specified criteria and can be used among the schools that are the target population in disseminating the research results throughout the country. This online self-training program consisted of two projects: 1) the development project for teachers' learning, consisting of seven self-training modules for teachers' learning, and 2) the project for teachers using learning outcomes for student development, consisting of a self-training module used as teachers' practice guideline (The program structure and other details are presented in Figure 1).

1.2 Research Hypothesis

The research studies, namely "Empowering Teachers' Learning to Develop Innovative Skills for Students" by Hatsanmuang and Sanrattana (2023); "Developing Teachers to Enhance Students' Effective Teamwork Skills" by Saysin and Dhammapissamai (2023), and "Empowering Teachers' Learning to Develop Students' Inspirational Skills" by Kromthamma and Supakicco (2023) which aimed to develop educational innovations for teacher development and teachers continuously use the knowledge for student development provided the research findings by the research hypotheses. For this reason, this research was also believed to produce an effective "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills". The research hypotheses were as follows.

- The development project for teachers' learning: The post-test scores of the teachers meet the standard criteria of 90/90 and are significantly higher than the pre-test scores.
- The teachers using learning outcomes for student development project: The post-test scores of the students are significantly higher than the pre-test scores.

1.3 Literature Review

Based on the literature review, many experts have given suggestions on ways to enhance design thinking skills.

When searching for information from the Internet, various viewpoints were considered valuable knowledge that can be used in this research and development to produce an educational innovation, called "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills". The researchers also reviewed the literature related to design thinking skills in a wider variety of issues than previously studied to gain knowledge that can be used to create self-training modules for teachers' learning in the following seven areas: 1. The definition from the perspectives of CreatEdu (n.d.), Dam and Siang (n.d.), Hwa (n.d.), Simon (n.d.), and Sliver et al (2018). 2. The importance from the perspectives of Chrisos (2020), Leinen (2017), Pappas (2015), Verma (2018), and Verma (2020). 3. The characteristics from the perspectives of Brody (2018), Lewis (2016), Porcini (2015), Taylor (2011), and Tschepe (2018). 4. The obstacles and ways to overcome obstacles from the perspectives of Dam and Siang (2020), Moldoff (2021), and Sheikh (2019). 5. The development guidelines from the perspectives of Christens and Miranda (2017), Dam and Siang (n.d.), Dimitriadis (n.d.-a), and Dimitriadis (n.d.-b). Fanguy (2018), Felix and Griff (2019), Majeed (2021), Manfre (2021), Naiman (n.d.), Noel (n.d.), and Sujlana (2020). 6. The development stage from the perspectives of Pferdt (2019), Professional Mit. Edu (2019), Stevens (2021), and Zhou (2020). 7. The evaluation from the perspectives of Blizzard et al (2015), Dosi, et al (2018), and Gompel (2019).

