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Effects of a mobile technology-based crowdsourcing approach to enhance 11th Graders' innovative creation competencies

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Abstract

Mobile technology is defined as portable equipment with wireless communication facilities that could be used for educational purposes via specific affordances of learners, whereas Crowdsourcing technology is widely used to create innovative solutions that instigate creative integration and promote innovations that meet social needs. The aim of the present study was to analyze the potential of a mobile technology-based crowdsourcing approach in enhancing senior high school students' innovative creation competencies. A quasi experiment was conducted. The data were collected from 35 grade 11 students (17 in the experimental group and 18 in the control group) who were studying Independent Study for 6 months. The post-test scores of the two groups were compared using the Mann-Whitney U test to determine if they were significantly different. The findings revealed that after the implementation of learning activities, the experimental group students' innovative creation competencies (M = 70.53, SD = 2.34) were better than those of the control group (M = 66.00, SD = 2.52) at the .05 level. Moreover, the experimental group developed product innovation better than those of the control group. The findings found that the four sections of mobile technology-based crowdsourcing approach significantly improved 11th Graders' innovative creation competencies. Students were educated to generate ideas by combining internal and external sources with the crowdworkers through the creativity section and the open innovation section. The microtasking section allowed students to work with crowdworkers for creating prototype innovations. In addition, the crowdtesting section encouraged students to test prototype innovations with actual people.

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Introduction

Local innovators, by definition, are attempting and doing things that have not been accomplished previously in their local settings. For example, if local fabricators lack the skills to build the parts they envision, they may need to work with local innovators to develop the necessary expertise, pushing these workers to develop techniques they have not previously used (Hoffecker, 2018). The local innovators who can create useful innovations for their community need to have innovative creation competencies for developing the local resources to be appropriate innovations for the community, and they also must find out how to implement their innovations with the target group (Kumsubha, 2021). According to the innovative creation competencies which learners must acquire, there are four factors that students must learn; that is, "Critical thinking" (gaining knowledge and exploring information, analyzing and interpreting, logical reasoning, solving problems and finding solutions, constructing persuasive arguments, and reflecting on one's own thinking and actions), "Collaboration" (Exercising leadership and taking initiative, fostering teamwork, adapting to different situations, taking responsibility, maintaining productivity, utilizing technology tools for both real-time and delayed collaboration, being responsive, and engaging in self-regulation and reflective practices), "Communication" (engaging in meaningful conversations and discussions, leveraging modern communication tools, actively listening, effectively communicating in diverse environments, delivering articulate oral presentations, and engaging in self-regulation and reflective thinking), and "Creativity" (generating innovative ideas, refining and designing concepts, embracing curiosity and fearlessness in exploration, collaborating creatively with others, producing novel and imaginative outcomes, and engaging in self-regulation and reflective practices) (Cuenca et al., 2016; Hamdu et al., 2020).

However, foreign researchers discovered that Thai senior high school students excelled in academic subjects but lacked critical competences, such as creativity. Therefore, learning achievement among Thai students cannot be used to support the claim that Thai students excel in both academic subjects and skills (Lichtenberg et al., 2008; Van Ark et al., 2009). Consistent with the results of international assessments of mathematics and science (TIMSS 2015), the findings indicated a problem with the quality of Thai education. According to the 2015 TIMSS results, Thai students ranked 26th out of 57 nations in mathematics and science. Moreover, according to the PISA 2012 and PISA 2015 results, Thailand was ranked 50 and 55, respectively, with lower average scores in Reading, Mathematics, and Science than The OECD countries. This indicated that Thai students have low academic skills in Reading, Mathematics, and Science. In order to develop Thailand's economy and industry, it is crucial to develop students' skills of comprehensive reading and creativity as well as other higher order thinking abilities, particularly in Mathematics and Science, which are essential for creative thinking and innovation creation (Office of the Education Council, Ministry of Education, Thailand, 2018).

