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The Outcomes of Analytical Thinking and Curiosity from the Virtual Smart Classroom using the Cooperative Problem-Based Learning

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Abstract

This research is intended to study the outcomes of analytical thinking and curiosity derived from the virtual smart classroom using the cooperative problem-based learning; thereby the said virtual smart classroom is a research tool initiated from the integration of the problem-based learning and the cooperative learning coupled with the aid of artificial intelligence and virtual technologies to facilitate learning activities. The development of the said research tool was conducted with the Spatial.io platform and the application ClickUp, which is widely employed to promote learning and organize the works with high quality and attractiveness. This research relies on the pre-experimental research method. The data in this study were collected from 30 research participants, who are vocational certificate students (dual vocational education) of Year 1 and Year 2 in Semester 2 of Academic Year 2024 at Nakornluang Polytechnic College. These participants were derived by means of cluster sampling and well protected with the policies of confidentiality and anonymity in accordance with educational ethics. The research instruments used for data collection include the evaluation form on analytical thinking, and the evaluation form on curiosity. The results of this study correspond to the three research hypotheses and this insists that: (1) the outcomes of analytical thinking after learning with the platform are at a very good level (mean=7.23, SD=1.41); and (2) the outcomes of curiosity after learning with the platform are at a very good level (mean=10.43, SD=1.65). It can be clearly seen from the aforementioned results that the virtual smart classroom using the cooperative problem-based learning is so efficient that it can be applied in practical use so as to promote learners' analytical thinking and curiosity. This is because the said platform provides learners with hands-on self-learning experiences coupled with active learning and collaborative learning, which is said to enhance their learning achievement as well.

Keywords: analytical thinking, curiosity, virtual smart classroom, cooperative problem-based learning

1. Introduction

Learning in the virtual world is regarded as a new style of learning management that can provide learners in such digital age like today with essential learning skills needed in the 21st century. This is because this learning format makes use of modern technologies or platforms that are able to create learning environments in such a way that learners can use their mobile devices to access these learning environments anywhere and anytime and then receive learning experiences directly from the continuous interaction with the platform (Chatwattana, 2022). Due to technological and social changes in the 21st century, it is highly essential for modern learners to be well equipped with the skills necessary for self-adaptation and self-development in many aspects in order to develop life skills and apply them to their future careers. These are considered the learning characteristics consistent with Education 4.0, which is designated to increase learners' engagement, interaction, interest, and enthusiasm for learning (Ministry of Education, 2022).

The advances of online technologies have brought about the changes in instruction models that are not limited merely to the classroom learning. Learners are encouraged more to seek knowledge by themselves and focus more on active-learning so that they can develop not only vital skills but also positive attitudes towards lifelong learning. At the meantime, learners must be allowed to have participation in setting up the learning plans and evaluating their learning outcomes, while instructors must facilitate learning activities that can provoke learners' motivation, encourage exchange of learning, and provide opportunities for learners to think, analyze, and criticize what they have seen (Chatwattana, 2021). All of these are in concordance with the New Normal learning

that always relies on modern technologies to promote learning with an effort not only to improve the quality of social services, especially in terms of network education (Sapliyan et al., 2023), but also to organize education that can help learners gain varied skills and new bodies of knowledge.

2. Research Gaps

The main problem addressed in this research is the pandemic of COVID-19. At that time, people around the world felt like they were forced to adapt themselves to the unexpected situations. Since then, learning methods have shifted to the form of digital online learning, and this situation has also led to major changes in instruction models and learning methods (Chatwattana et al., 2024), resulting in a variety of instruction models that integrate online and virtual technologies into education. Several theories and researches have recently discussed about digital online learning (Rozalina, 2020), and at the same time, learning through virtual environments has become increasingly popular. The significant part of this transition is the change of traditional teaching methods, which has been changed from traditional classroom learning to online education (Toomnan, 2024), in which learners can participate in and access learning resources anywhere and anytime at their own pace.