Regarding the aforementioned seven topics, it can be seen that the viewpoints on the development of design thinking skills are important because they are the suggestions demonstrating the principles/ concepts/ techniques/ methods/ activities for teacher learning. Consequently, teachers can use the learning outcomes as a guideline for developing students to have design thinking skills. For this reason, the issues guiding the development of design thinking skills from the viewpoints of Christens and Miranda (2017), Dam and Siang (n.d.), Dimitriadis (n.d.-a), and Dimitriadis (n.d.-b). Fanguy (2018), Felix and Griff (2019), Majeed (2021), Manfre (2021), Naiman (n.d.), Noel (n.d.), and Sujlana (2020). were synthesized. As a result, the following 78 guidelines were gained: 1) be visual, 2) the evolving discipline of design, 3) create concepts and visualize ideas, 4) optimistic, compassionate, and enthusiastic, 5) learn from the experts or knowledgeable person, 6) signature pedagogies in design, 7) being open-minded, 8) create new designs, 9) study, learn, and research websites, 10) increase your observation power, 11) experiment with a variety of tools, 12) get some help and collect feedback, 13) train yourself and explore different styles, 14) do some side hustles, design a variety of works, 15) make the problem an actionable question, 16) be smart training, 17) aiming for the best, 18) the art of questioning, 19) spark yourself with motivation, 20) working in teams – being a team player, 21) failing is an opportunity to learn, 22) skill building through design thinking, 23) understanding people, developing empathy, 24) study the theoretical aspect and learn the principles of research on trends, 25) astute observation, 26) wait on the fine-tuning, 27) implementing design thinking, 28) study design thinking approach, 29) divergent and convergent thinking, 30) use design thinking for process improvement, 31) 2 1 st-century skills and predictors of student success, 32) creative in their ability to adapt and respond to new challenges, 33) everything doesn't work, 34) get rid of the fear of failure, 35) maximize each learning experience, 36) imagine from multiple perspectives, 37) development of design thinking skills, 38) accept all ideas open-minded, 39) look around, listen to others, be smart and learn, 40) document learnings and define the hypothesis, 41) a framework for design thinking, 42) co-creation and working together, 43) learn how to teach and facilitate creativity, 44) learn how to be a thinker/designer from expert practitioners, 45) build confidence in your creativity with low-risk experiments, 46) be able to identify and develop innovative, creative solutions to problems they and others encounter, 47) don't expect perfection, 48) build on each other ideas, 49) encourage weird, wacky, and wild ideas, 50) defer judgment or criticism, including non-verbal, 51) creativity, innovation, and leadership skills development, 52) making a case for design-based learning at the primary and secondary level, 53) understand the value of collaboration and feedback, 54) invest equal time in research, bio design, and feedback, 55) identify problems and reframe them as actionable opportunities, 56) view obstacles and failures as valuable learning moments, 57) promote diverse perspectives frame new constraints as opportunities and examine assumptions, 58) active learning, 59) learning commons, 60) develop empathy, 61) develop a growth mindset, 62) focusing on both the future and the solutions, 63) creativity and innovation, 64) critical thinking and problem-solving, 65) develop self-confidence as a problem solver, 66) appreciate hard work and perseverance, 67) write, create, and communicate, 68) collaborate and discuss, 69) design thinking in practice, 70) tackling common challenges, 71) support student learning through collaboration, 72) clarity with precise academic language, 73) explore the key elements that make it unique, 74) teach math concepts to accomplish tasks quietly, without questioning, 75) applying concepts in the real world, 76) emphasize a holistic approach to testing things. integrated thinking, 77) attraction with a combination of audience engagement or storytelling, and 78) deep understanding of content knowledge of the "what, why, how, and when" topic.

2. Research Methods

2.1 Concepts and Process

This research employed the Research and Development (R&D) methodology according to the viewpoint of Sanrattana (2023) who stated that educational innovations developed by this research methodology are intended to be used to develop people to gain knowledge. It is expected that they will apply the obtained knowledge to action which will create power for effective work according to the concept: "knowledge and action are power". This concept guided the concept of this research: "Start with teacher development and teachers subsequently apply the learning outcomes to student development". Four steps were employed for this research.

Step 1: The literature review related to design thinking skills in seven issues was conducted. The content in each issue was used to create seven online self-training modules for teacher's learning and a self-training module used as teachers' practice guideline. The seven modules included 1) definitions, 2) importance, 3) characteristics, 4) obstacles and ways to overcome obstacles, 5) development guidelines (principles/ concepts/ techniques/ methods/ activities), 6) development steps, and 7) evaluation.

Step 2 : The quality of online self-training modules was examined, which was conducted in two phases: *Phrase 1:* Preliminary Field Testing and Revision was conducted with 5 teachers at a school that is not the experimental site. *Phrase 2:* Main Field Testing and Revision was conducted with 10 teachers at a school that is not the experimental site. Focus group discussion was employed for both phrases.

Step 3 : Two sets of research tools were constructed: 1) the teachers' learning outcomes test and 2) the students' design thinking skills assessment form (details are discussed in the "Research Tools" topic).

Step 4 : The effectiveness of the online self-training program was tested according to the research hypotheses. One group pretest-posttest design was employed for the experiment of "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills" in the school randomly selected as the research site. The experimental group was 16 teachers and 300 students in the second semester of the Academic Year 2023. The research was divided into 2 phases: 1) one-month experimental research of the development project for teachers' learning and 2) 2-month experimental research of the project for teachers using learning outcomes for student development.

2.2 Research Tools

The teachers' learning outcomes test was created in a multiple-choice format with four options which was employed to assess the teachers' learning outcomes before and after the experiment of the teachers' learning development project. The researchers constructed the test based on the following six issues: definitions, importance, characteristics, developmental guidelines, developmental processes, and evaluation of the cognitive domain, ranged from lower-order thinking skills to higher-order thinking skills, including remembering, understanding, applying, analyzing, evaluating, and creating according to the Revised Taxonomy 2001 of Benjamin S. Bloom (Armstrong, 2010). The test's quality was checked with the following two phases:

Phrase 1: The content validity was examined using the method of Rovinelli and Hambleton (1977), called Indexes of Item-Objective Congruence (IOC). The IOC was conducted by five experts in the fields of Curriculum and Instruction and Educational Measurement and Evaluation. The results revealed that the IOC values of all questions exceeded the criterion of 0.50 (Chaichanawirote & Vantum, 2017).