Local innovators' major obstacles for students who need to have innovative creation competencies in implementing their innovations in the community lack credibility because local innovators do not have the opportunity to show their expertise and collaborate with others in the community, and community innovators are perceived as inexperienced in the field of innovation because of their young age (Kumsubha, 2021). The solution should be web-based collaborative problem-solving activities with the assistance from community members and teachers (Kuo et al., 2012). As a result, using an online crowdsourcing platform can encourage students to access knowledge and share diverse ideas with others, allowing them to obtain different kinds of learning experience in the real world by creating innovations for problem solving and providing public services to the community (Berg et al, 2006; IDEO.org, 2015; Department of Education, Queensland Government, 2020). The creation of innovations must allow students to design and create innovations with the community to empathize and ideate within the community what they want to have for creating innovations that can solve the problems or respond to practical needs (Kuo et al., 2012). Therefore, the crowdsourcing ecosystem could be helpful in resolving a variety of problems, from essential (e.g., image labelling, fundraising, and making choices) to complicated tasks (e.g., innovation, design, and strategy development). Furthermore, the value now lies in the increased accessibility to knowledge offered by the collective, along with the seamless exchange of diverse ideas facilitated by crowdsourcing. This enables students to leverage crowdsourcing advantages in order to expedite the process of designing and prototyping innovations within their immediate surroundings (Deloitte, 2016).

Although prior research indicates that the use of crowdsourcing contributes to the improvement of innovation competencies, there are still obstacles to be overcome for elevating the use of crowdsourcing in educational settings. Learners require a consistent, valid, accurate, and educated online community (Alenezi & Faisal, 2020). In addition, previous research has demonstrated that coordinating the development and evaluation for quality control requires time and effort when crowdsourcing educational content among an online crowd. Additionally, the design must be acceptable to educators and students (Zhang, 2022). Consequently, this study aimed to analyze the potential of a mobile technology-based crowdsourcing approach in enhancing 11th Graders' innovative creation competencies. It is important to implement a crowdsourcing platform that can support the mobile technology-based learning approach in improving 11th Graders' innovative creation competencies.

Literature Review

Mobile Technology-Based Learning

Mobile technology, with wireless devices, enriches education through features like instant feedback and peer assessment, providing a versatile learning experience. Recent studies emphasize swiftly collecting student data for personalized instruction (Denk et al., 2007; Yeung & Sun, 2021). Wang et al.'s (2022) research links mobile technology to positive learning outcomes, especially in language and science simulations (Alfadil, 2020; Chang et al., 2020). Mobile devices, recognized as engaging tools, alleviate learning anxiety and enhance affective outcomes (Lee et al., 2019; Sahin & Yilmaz, 2020). Their mobility supports social interaction and collaborative learning, but concerns include potential distractions and cognitive load (Chu, 2014; Zhai et al., 2019; Troll et al., 2020). Advances in mobile and wireless technologies create opportunities for face-to-face interactions in education (Hsia & Hwang, 2021). Our research explores integrating mobile learning with crowdsourcing, promoting the use of portable computers on a crowdsourcing platform by students, teachers, and crowdworkers.

Crowdsourcing Technology

Crowdsourcing technology, facilitating creative integration, is widely used for collecting and selecting popular ideas on specific topics through transparent platforms (Isman et al., 2012). Safeguards and challenges from sponsoring organizations incentivize solutions (Isman et al., 2012). Jiang et al. (2018) identified four crowdsourced contributions in learning and teaching: creating educational materials, providing practical experience, exchanging complementary information, and combining crowdsourcing with feedback mechanisms (Jiang et al., 2018; Shaikh et al., 2017). Previous research highlights challenges in crowdsourcing's educational application, emphasizing the need for a consistent, valid, and educated online crowd. Collaboration within online crowds and coordinated efforts for effective use are crucial (Zhang, 2022). This study analyzes the benefits of a mobile technology-based crowdsourcing approach in enhancing senior high school students' innovative competencies.