According to the thorough review of the overall theory framework and relevant literatures, this study still has some significant research gaps. Thus, there should be some approaches to study the outcomes of analytical thinking and curiosity derived from the virtual smart classroom using cooperative problem-based learning. Accordingly, this research is intended primarily to study the perspectives towards the development of the virtual smart classroom using the cooperative problem-based learning from the research participants who were willing to complete the evaluation forms under the policies of confidentiality and anonymity. This is all to find out to what extent the outcomes of analytical thinking and curiosity derived from the virtual smart classroom using the cooperative problem-based learning can promote learning and satisfy the needs of learners.

3. Theory Framework

The theory framework of this research was fabricated from the theories and literatures concerning analytical thinking and curiosity gained from the virtual smart classroom using the cooperative problem-based learning, which include:

- Cooperative Problem-based Learning
- Virtual Smart Classroom
- Analytical Thinking Theory and Curiosity Theory

3.1 Cooperative Problem-based Learning

The development of instruction management in different formats with great emphasis on learners' engagement and hands-on practices in order to develop work skills (Mandee et al., 2021) is considered a teaching method that enables learners to see the problems that will arise, resulting in the learning outcomes that can be proven. Instructors are responsible for determining the problem situation and encouraging learners to perform a systematic analytical thinking process (Phunaploy et al., 2021) coupled with the cooperative problem-solving process. This is said to help learners search for knowledge and solutions in order that they can have the clear understanding of the said problem.

Problem-based learning is an instruction management in which teachers define a situation or problem with an aim to provoke students' curiosity in that situation or problem, which shall force them to perform analytical thinking and decomposition (Sankoke, 2022). Referring to the study of related theories and researches, the problem-based learning process (Sankoke, 2022; Puttiwanit et al., 2020; Marthaliakirana et al., 2022; Phunaploy, 2020; Amin et al., 2021; Poonsawad et al., 2022) can be summarized into 6 steps, i.e., defining the problem, understanding the problem, studying the contents, synthesizing knowledge, conclusion, and presentation and evaluation, respectively.

Cooperative learning is a learner-centered instruction management, in which learners with different abilities are divided into small groups and then allowed to employ the cooperative or teamwork processes to exchange knowledge and jointly solve problems. By this way, learners are encouraged to carry out hands-on practices and use the acquired knowledge to analyze and solve problems. It is expected that this can urge learners to develop thinking skills, inquiry skills, problem-solving skills, and collaboration skills in an effective manner. According to the investigation into the relevant theories and researches, the cooperative learning process (Sermsri et al., 2022; Praimee et al., 2022; Bousalem et al., 2023; Dang et al., 2023) can be concluded into five steps, i.e., join the group, present the lessons, small group study, do the tests, and give scores to the group achievement, respectively.

In reference to the above learning concepts and theories, the researchers realized the importance of both learning processes and had an idea to apply them as guidelines for learning management that can promote analytical thinking and curiosity. As a result, the researchers have gained a new theoretical approach based on the cooperative problem-based learning for use in this study.

Cooperative problem-based learning is a learning model that integrates education technologies with the problem-based learning and the cooperative learning in order to improve learners' analytical thinking through reflection, review, and analysis. This process is believed to help learners obtain many aspects of facts and use them to solve the problems by means of group working, in which all members have different abilities. In addition, learners in the same group will have chances to exchange their bodies of knowledge gained from the assigned problems; this can lead to the systematic analysis on the real causes of what happened.

3.2 Virtual Smart Classroom

Immersive learning is a simulation of learning activity environments using a variety of in immersive technology features to create varied interactions via online platforms, which combine the physical world with the digital world together in order to extend the capabilities of communication and create a virtual society where different formats of information can be presented at a deeper level (Phommanee & Diteeyont, 2021). The concept of virtual technology refers to the application of various technologies to miscellaneous tasks so as to maximize the benefits of working under virtual learning environments (Chatwattana, 2023) and meanwhile to enhance efficiency and learning skills that can make learners well-prepared for the transition to digital world in the near future.