Phrase 2: The test was tested with 30 sample teachers in the school that was not the experimental site for quality checking. The data analysis results were as follows. 1) All the test items showed an index of difficulty within the range of 0.20-0.80 and a power of discrimination within the range of 0.20-1.00. 2) The KR-20 coefficient, indicating the test's reliability, was 0.89 exceeding the criterion of 0.70. 3) The test difficulty was 47.50

The students' design thinking skills assessment form was a 5-point rating scale assessment developed by the researchers based on the characteristics of design thinking skills presented by Brody (2018), Jonathan (2016), Porcini (2015), Taylor (2011), and Tschepe (2018) and the concepts of evaluating design thinking skills presented by Blizzard et al (2015), Dosi, et al (2018) , and Gompel (2019). The assessment form's quality was checked in the following two phases.

Phrase 1: The content validity was examined by the method of Rovinelli and Hambleton (1977) by five experts in the fields of Curriculum and Instruction and Educational Measurement and Evaluation. The results showed that the IOC values of all items exceeded the criterion of 0.50, indicating that this assessment form can be used for its intended purpose (Chaichanawirote & Vantum, 2017).

Phrase 2: The reliability or internal consistency was examined. The assessment was tested with 30 students in a school that was not the experimental site. The findings showed that the alpha coefficient of reliability of the entire assessment form was 0.91 After each dimension was analyzed, it was found that the reliability coefficients of awareness and consciousness, teamwork, learning and psychology, personal attributes and multi-perspective mindset, and communication and technology use were 0.80, 0.88, 0.98, 0.96, and 0.96, respectively. When comparing these reliability coefficients with the criterion of 0.70 or higher (UCLA: Statistical Consulting Group, 2016), they were higher than the specified criterion, which indicated that the items had relatively high internal consistency.

2.3 Data Analysis

The following data analysis was conducted. 1) The teachers' scores were compared with the standard criteria of 90/90, where the first 90 represents the percentage of the mean scores of all teachers and the second 90 represents the percentage of teachers passing the test for all learning objectives (Yamkasikorn, 2008). 2) The pre-test and post-test scores were compared using a t-test dependent.