Innovative Creation Competencies

Local innovators, aiming to address community needs, must possess innovative competencies for developing and implementing fitting solutions. According to Kumsubha (2021), learners should focus on four crucial factors for innovative creation competencies: Critical Thinking (gaining knowledge, analyzing data, problem-solving, constructing arguments, and reflecting), Collaboration (exercising leadership, adapting to situations, utilizing technology for collaboration, and engaging in self-regulation), Communication (engaging in meaningful conversations, leveraging modern tools, delivering articulate presentations, and engaging in self-regulation), and Creativity (generating ideas, collaborating creatively, producing novel outcomes, and engaging in self-regulation) (Cuenca et al., 2016; Hamdu et al., 2020).

Figure 1 shows the conceptual framework of a mobile technology-based crowdsourcing approach.

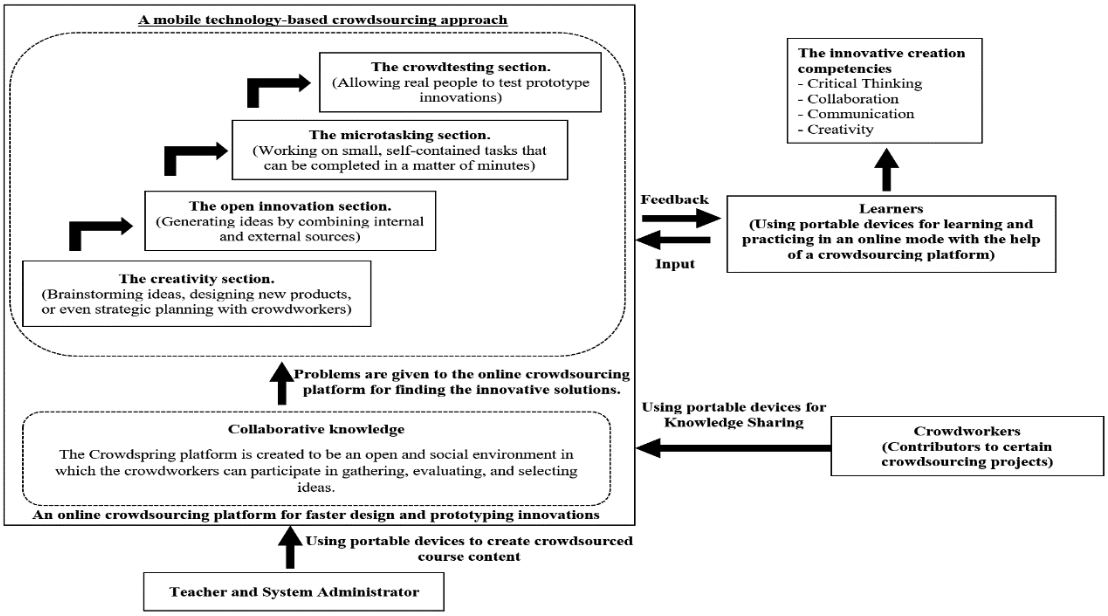

Figure 1 The conceptual framework of a mobile technology-based crowdsourcing approach

Methodology

Participants

The study involved 35 grade 11 students (17 in the experimental group and 18 in the control group) studying Independent Study for 6 months in a large provincial high school in Thailand. Participants were selected through purposive sampling and randomly assigned to either a mobile technology-based crowdsourcing approach or the conventional mobile learning approach. The experimental group utilized the crowdsourcing approach, while the control group followed the traditional mobile learning method.