The virtual smart classroom is initiated from the integration of artificial intelligence technology and virtual technology for use as a tool to implement learning activities with an intention to allow learners to monitor their learning progress in real time by means of interaction with instructors. In this study, the researchers have established six elements of the virtual smart classroom (Lu et al., 2021; Siriwan, 2022), i.e., 1) flexible cloud-based learning environments, 2) comprehensive working tools and communication technologies, 3) learning systems with enhanced interaction/engagement, 4) automated education management systems, 5) innovative teaching methods, and 6) supporting different learning styles of learners.

3.3 Analytical Thinking Theory and Curiosity Theory

Analytical thinking refers to the ability to think and classify different elements of any information or problems into many small issues, including the finding of relationships among these elements, and then analyze them systematically in order to find out the real causes of what happened, which will lead to the facts of specific accounts. In reference to the related theories (Nakkunlabut, 2021; Binsulatan, 2022; Alimalbari et al., 2021; Chaimin, 2023), analytical thinking can be divided into three categories, i.e., analysis of elements, analysis of relationships, and analysis of organizational principles. According to the research of Ramadani et al. (2021), it is found that analytical thinking skills are also closely related to problem solving; therefore, it is believed that students are likely to identify and solve problems easily by means of analytical thinking skills. Fundamentally, it can be said that analytical thinking skills are significant for students to deeply understand and connect information or concepts in a systematic manner in order to find the real causes.

Analytical thinking is considered such an important foundation that it can further foster the ability to evaluate or think in a creative manner. The National Strategy 2018-2025 provides that analytical thinking is one of the competencies that must be developed in school-age children, who are the significant resource to gear up national development, so that they are able to think analytically, criticize creatively, and then keep up with the on-going changes in society (Sripanwong et al., 2023). Analytical thinking skills are a part of critical thinking skills, which are one of the characteristics of higher order thinking skills; therefore, analytical thinking skills are highly essential for work and daily life of students in the 21st century. Particularly, these skills are also highly demanded in the Industry 4.0 sector and the vision of sustainable development (SDGs) (Noris et al., 2024). The abilities related to analytical thinking consist of 1) the ability to decompose and understand problems, 2) the ability to explain and provide reasons to support or define the steps to solve problems, 3) the ability to compare and contrast, 4) the ability to evaluate and criticize characteristics, and 5) the ability to analyze by defining new formats of knowledge frameworks (Perdana et al., 2019).

Curiosity has been a part of human psychology since the age of early humans. Today, researchers suggest that curiosity stimulates creativity that can lead to problem-solving. In case we can respond our curiosity in a positive way, it is believed that curiosity can increase our happiness and pleasant feelings (Thomas, 2024). Curiosity is the inquisitive nature that provokes some natural curious behaviors, such as exploration, inquiry, and learning, all of which lead to motivations to learn new things. The indicators of curiosity (Scrivner, 2024; Kaczmarek et al.,

2024) can be divided into four aspects, i.e., 1) engagement and interest 2) behaviors related to research, 3) degree of efforts to search, and 4) emotional responses.

4. Research Objectives and Hypotheses

This research is designated to study the outcomes of analytical thinking and curiosity that the research participants gained from the virtual smart classroom using the cooperative problem-based learning. Thereby, these research participants gave their consent to join this study under the policies of confidentiality and anonymity in accordance with educational ethics. The main objective of this study is to find out to what extent the cooperative problem-based learning system can satisfy learners' needs and support learning. The research objectives of this study are as below:

OB1: Synthesize the theory framework of the virtual smart classroom using the cooperative problem-based learning.

OB2: Study the outcomes of analytical thinking of the students after learning with the virtual smart classroom using the cooperative problem-based learning.

OB3: Study the outcomes of curiosity of the students after learning with the virtual smart classroom using the cooperative problem-based learning.

This study relies on the pre-experimental research method with one - shot case study, and the research hypotheses are as follows:

H_1: The outcomes of analytical thinking of the students after learning with the virtual smart classroom using the cooperative problem-based learning are at good level.

