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Enhancing Elementary Preservice Teachers' Scientific Literacy by Using Flipped Problem-Based Learning Integrated with E-campus

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ABSTRACT

This study aimed to enhance the elementary preservice teachers' scientific literacy at Pelita Bangsa University by using flipped problem-based learning integrated with e-campus. This Classroom Action Research was done in three cycles and each cycle was conducted with planning, action, observation, and reflection stages. The subjects of this study were 32 preservice teachers in the elementary teacher education program of Pelita Bangsa University in the academic year 2021-2022. Instruments and data collection techniques were observation, questionnaire, and test. The result of this study showed that the implementation of flipped problem-based learning integrated with e-campus improved elementary preservice teachers' scientific literacy.

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The rapid technological development in this current era made education sectors should create literate and globally competitive generations (Muyassaroh & Sunayarti, 2021). The literate generations mentioned are generations who have literacy, the ability to understand, evaluate, reflect, critically analyze information, and use it in decisions making. Facing the 21st century, the basic literacy skills that must be mastered are language literacy, numerical literacy, digital literacy, scientific literacy, financial literacy, and cultural citizenship literacy. To equip students with these competencies, innovations, and technology integration are needed in the learning process. The use of technology in education has improved the quality, efficiency, and effectiveness of the learning process and provided students with new skills, experiences, and knowledge (Abdurrahman et al., 2019; Ramadhani et al., 2019; Syazali et al., 2019) Technology integration is currently to be the main focus of education in the industrial revolution 4.0 and society 5.0 era.

A digital campus is a goal that many higher education institutions want to achieve (Susilana et al., 2020). Many higher education institutions have invested large amounts of money to buy educational tools (Coleman & Mtshazi, 2017). One of the educational tools that are currently being worked on to improve the quality of learning is Learning Management System (LMS). LMS is a web-based software application designed to manage administrative data and support learning systems such as managing learning content, media that connects teacher and students' interaction, assessment tools, and reporting learning progress especially students' activities (Kasim & Khalid, 2016; Suryaningsih & Septiani, 2015). Integrating LMS in the learning process provides many benefits in the world of education. LMS provides continuous accessibility and facilitates lecturer assignments, provides centralized information about students as well as an interactive platform that facilitates easy communication with students, and supports an interactive and collaborative learning (Coleman & Mtshazi, 2017; Oktaviani et al., 2018). To support the online learning process, Pelita Bangsa University also develops a learning management system, E-campus Pelita Bangsa. E-Campus is a system that provides various services not only to support new student admissions and student administration records but also to support the learning process effectively and efficiently (Danny, 2018). According to the educational concept in the society 5.0 era, it is necessary to improve the human resources quality to balance the sophistication of technology.

The e-learning platform on e-campus has been used intensively during the covid-19 pandemic to support the online learning process. At the first, the implementation of e-campus still faced many issues such as server errors due to many people accessing at the same time. The features were also still not optimally used. Both students and lecturers were still adapting to the use of e-campus. Not only being faced with problems related to the e-campus, but the implementation of online learning also faced other common issues related to the lack of internet access, the availability of learning tools, and low student motivation. Some students were late attending class, not collecting the task, and complained about the amount of data cellular costs. The same problems were also experienced by several universities that implemented online learning (Maulah et al., 2020; Tuncay et al., 2011). Students felt that the home atmosphere and the environment did not support effective learning. They felt difficult to concentrate while studying due to environmental conditions. This impacted on the low learning outcomes and students' understanding, especially in a science subject.

The preliminary study showed that their scientific literacy skills needed to be improved. The pretest results on students' scientific literacy skills indicate that students had difficulties relating science concepts, but they could memorize scientific terms even though they still got a misconception. Besides that, the students could not connect to environmental phenomena, ultimately, causing difficulties for the students in dealing with complex problems as complex problems cannot be separated from critical thinking and problem-solving. Scientific literacy is one of the essential skills required in this digital age literacy (Ratini et al., 2018; Turiman et al., 2012), but some previous studies showed that students' scientific literacy at various education levels in Indonesia was still low (Ahied et al., 2020; Jufrida et al., 2019; Rubini et al., 2016; Rusilowati et al., 2016). Students scientific literacy in Indonesia is very low and far below to the international standard set by EOCD (Winarni & Purwandari, 2020).