Research Instruments

The instrument to measure senior high school students' innovative creation competencies was a rubric-based assessment of innovative creation competencies form. The assessment of senior high school students' innovative creation competencies was based on the rubrics for innovation competencies proposed by Cuenca et al. (2016); Hamdu et al. (2020); Hassan (2021); Hero et al. (2017); and Keinänen et al. (2018). The components and observed variables were adopted to assess the students' learning performance, including critical thinking, collaboration, communication, and creativity. This instrument was determined for the content validity using the Index of Item - Objective Congruence (IOC) by three experts, who were experienced in assessing students' innovative creation competencies. The range of the Index of Item - Objective Congruence (IOC) was between 0.67 and 1.00. Moreover, this instrument was determined for the reliability using the Pearson's Correlation Coefficient. The reliability of a rubric-based assessment form was 0.84. Furthermore, the created lesson plans in a mobile technology-based crowdsourcing approach and the conventional mobile learning approach were submitted to five experts who were lecturers in curriculum and instruction in order to check the quality of the created lesson plans. The quality check of the created lesson plans was appropriate to implement with the experimental (M = 4.47, SD = 0.85) group and the control group (M = 4.45, SD = 0.67) respectively.

Data Analysis

In order to investigate students' innovative creation competencies when using a mobile technology-based crowdsourcing approach, and the conventional mobile learning approach, data were collected from a rubric-based assessment of innovative creation competencies form. After that, the means of the two groups were compared using the Mann-Whitney U test.

Procedure

During the experiment, the experimental group learned with the mobile technology-based crowdsourcing approach. The researchers helped participants to create their account in the online platform for crowdsourcing in Crowdspring© and taught them how to use portable computers with wireless communications to participate in Crowdspring©. There were 4 sections of a mobile technology-based crowdsourcing approach as follows:

1. Creativity section (4 days in 1st – 4th week). This section gave students the opportunity to generate ideas, design new products, and even engage in strategic planning with crowdworkers.

2. Open innovation section (4 days in 5th – 8th week). This section provided students with the opportunity to generate ideas by combining internal and external sources. Students participated in the gathering, evaluating, and selection of ideas alongside crowdworkers. Moreover, this section encouraged students to develop more creative solutions.

3. Microtasking section (4 days in 9th – 12th week). This section provided students with the opportunity to work on small, self-contained tasks that could be completed in minutes. Students collaborated with crowdworkers to develop prototype innovations for the process of dividing a large job into small tasks that could be distributed online to crowdworkers.

4. Crowdtesting section (8 days in 13th – 20th week). This section permitted the testing of prototype innovations by real people. Students implemented their prototype innovations with users in order to obtain as many diverse perspectives as possible. Then, all perspectives were modified in order to develop and enhance the quality of their projects.

Figure 2 illustrates the architectural design of a mobile technology-based crowdsourcing approach.

On the other hand, a control group was educated using the conventional mobile learning approach. The researchers implemented the online assignments to assist the performance of students from the beginning to the end of the projects such as Google classroom, Line, Online databases, Infographics etc. The contents and learning activities were based on course syllabus of Independent Study. The following activities were conducted using the conventional mobile learning approach.

Step 1: Identification of a Problem (4 days in 1st – 4th week). Students identify a real-world problem in their environment that necessitates painstaking effort and an innovative solution. The problems may affect a school, a community, a city, or a country. This step provided students with the opportunity to learn how to question and search from different kinds of online databases in order to identify and select interesting problems for use as project topics. After that, the teacher asked such questions that could help students frame the problem in an appropriate context. When students were working on a real-world problem, they had to consider how a solution would benefit the end user.