3. Results

3.1 Educational Innovation

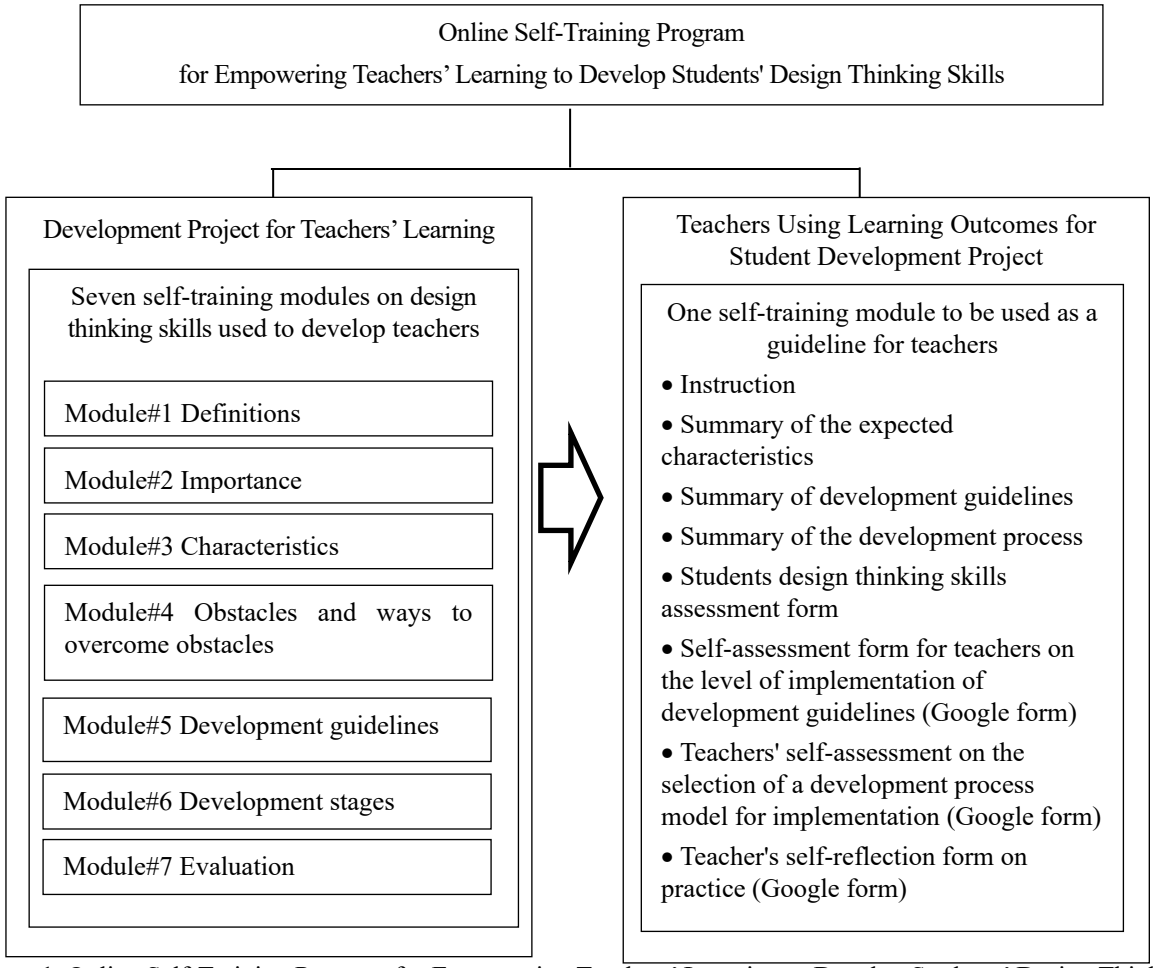

Figure 1. Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills (see the original Thai modules from https://shorturl.at/axC69)

An educational innovation, called "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills", was obtained from this research. It consisted of two projects that were sequentially proceeded, namely: 1) *The Development Project for Teachers' Learning*, consisting of seven self-training modules for teachers' learning, a) definitions, b) importance, c) characteristics, d) obstacles and ways to

overcome obstacles, e) development guidelines, f) development stages, and g) evaluation, and 2) *The Project for Teachers Using Learning Outcomes for Student Development*, consisting of a self-training module used as teachers' practice guideline. It consists of the following issues: a) instruction, b) summary of the expected characteristics, c) summary of development guidelines, d) summary of the development process, e) students design thinking skills assessment form, f) self-assessment form for teachers on the level of implementation of development guidelines (google form), g) teachers' self-assessment on the selection of a development process model for implementation (google form), and h) teacher's self-reflection form on practice (google form). The details are presented in Figure 1.

3.2 Results of the Efficiency Test of the Online Self-Training Program

The experimental research results of the development project for teachers' learning were in line with the research hypothesis. It was found that the teachers' post-test mean score was 33.75 points, accounting for 93.67 % of the full score. Moreover, 100 % of the teachers passed all the learning objectives meeting the standard criterion of 90/90. 2) The post-test mean score was significantly higher than the pre-test mean score at the level of 0.05 as shown in Table 1.

Table 1. Mean of Teachers' Pre-test and Post-test Scores Using Dependent t-test

Testing	Sample size	Mean	Standard Deviation	t
Pre-test	16	20.75	4.37	15.53*
Post-test	16	33.75	1.12	

* $p < 0.05$

The experimental research results of the project for teachers using learning outcomes for learner development were consistent with the research hypothesis. It was presented through the analysis of the mean and standard deviation of the scores of the students' design thinking skills before and after the experiment shown in Table 2 and the results of the comparative analysis using the dependent t-test presented in Table 3.

Table 2. Mean and Standard Deviation of the Assessment Results of the Students' Design Thinking Skills Before and After the Experiment

Characteristics of students' design thinking	Assessment results			
	Pre-test		Post-test	
	$\bar{\chi}$	S.D.	$\bar{\chi}$	S.D.
Awareness and consciousness	**3.63**	**0.07**	**3.88**	**0.98**
• I control my emotions and understand the needs of myself and others.	3.74	1.03	3.98	0.95
• I carefully, mindfully, and intelligently consider things.	3.59	1.01	3.84	0.97
• I can handle different situations.	3.52	1.05	3.77	1.00
• I can evaluate situations and make proper decisions.	3.57	0.99	3.85	1.00
• I avoid making decisions that cause failure or damage.	3.72	1.18	3.95	0.97
Teamwork	**3.96**	**0.02**	**4.01**	**0.97**
• I can work with other people or groups.	3.88	1.06	3.90	1.00
• I am willing to develop work with other team members.	4.01	1.06	4.00	0.98
• I work with others and always take responsibility and help others.	3.93	1.04	3.99	0.98
• I always welcome suggestions from others or stakeholders.	4.12	1.03	4.11	0.95
• I accept the members' decisions although I have a different opinion.	3.97	1.04	4.07	0.94
• I am responsible for group work for the success and efficiency of work.	3.84	1.04	4.02	0.96
• I believe that diverse team members will produce superior results.	3.97	1.08	4.01	1.00
Learning and psychology	**3.71**	**0.07**	**3.89**	**0.98**
• I solve problems with reasons.	3.81	0.99	3.94	0.98
• I like to experiment with different methods.	3.68	1.07	3.81	1.01
• I am imaginative and creative.	3.61	1.17	3.86	0.99