H_2: The outcomes of curiosity of the students after learning with the virtual smart classroom using the cooperative problem-based learning are at good level.

5. Methodology

The survey to find out the outcomes of analytical thinking and curiosity was conducted by means of the virtual smart classroom using the cooperative problem-based learning, a research tool designed based on the concepts of systems approach that has been widely used to design and develop instruction systems (Khemmani, 2018; McGriff, 2000). Thereby, the methodology of this research can be divided into three stages as below:

Stage 1: Synthesize the theory framework of the virtual smart classroom using the cooperative problem-based learning. In this stage, the researchers studied the relevant documents and researches in order to find out the elements for use in the design of learning process and develop the virtual smart classroom using the cooperative problem-based learning.

Stage 2: Develop the virtual smart classroom using the cooperative problem-based learning. The researchers began to develop the research tool for use in the study of analytical thinking and curiosity gained from the virtual smart classroom using the cooperative problem-based learning.

Stage 3: Study the outcomes of analytical thinking and curiosity gained from the virtual smart classroom using the cooperative problem-based learning. This stage is related mainly to the study of learning outcomes from the research participants who are vocational certificate students (dual vocational education) of Year 1 and Year 2 in Semester 2 of Academic Year 2024 at Nakornluang Polytechnic College.

5.1 Participants

The participants in this research include 30 vocational certificate students (dual vocational education) at Nakornluang Polytechnic College, who are studying in Year 1 and Year 2 in Semester 2 of Academic Year 2024. Derived by means of cluster sampling, these participants gave their consent to join this study under the policies of confidentiality and anonymity.

5.2 Research Instruments

The research instruments used for data collection are (1) the virtual smart classroom using the cooperative problem-based learning, (2) the evaluation form on analytical thinking designated for authentic assessment using rubric score with a scoring scale of four levels, and (3) the evaluation form on curiosity designated for authentic assessment using rubric score with a scoring scale of four levels.

5.3 Data Analysis

The statistics used for data analysis are mean, standard deviation, and percentage (Srisa-Ard, 2013). The said measurement and evaluation forms were proved by the experts for validity and for index of item objective

congruence (IOC) before asking the research participants to complete them with freedom of decision-making. These participants were assured that the information they had given herein would not be disclosed and could not be used to identify their identities.

6. Findings

The outcomes of analytical thinking and curiosity were studied with the aid of the virtual smart classroom using the cooperative problem-based learning, which can be summarized as below:

6.1 Results of the Synthesis of the Theory Framework of the Virtual Smart Classroom using the Cooperative Problem-based Learning

The researchers carried out the study on the related documents and researches to find out the elements for use in the design of learning process and develop the virtual smart classroom using the cooperative problem-based learning. The conceptual framework of this research is acquired from the study on the theories and literatures related to analytical thinking and curiosity from the virtual smart classroom using the cooperative problem-based learning. Whereby the supporting theories include cooperative problem-based learning, virtual smart classroom, analytical thinking theory, and curiosity theory.

In reference to the synthesis of the theories above and their relationships with the virtual smart classroom using the cooperative problem-based learning, the authors acquired the theory framework as shown in Figure 1.