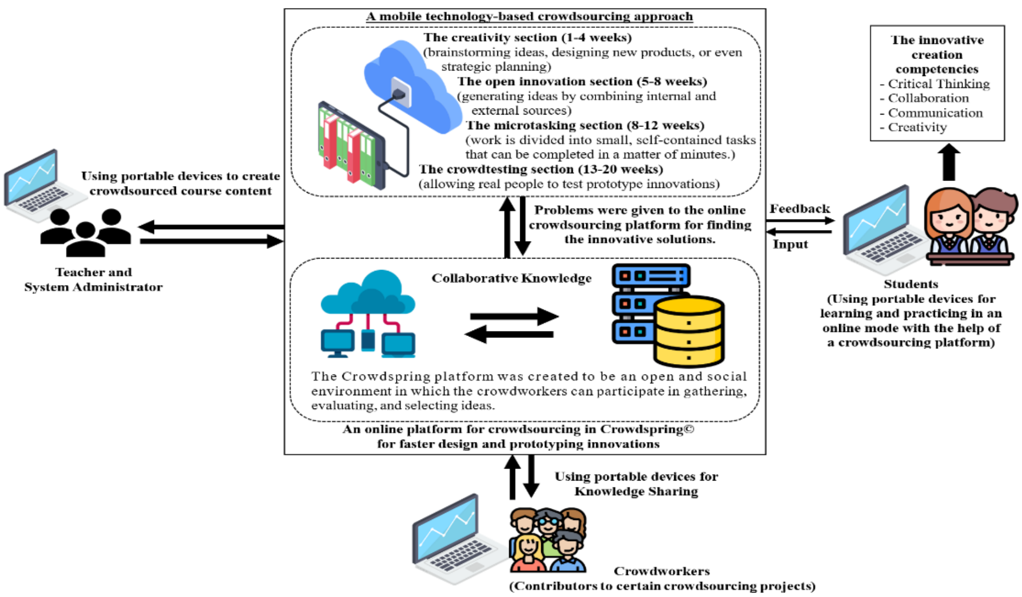

Figure 2 The architectural design of a mobile technology-based crowdsourcing approach

Step 2: Project planning (4 days in 5th – 8th week). Students were instructed on how to create plans for the projects. Because students needed a deeper understanding of the concepts in order to complete the projects, the teacher prepared and imparted extensive content knowledge. Moreover, this step afforded students the opportunity to collaborate with their teammates on a learning plan and project proposal details. Students were given the opportunity to brainstorm and discuss their ideas for solving the problem in which they were able to think creatively and give everyone a chance to refrain from judgement of others' ideas, and to build on the ideas of others.

Step 3: Schedule and Monitor the Progress (4 days in 9th -12th week). This step allowed students to collaborate with their teammates to create a timeline and schedule for the project activities. The teacher was involved in this step from start to finish in order to monitor student work and progress. Furthermore, the teacher instructed students on how to use technology for prototyping solutions. A prototype could take many forms, including a mock-up, a storyboard, a role-play, or even an object made from readily available materials. The focus of this step was to encourage students to quickly and easily iterate on their designs, incorporate feedback into their designs, and continually hone their problem solutions.

Step 4: Assessment the Experience (8 days in 13th – 20th week). This step allowed students to put their prototypes to the test in a real-world setting. Following that, the prototypes were modified based on important feedback in order to make the prototypes highly appropriate. Students created infographics at the end of the project to present the results of their work and progress. Aside from that, teachers could provide effective feedback to individual students to improve their skills and thus boost their confidence.

After the implementation of a mobile technology-based crowdsourcing approach and the conventional mobile learning approach, both groups were assigned a post-test assessment of their innovative creation competencies.

Results

The results revealed that after the implementation of the learning activities, senior high school students' innovative creation competencies (*M* = 70.53, *SD* = 2.34 for the experimental group) were enhanced and were significantly higher than the performance of the control group (*M* = 66.00, *SD* = 2.52) at the .05 level. The results are presented in Table 1.

Moreover, the experimental group developed product innovation better than those of the control group. The experimental group created 5 products innovation whereas, the control group invented 4 products innovation. The results are shown in Table 2.

Table 1 Comparison of two groups' innovative creation competencies

Group	*n*	Total	*M*	*SD*	Mean Rank	Mann-Whitney U	*Z*	*p*
Experiment	17	35	70.53	2.34	25.12	32.000	4.025*	.000
Control	18		66.00	2.52	11.28			

Note: * $p < .05$.