Characteristics of students' design thinking	Assessment results			
	Pre-test		Post-test	
	$\bar{\chi}$	S.D.	$\bar{\chi}$	S.D.
• I think outside the box, not stuck in the old ways.	3.68	1.03	3.83	1.01
• I like sharing knowledge and experiences.	3.65	1.12	3.86	1.01
• I apply knowledge appropriately and skillfully.	3.56	0.95	3.81	0.99
• I am always adaptable and able to keep up with changing situations.	3.72	1.02	3.89	0.94
• I experiment or learn from mistakes and experiences.	3.87	1.03	3.97	0.96
• I listen to other people's opinions and view failure as an opportunity to learn.	3.88	1.02	4.03	0.92
• I apply knowledge, principles, and theories of psychology to bring about concrete benefits.	3.63	1.02	3.92	0.99
Personal attributes and multi-perspective mindset	**3.79**	**0.04**	**3.89**	**0.99**
• I am a curious and observant person.	3.78	0.99	3.81	1.04
• I am a confident and humble person.	3.61	1.05	3.72	0.99
• I am an active and curious person.	3.72	1.01	3.86	1.00
• I am ready and willing to adjust and change my thinking.	3.94	1.02	4.01	0.96
• I am an extrovert, optimistic, and broad-minded person.	3.73	1.11	3.88	0.99
• I am attentive, collaborative, and inspiring.	3.84	1.03	3.95	0.97
• I am open to working with people from different backgrounds.	3.97	0.99	3.99	0.99
• I view problems as opportunities for learning and self-development.	3.74	1.05	3.88	1.00
Communication and technology use	**3.90**	**0.07**	**4.02**	**0.97**
• I play video games.	3.82	1.22	3.89	1.12
• I use a mobile phone or a camera.	4.15	1.11	4.21	0.87
• I can communicate in a variety of ways.	4.29	1.04	4.27	0.88
• I can convey new ideas to others.	3.84	1.03	4.00	0.99
• I can solve problems in normal and new ways.	3.84	0.97	3.96	0.94
• I can use technology to work and solve problems.	3.96	1.03	4.08	0.94
• I am willing to be a role model in presenting new ideas.	3.61	1.09	3.86	1.03
• I can post good questions to understand different perspectives.	3.61	1.08	3.84	1.01
• I need feedback and suggestions for improvement.	3.99	0.99	4.09	0.96
• I can communicate in different environments and for different reasons.	3.92	1.07	4.05	0.98
Total	**3.80**	**0.05**	**3.94**	**0.98**

Table 2 , indicates that the average score from students' design thinking skills assessment after the experiment was higher than before the experiment, that is, the average score after the experiment was 3.94 (standard deviation was 0.98). the average score before the experiment was 3.80 (standard deviation was 0.05). Based on the results of the dependent t-test, the mean score of students' design thinking skills after the experiment was significantly higher than that of before the experiment at the 0.05 level as presented in Table 3.

Table 3. The Results of Data Analysis Comparing the Mean Scores of the Pre-test and Post-test of the Students Using a Dependent t-test

Evaluating	Sample size	Mean	Standard Deviation	t
Pre-test	300	3.80	0.05	2.13*
Post-test	300	3.94	0.98	

* $p < 0.05$

4. Discussion

This research was conducted using R&D methodology with one group pretest-posttest in the school that was randomly selected as the research site. There were 16 teachers in the experimental group and 300 students who were the target group of the development. This research aimed to test the effectiveness of the "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills", an educational innovation obtained from this research. It was found that this educational innovation was effective by the research hypotheses regarding the development project for teachers' learning and the experimental research project for teachers using the learning outcomes for student development. The teachers' posttest scores met the standard criterion of 90/90 and were significantly higher than the pretest scores. The post-test scores of the students were also significantly higher than the pretest scores. The results of this research are consistent with the findings of other research studies using the R&D methodology with similar research design, namely "Empowering Teachers' Learning to Develop Innovative Skills for Students" by Hatsanmuang and Sanrattana (2023), "Developing Teachers to Enhance Students' Effective Teamwork Skills" by Saysin and Dhammapissamai (2023), and "Empowering Teachers' Learning to Develop Students' Inspirational Skills" by Kromthamma and Supakicco (2023), "Developing Teachers to Enhance Project Management Skills for Students" by Nukoonkan and Dhammapissamai (2023), and "Enhancing Teachers' Learning to Develop Students to Become Successful Students" by Thammabut and Thacha (2023).