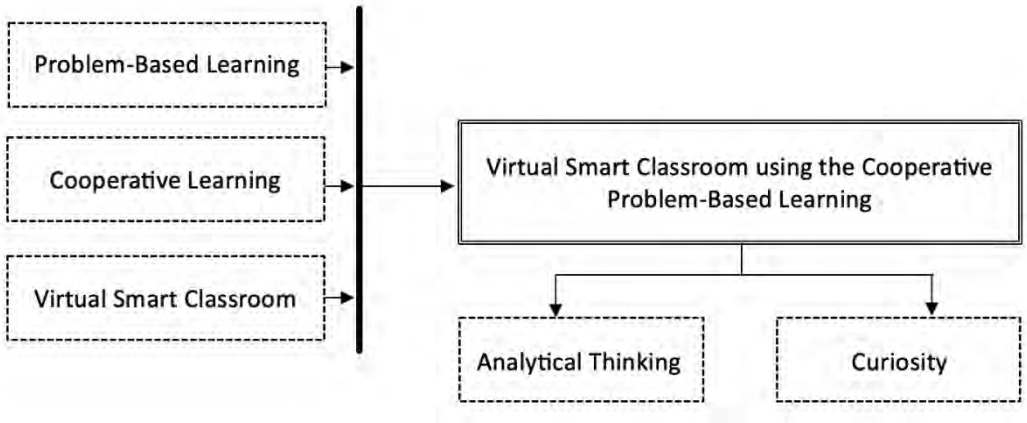

Figure 1. Theory Framework the virtual smart classroom using the cooperative problem-based learning

6.2 Results of the Development of the Virtual Smart Classroom using the Cooperative Problem-based Learning

The virtual smart classroom using the cooperative problem-based learning is an online research tool that is suitable for problem-based instruction management with cooperative learning. The virtual smart classroom is aided by virtual reality and artificial intelligence technologies, and it is integrated with the learning management that encourages learners to think analytically and become more curious. This tool not only promotes the access to learning contents, hands-on practices, and collaboration in small groups, but also allows learners to track their own progress in every activity via gadgets, devices, and smartphones anywhere and anytime.

The virtual smart classroom using the cooperative problem-based learning was developed with the Spatial.io platform and the application ClickUp, which is widely used to promote learning and organize the works with high quality and attractiveness. This study is also intended to present the virtual smart classroom using the cooperative problem-based learning with an interactive screen design that can fulfill the needs of users, including structures and components that are in line with the learning contents in the subject “Implementation of Advanced Spreadsheet”. The researchers also make use of cloud technology and virtual learning technology via metaverse in this development so that learners are able to receive brand-new experiences that can further lead to self-directed learning.

6.3 The Outcomes of Analytical Thinking and Curiosity from the Virtual Smart Classroom using the Cooperative Problem-based Learning

This research is primarily concerning the study of the outcomes of analytical thinking and curiosity of the research participants derived from the virtual smart classroom using the cooperative problem-based learning. The participants herein are 30 vocational certificate students (dual vocational education) at Nakornluang Polytechnic

College, who are studying in Year 1 and Year 2 in Semester 2 of Academic Year 2024. Derived by means of cluster sampling, these participants were well protected under the policies of confidentiality and anonymity according to educational ethics. The study results can be summarized as follow:

A. Results of Evaluation on Analytical Thinking after learning with the Virtual Smart Classroom using the Cooperative Problem-based Learning.

The evaluation on analytical thinking was performed by means of authentic assessment using rubric score with a scoring scale of four levels. The interpretation criteria thereof are as follows:

- 7.00 - 9.00 points means the analytical thinking is at very good level.
- 4.00 - 6.99 points means the analytical thinking is at good level.
- 0.00 - 3.99 points means the analytical thinking is at low level.

Table 1. Results of evaluation on analytical thinking after learning (N=30)

Full score on analytical thinking is at 9 points					
No.	Score	Result	No.	Score	Result
1	8	Very good	16	7	Very good
2	6	Good	17	8	Very good
3	8	Very good	18	9	Very good
4	5	Good	19	8	Very good
5	5	Good	20	8	Very good
6	5	Good	21	7	Very good
7	6	Good	22	8	Very good
8	5	Good	23	9	Very good
9	8	Very good	24	8	Very good
10	6	Good	25	9	Very good
11	8	Very good	26	9	Very good
12	7	Very good	27	9	Very good
13	8	Very good	28	5	Good
14	8	Very good	29	5	Good
15	8	Very good	30	7	Very good

Mean = 7.23; SD = 1.41 (Very good)

In reference to the results of evaluation on analytical thinking after learning with the virtual smart classroom using the cooperative problem-based learning in Table 1, which was conducted with authentic assessment using rubric score with a scoring scale of four levels, it is evident that the mean score of analytical thinking of the students after learning is at very good level (mean=7.23, SD=1.41), which is in compliance with the *hypothesis 1 (H_1)*. However, there is an interesting point found in the research results, that is, the virtual smart classroom using the cooperative problem-based learning consists of the learning steps and learning activities that can encourage learners to think analytically through reflection, review, and analysis. This helps them obtain many aspects of facts for use in solving problems by means of group working, which can lead to the systematic analysis on the real causes of what happened and then lead to their curiosity.