Table 2 The product and process innovation of two groups

Group	Title of Innovation	Type of Innovation
Experimental group	Bioplastic from fruit peels	Product
	Smart and Easy SAE; smart scale with height measurement and BMI using Ultrasonic sensor and Arduino Uno R3	Product
	Veggie Powder	Product
	Shirt Screen Color from Betel Nut, Beetroot, and Roselle	Product
	Mask Drop Festival	Product
Control group	The Non-Electric Projector	Product
	Marijuana Inhaler	Product
	Effect of ACA extract from Galangal on Rhizopus stolonifera's Inhibition in Bread	Product
	CO_2-less Scented Candle	Product
	Strategies for the surveillance of COVID-19 in School	Concept

Discussion

Several factors contributed to the significant enhancement of senior high school students' innovative creation competencies, which is why the mobile technology-based crowdsourcing approach had a greater impact on senior high school students' innovative creation competencies than the conventional mobile learning approach. Students actively participated in the online platform for crowdsourcing in Crowdspring© that was adopted to encourage students using portable computers with wireless networks in which students, teachers, and the crowdworkers participated in knowledge sharing, gathering, evaluating, selecting ideas, and assessing performance via the online crowdsourcing platform. There were four sections of the crowdsourcing platform that supported the mobile technology-based learning approach, which enabled students to have the opportunity for faster design and prototyping innovations with the crowdworkers during the implementation of the mobile technology-based crowdsourcing approach. The Crowdspring© platform was created to be an open and social environment where students and crowdworkers could share knowledge, gather, evaluate, select ideas, and assess performance. The teacher and system administrator were in charge of assessing students' performance and creating crowdsourced course content on the Crowdspring© platform, which allowed students to participate in a variety of learning experiences with the crowdworkers who contributed to specific crowdsourcing projects, while the crowdworkers were in charge of sharing knowledge and assessing students' performance on the Crowdspring© platform. Students were educated through the activities of a mobile technology-based crowdsourcing approach including four sections.

First, the creativity section allowed students to generate ideas, design new products, and even collaborate on strategic planning with the crowdworkers.

Second, the open innovation section provided students with the opportunity to generate ideas by combining internal and external sources. Students assisted crowdworkers in the gathering, evaluating, and selection of ideas. Moreover, this section encouraged students to develop more creative solutions. By combining ideas from internal and external sources and engaging in brainstorming, innovative solutions were developed. Students and crowdworkers used this section to find ideas and solutions that foster creative integration and innovations that address a community's social needs. Students assisted the crowdworkers in the collection, evaluation, and selection of ideas. This section also encouraged students to come up with more creative solutions.

Third, the microtasking section allowed students to work on small, self-contained tasks that could be completed in minutes. Students worked with crowdworkers to create prototype innovations for the process of breaking down a large job into small tasks that could be distributed to crowdworkers online.

Fourth, the crowdtesting section allowed actual people to test prototype innovations. The prototype innovations were developed through the utilization of various methods, such as mock-ups, storyboards, role-plays, or even objects crafted from easily accessible materials. Fourth, the crowdtesting section allowed students to test their prototype innovations with users in order to obtain as many different perspectives as possible. After that, all perspectives were altered to adjust the prototypes for better use. The last section also provided the opportunity for teachers and crowdworkers to assess students' innovative creation competencies in order for students to receive important feedback and perspectives. Teachers and the crowdworkers could provide effective feedback to individual students in order to help them improve their innovative creation competencies.

On the other hand, the conventional mobile learning approach was implemented with a control group. Students actively participated in the implementation of the conventional mobile learning approach via onsite and online platforms (Google Classroom, Line, online databases, Infographics etc.). Although the conventional mobile learning approach helped to improve students' innovative creation competencies, the control group performed significantly worse than the experimental group. There were still challenges and limitations to improving students' innovative creation competencies. The conventional mobile learning approach did not enable students to participate in a variety of learning experiences with others who contributed to specific projects via the online crowdsourcing platform for faster design and prototyping innovations. Students spent so much time on the project that they missed out on important course content and information. Students who completed the course using the conventional mobile learning approach failed fact-based assessments for identifying a real-world problem as a result. Another reason why the conventional mobile learning approach had a lower impact on the innovative creation competencies than the mobile technology-based crowdsourcing approach was that some lazy students took advantage of the students working on the group activity. This can have an impact on students' willingness to collaborate with others on their projects. Furthermore, students lacked the required knowledge. Although the activity can address a relevant and tangible problem, students need the opportunity to collaborate their expertise within the community in order to access new or abstract information for creating an innovative solution that instigates creative integration and promotes innovations that meet a community's social needs.