In addition to testing the effectiveness of the developed educational innovation, the research team also sought additional knowledge from the teachers in the experimental group, especially the reflection on the application in the fieldwork. Some interesting points will be discussed below.

To develop design thinking skills for students, the teachers in the experimental group encountered many obstacles, such as barriers of empathy, limiting ideas, closed-mindedness, old pattern thinking, groupthink, lack of understanding, lack of Imagination, or being too serious/boring, and negative cognitive biases. These obstacles are part of the obstacles obtained from the synthesis of the academics' views. According to Dam and Siang (2020), Moldoff (2021), and Sheikh (2019), the obstacles that have been found include 1. lack of good communication to create understanding and empathy, 2. lack of opportunity to access resources, 3. lack of training and experience, 4. unconducive environment to freedom of expression and flexibility, 5. adhering to originality without accepting new things and not being open-minded, and 6. lack of imagination, having old ideas, and using old methods, statistical data, and logic, causing people to lose the ability to think outside the box.

However, the teachers in the experimental group sought approaches to overcome these obstacles. Moldoff (2021) suggested the following approaches to overcome obstacles in developing design thinking skills. 1. Reinforce a positive outlook. 2. Ask questions to understand the problem. 3. Be open-minded. 4. Look down on a problem. 5. Define the problem completely. 6. Take bite-sized chunks. 7. Think logically. 8. Find similarities. 9. Mistakes happen. 10. Keep emotions in check. 11. Focus on the end game. 12. Take notes and record progress. 13. Challenge assumptions. 14. If don't find success, start over. 15. Be honest and realistic.

To develop design thinking skills for the students in this research, even though there were many obstacles, the teachers in the experimental group cooperated and put effort into their practice until the "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills" developed by using R&D methodology was effective for the development of teachers' learning and using learning outcomes for student development. This educational innovation can be used to benefit teachers and students in schools that are the target population for further dissemination of the research results.

5. Conclusion

From the results of the research, it can be shown that educational innovations called the "Online Self-Training Program for Empowering Teachers' Learning to Develop Students' Design Thinking Skills" developed with R&D methodology with details of operations as mentioned in the research methodology section above. Including the use of the concept of "knowledge and action are power" in designing this research. By adopting various perspectives on design thinking skills in various aspects as a guideline for teacher development to make learning a priority for teachers. Then stimulate and encourage teachers to use the learning results to develop students so that students develop design thinking skills according to the specified indicators, resulting in effective educational innovations as expected. Therefore, The educational innovations obtained from this research can then be disseminated for the benefit of teachers and students in schools that are the target population for this research throughout the country.

6. Recommendations

Regarding the application of this educational innovation, from the perspective of the research team, users should be encouraged to realize the importance of design thinking skills in many ways to create motivation and inspiration for effective practice. According to the synthesis of the views of Chrisos (2020), Leinen (2017), Pappas (2015), Verma (2018), and Verma (2020), it can be concluded that design thinking skills are important in the following aspects. 1. It is a new way of thinking in solving the problems we are facing today by thinking out of the box, creating new perspectives and creative thinking, using innovations, and searching for new solutions to problems with a better way of thinking to avoid repetitive problems. 2. It relies on innovation, creativity, and changing perspectives to be able to answer questions arising from a rapidly changing work environment. It is the path toward the future of work to succeed, grow, and be a part of the future. 3. It promotes good adaptation and skills in dealing with rapidly changing situations. It is practical and can be integrated with learning skills and educational administration in the 21st century. 4. It helps develop a creative mindset and imagination for being a good design thinker in the future. This is one way to go beyond the old potential and move towards new things. 5. The overall advantages and benefits of design thinking skills can be revealed, which are (a) giving a way of thinking, building confidence in adapting and responding more creatively to new work environments; (b) helping to identify and develop innovative and creative solutions for managing problems to adjust and change the way of thinking to solve the problems creatively and intelligently; (c) integrating work in many different dimensions, increasing thinking skills that are not stuck in the same old ways, opening worldview, seeing the world in a positive light, being considerate, solving problems creatively and sympathizing with people working together and (d) creating new thinking processes that promote higher-order thinking skills to develop work into the future world in a concrete and creative way.