B. Results of Evaluation on Curiosity after learning with the Virtual Smart Classroom using the Cooperative Problem-based Learning.

The evaluation on curiosity was conducted by means of authentic assessment using rubric score with a scoring scale of four levels. The interpretation criteria thereof are as follows:

- 9.00 - 12.00 points means the curiosity is at very good level.
- 5.00 - 8.99 points means the curiosity is at good level.
- 0.00 - 4.99 points means the curiosity is at low level.

Table 2. Results of the curiosity after learning (N=30)

Full score on curiosity is at 12 points					
No.	Score	Result	No.	Score	Result
1	12	Very good	16	11	Very good
2	11	Very good	17	10	Very good
3	11	Very good	18	12	Very good
4	7	Good	19	12	Very good
5	8	Good	20	10	Very good
6	8	Good	21	11	Very good
7	9	Good	22	10	Very good
8	9	Very good	23	12	Very good
9	12	Very good	24	12	Very good
10	8	Good	25	12	Very good
11	12	Very good	26	12	Very good
12	10	Very good	27	11	Very good
13	12	Very good	28	8	Good
14	12	Very good	29	8	Good
15	12	Very good	30	9	Very good

Mean = 10.43; SD = 1.65 (Very good)

According to the results of evaluation on curiosity after learning with the virtual smart classroom using the cooperative problem-based learning in Table 2, which was conducted with authentic assessment using rubric score with a scoring scale of four levels, it is found that the students' mean score of curiosity after learning is at very good level (mean=10.43, SD=1.65), which is in line with the *hypothesis 2 (H_2)*. There is also a remarkable point found in this case. To illustrate, the behavior related to curiosity has a significant effect on analytical thinking as it can stimulate learners to learn new things by breaking down the facts into several sub-issues and using them to solve problems.

7. Conclusion and Discussion

This research is mainly related to the study of the outcomes of analytical thinking and curiosity from the virtual smart classroom using the cooperative problem-based learning, and the main objective thereof is to prove that the virtual smart classroom using the cooperative problem-based learning can enhance the learning achievement of students and meanwhile enable them to develop analytical thinking and curiosity that can respond to the learning styles in the 21st century. It is found that this study can help students develop analytical thinking and curiosity after conducting self-directed learning with "the virtual smart classroom", which was fabricated with the combination of virtual reality and artificial intelligence technologies. The virtual smart classroom supports the cooperative learning and it can be effectively applied in the instruction management that is corresponding to the current world's contexts. This is all to enable learners to perceive new bodies of knowledge in a rapid manner and adapt their learning styles as to their needs, which is believed to lead to the improvement of their knowledge and skills.

The study results are consistent with all 2 hypotheses. It is found that (1) the outcomes of analytical thinking after learning are at very good level (mean=7.23, SD=1.41); and (2) the outcomes of curiosity after learning are at very good level (mean=10.43, SD=1.65). The study results above are in accordance with the research of Suvandy et al. (2024), who stated that the use of learning activities in a virtual environment to create a network of knowledge and collaboration can increase learners' interest and develop their digital literacy and digital empathy. Both digital literacy and digital empathy are essential skills for learners in the 21st century, or digital learners, since these skills enable them to employ technologies as the tools to promote online learning that can be accessed anywhere and anytime. Furthermore, this is also in line with the research of Phunaploy et al. (2021), who conducted the research on problem-based learning processes on cloud-based learning environments. It is found that the design of activities based on problem-based learning processes can help learners achieve better learning achievement, promote their analysis thinking in a systematic manner, provide systematic learning, and foster positive attitudes towards lifelong learning.

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 Canadian Center of Science and Education.

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.

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