The findings were consistent with Kuo et al. (2012), who investigated the implementation of Web-based collaborative problem-solving activities aimed at improving students' problem-solving abilities and learning attitude toward social science with the assistance of community members and teachers who can devote more time to helping those in need. The findings revealed that the creation of innovations must allow students to design and create innovations with the community in order for students to empathize with and ideate within the community about what they want to have for creating innovations that can solve problems or respond to the community's needs. The results were also in line with Berg et al. (2006); IDEO.org (2015); and the Department of Education Queensland Government, (2020), all of whom asserted that the use of a crowdsourcing platform on the internet network can encourage students to access knowledge and share diverse ideas with others, allowing them to obtain different kinds of learning experiences in the real world by creating innovations for problem solving and providing public services to the community. Furthermore, the crowdsourcing ecosystem can provide assistance across a broad spectrum of challenges, ranging from basic repetitive tasks like image labelling, fundraising, or voting to more intricate problems such as brainstorming ideas, developing new products, or strategic planning. The increased access to knowledge by the crowd and the seamless exchange of diverse ideas facilitated by crowdsourcing are key factors that generate value. As a result, students can leverage the benefits of crowdsourcing to expedite the design and prototyping of innovations within their local environments (Deloitte, 2016).

Conclusion and Recommendation

This research aimed at enhancing senior high school students' innovative creation competencies through the implementation of a mobile technology-based crowdsourcing approach. According to the findings of the study, the mobile technology-based crowdsourcing approach had a greater impact on senior high school students' innovative creation competencies than the conventional mobile learning approach. As a result, the crowdsourcing platform should be designed to be an open and social environment where students, teachers, and the crowdworkers can gather, evaluate, and select ideas. Furthermore, to find innovative solutions, the four sections of a mobile technology-based crowdsourcing approach must be implemented with students. The creativity section allows students to collaborate with the crowdworkers on brainstorming ideas, designing new products, and even strategic planning, whereas the open innovation section allows students to generate ideas by combining internal and external sources. The microtasking section is essential for work, which is divided into small, self-contained tasks that can be completed in a matter of minutes. The crowdtesting section allows students to test their prototype innovations with users in order to gather as many different perspectives as possible for improving the quality of product and process innovations that are adjusted for better use based on all perspectives.

Recommendations for a Mobile Technology-Based Crowdsourcing Approach in Enhancing Innovative Creation Competencies of 11th Graders

Based on the findings of effects of a mobile technology-based crowdsourcing approach on 11th Graders' innovative creation competencies, it was revealed that the experimental group students' innovative creation competencies (M = 70.53, SD = 2.34) were better than those of the control group (M = 66.00, SD = 2.52) at the .05 level. Moreover, the experimental group developed product innovation better than those of the control group. Teachers should assist pupils to create their account in the online platform for crowdsourcing in Crowdspring© and taught them how to use portable computers with wireless communications to participate in knowledge sharing, gathering, evaluating, selecting ideas, and assessing performance via an online crowdsourcing platform.

Recommendations for Future Research

The research scope focused on enhancing 11th Graders' innovative creation competencies. Further research should focus on monitoring the performance of 11th Graders' innovative creation competencies so that students can apply their innovation to benefit the community. Moreover, in order to generalize the research findings, future studies should expand the sample to other institutions with different characteristics such as primary school students, junior high school students, university or college students, and vocational education. This is because these samples must be educated for enhancing innovative creation competencies in order to prepare students for accessing and obtaining new knowledge and skills, so that they are able to enter into the future workforce, and prosper.

Conflict of Interest

The authors declare that there is no conflict of interest.

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