References

Armstrong, P. (2010). *Bloom's Taxonomy*. Vanderbilt University Center for Teaching. Retrieved from https://shorturl.at/koN07

Blizzard, J., Klotz, L., Potvin, G., Hazari, Z., Cribbs, J., & Godwin, A. (2015, May). Using survey questions to identify and learn more about those who exhibit design thinking traits. *Design Studies, 38*, 92-110. https://doi.org/10.1016/j.destud.2015.02.002

Brody, H. (2018, August 09). *Top qualities of design thinking leaders.* Retrieved from https://shorturl.at/txzVX

Chaichanawirote U., & Vantum, C. (2017). Evaluation of content validity for research instrument. *Journal of Nursing and Health Sciences*, *11*(2), 105-111.

Chrisos, M. (2020, January 23). *Benefits of design thinking for business strategy*. Retrieved from https://shorturl.at/jvxP8

Christens & Miranda, M. D. (2017, September 22). *Developing skills for life through design thinking*. Retrieved from https://shorturl.at/akpAP

CreatEdu. (n.d.). *What is design thinking?* Retrieved from https://shorturl.at/gyPTU

Dam, R., & Siang, T. (n.d.). *Stage 3 in the design thinking process: ideate.* Retrieved from https://shorturl.at/qxHJZ

Dam, R. F., & Siang, T.Y. (2022). *What is design thinking and why is it so popular?* Retrieved from https://shorturl.at/ntGOY

Dam, R. F., & Siang, T. Y. (2020, October 03). *14 Barriers to ideation – and how to overcome them.* Retrieved from https://shorturl.at/uY029

Dam, R. F., & Siang, T. Y. (n.d.). *What is design thinking and why is it so popular?* Retrieved from https://shorturl.at/akHWY

Dimitriadis, M. (n.d.-a). *Why design thinking should be taught in primary, elementary & middle schools.* Retrieved from https://shorturl.at/giHLR

Dimitriadis, M. (n.d.-b). *What is design thinking? A handy guide for teachers*. Retrieved from https://shorturl.at/KTXY2

Dosi, C., Rosati, F., & Vignoli, M. (n.d.). Measuring design thinking mindset. *International Design Conference - Design 2018, Human Behaviour and Design*, p. 1991-2002. http://doi.org/10.21278/idc.2018.0493

Fanguy, W. (2018, July 27). *4 Ways to improve your design thinking process.* Retrieved from

https://shorturl.at/msBK9

Felix, E., & Griff, A. (2019, January 22). *Using design thinking to enable student success and build community.* Retrieved from https://shorturl.at/bpDEW

Gompel, K. V. (2019). *Cultivating 21st-century skills: An exploratory case study of design thinking as a pedagogical strategy for elementary classrooms*. A dissertation submitted in partial satisfaction of the requirements for the Degree of Doctor of Education in Learning Technologies, Graduate School, of Education and Psychology, Pepperdine University

Han, A. (2022, January 18). *What is design thinking & why is it important?* Retrieved from https://shorturl.at/oALN1

Hatsanmuang, N., & Sanrattana, W. (2023). Empowering Teachers' Learning to Develop Innovative Skills for Students. *World Journal of Education, 13*(2), 56-67. https://doi.org/10.5430/wje.v13n2p56

Hwa, L.C. (n.d.) *Design thinking?* Retrieved from https://shorturl.at/xDLV4

Kromthamma, M., & Supakicco, P. S. (2023). Empowering teachers' learning to develop students' inspirational skills. *World Journal of Education, 13*(2), 31-40. https://doi.org/10.5430/wje.v13n2p31

Leinen, P. (2017, January 9). *5 Benefits of design thinking.* Retrieved from https://shorturl.at/uzJM3

Lewis, J. (2016 January 21). *7 Qualities of design-thinking leaders*. Retrieved from https://shorturl.at/mBDIQ

Majeed, A. (2021, January 28). *17 Tips to improve the design thinking in 2021 (updated).* Retrieved from https://shorturl.at/gvwDF

Manfre, J. (2021, July 14). *How a simple presentation framework helps students learn.* Retrieved from https://shorturl.at/auxI9

Matter. (n.d.). *Design thinking.* Retrieved from https://shorturl.at/hiET3

Moldoff, D. K. (2021, August 05). *15 Problem-solving skills for overcoming obstacles.* Retrieved from https://shorturl.at/kHLR5

Naiman, L. (n.d.). *Design thinking as a strategy for innovation*. Retrieved from https://shorturl.at/oJRY1

Noel, L. A. (n.d.). *Using design thinking to create a new education paradigm for elementary-level children for higher student engagement and success.* Retrieved from https://files.eric.ed.gov/fulltext/EJ1137735.

Nukoonkan, C., & Dhammapissamai, P. (2023). Developing teachers to enhance project management skills for students. *World Journal of Education*, *13*(1), 58-67. https://doi.org/10.5430/wje.v13n1p58

Pappas, C. (2015, April 9). *The top 6 benefits of design Thinking in eLearning*. Retrieved from https://shorturl.at/lnvF0

Pferdt, F. G. (2019, October 1). *Design thinking in 3 steps: How to build a culture of innovation.* Retrieved from https://shorturl.at/jxzEY

Porcini, M. (2015, October 03). *The 8 qualities of the innovator and the 7 characteristics of the design thinker*. Retrieved from https://shorturl.at/avABK

Professional Mit. Edu. (2019, February 15). *The 10 steps to design thinking*. Retrieved from https://shorturl.at/fvzBV

Rovinelli, R. J., & Hambleton, R. K. (1977). On the use of content specialists in the assessment of criterion-referenced test item validity. *Dutch Journal of Educational Research*, *2,* 49-60.

Sanrattana, W. (2023). *Research in educational administration: Concepts, practices and case studies* (5th ed.). Thippishut Press.

Saysin, S., & Dhammapissamai, P. (2023). Developing teachers to enhance students' effective teamwork skills. *World Journal of Education, 13*(2), 1-11. https://doi.org/10.5430/wje.v13n2p1

Sheikh, N. (2019, February 01). *5 Ways good design breaks barriers.* Retrieved from https://shorturl.at/rH348

Simon, H. A. (n.d.). *What is design thinking?* Retrieved from https://shorturl.at/ovGOT

Sliver, D., Bemis, K. & Weston, S**.** (2018, July 9). *Is design thinking a skill?* Retrieved from https://shorturl.at/bcqrN

Stevens, E. (2021, August 05). *The key principles and steps of the design thinking process.* Retrieved from https://shorturl.at/BGJU1

Stobierski, T. (2022, January 11). *5 Design thinking skills for business professionals.* Retrieved from https://shorturl.at/ehkN5

Sujlana, A. (2020, January 14). *17 Ways to improve design thinking skills.* Retrieved from https://shorturl.at/AGLN1

Taylor, P. (2011, May 12). *Seven habits of effective design thinkers*. Retrieved from https://shorturl.at/bmnV6

Thammabut, B., & Thacha, W. (2023). Enhancing teachers' learning to develop students to become successful students. *World Journal of Education*, *13*(3), 13-23. https://doi.org/10.5430/wje.v13n3p13

Tschepe, S. (2018, October 02). *What are the most important qualities of design thinking coaches?* Retrieved from https://shorturl.at/afoKO

UCLA: Statistical Consulting Group. (August 22, 2016). *What Does Cronbach's Alpha Mean?* Retrieved from https://bit.ly/3O1ySxK

Verma, B. (2018, September 28). *Top 5 benefits of design thinking.* https://shorturl.at/cBFLQ

Verma, S. (2020, August 06). *Design thinking skills: Top 5 best reasons why school students must learn*. Retrieved from https://shorturl.at/uxCMY

World of Insights. (n.d.). *8 Design thinking skills for leadership development.* Retrieved from https://shorturl.at/dfqY4

Yamkasikorn, M. (2008). How to use efficiency criterion in media research and development: The Difference between 90/90 Standard and E1/E2. *Education Journal Burapha University, 19*(1), 1-16.

Zhou, Y. (2020 January 08). *4 Steps to implementing design thinking at your organization.* Retrieved from https://shorturl.at/ktB68

Acknowledgments

We would like to thank the teachers who participated in the group discussion to review the accuracy and usefulness of the learning modules used in the online self-training program and the teachers and students who were the experimental group to try out the program. We would also like to thank the measurement and evaluation experts who examined the tools used in the research and the teachers and students to try out the tools.

Authors contributions

Supat Srikongpan was responsible for conducting every step of the research. Starting with studying research problems, designing research methods, creating innovations for use in research, conducting field research, summarizing results and reporting research results. Assistant Professor Dr. Phrakhrusutheejariyawattana, and Dr. Akchatree Suksen provided advice and consultation. in the research process. Supat Srikongpan drafted the manuscript and revised it. Assistant Professor Dr. Phrakhrusutheejariyawattana, and Dr. Akchatree Suksen approved the final manuscript.

Funding

Not applicable

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.