Scientific literacy is well thought of as a benchmark of high and low-quality of science education in a country (Palines & Cruz, 2021; Rubini et al., 2016; Winata et al., 2016) Many educators and educational institutions worldwide have agreed that the common aim of science education is to produce a scientifically literate society (Ahied et al., 2020; Queiruga-Dios et al., 2020). A scientifically literate society is important because resolving many public issues requires some scientific background (Al Sultan et al., 2018). Therefore, scientific literacy is important for citizens at various levels of education. Science education should empower learners to develop understandings and habits of mind and make decisions (Sengul, 2019). Science is also the main component to create creativities, innovations, and developments since students can identify and explore world phenomena by having science (Santyasa et al., 2021). Learning science could develop learners' abilities to engage in scientific investigations and improve their problem-solving skills in science classrooms, which could lead them to make decisions about science-related issues and develop their technical and scientific abilities as educated citizens.

The problem of low students' scientific literacy can be solved by implementing constructivist science learning models, learning resources, and learning programs that support them to have Scientific literacy skills (Jufrida et al., 2019). The integration of technology was not sufficient to create meaningful learning. The technology integration needed to be combined with the application of innovative learning models, approaches, methods, and strategies to achieve the learning objectives. Good scientific learning outcomes are inseparable from effective and meaningful science learning approaches, strategies, and learning methods during the scientific learning process in class (Wahyu et al., 2020). Based on some previous studies, scientific literacy was improved by applying various appropriate learning models like problem-based learning (Hussa, 2018; Kim et al., 2022; Nasution et al., 2019; Wicaksono et al., 2019). Students' scientific literacy was low because students were not familiar with the socio-scientific issue (Winarni et al., 2020). So, many issues, facts, and problems in everyday life need to be presented in learning activities. Developing students' scientific literacy must be through a learning model that deals with daily problem-solving (Parno et al., 2020). PBL makes students systematically and logically determine alternative problem-solving through empirical data exploration to foster scientific attitudes. PBL apart from being a facility for students to build knowledge, can also be used to improve students' problem-solving abilities, critical and creative thinking skills. The characteristics of Problem Based Learning (PBL) have great potential for students to develop scientific literacy. PBL has significant benefit by combining with flip classroom (Santyasa et al., 2021; Shvetsova, 2019). Flipped classroom is a learning model when students learn content outside of class and in class, lecturer facilitate practice and application of content. In the first phase, the learning phase in the classroom is conducted through discussion activities, prioritizing students' low cognitive abilities as the main focus for improvement and making learning activities more active, interactive and meaningful. While learning outside the classroom is done using an online platform containing learning material and learning videos that provide opportunities for students to study material before the material is taught, and develop students' ability to learn independently (Çevikbaş & Argün, 2017; O'Flaherty & Phillips, 2015).

Based on what has been described before, Implementing Flipped-Problem Based Learning Integrated with E-campus is the appropriate solution to improve the scientific literacy skills of pre-service teachers at Pelita Bangsa University. The flipped classroom learning model can be supported by another learning model like problem-based learning that gives positive impacts, such as improving students' achievement, motivation, and activeness, and building the interaction between teachers and students (Paristiowati et al., 2019). Blending two approaches were found to have positive impacts on the learning process since these two approaches complement each other (Choden & Kijkuakul, 2020). The combination of the flipped classroom and the problem-based model helps students with limited internet access to understand the learning materials and serve them suitable student learning style (Asteria et al., 2020). The advantage of this combination of Flipped Classroom and Problem Based Learning is that students can learn more flexibly according to study time and student needs. Another benefit for students is that students are not only given contextual problem-solving skills but also are given technological literacy.

Based on what has been described previously, this research was focused on "enhancing elementary preservice teachers' scientific literacy by using flipped problem-based learning integrated with e-campus". The implementation of flipped-problem-based learning models used in research, both in the first phase (learning in the classroom) and in the second phase (learning outside the classroom) refers to the syntax of problem-based learning models.

METHOD

This study aimed to describe the learning activities by implementing flipped problem-based learning integrated with e-campus and to improve the scientific literacy skills of elementary pre-service teachers at Pelita Bangsa University. This research was categorized into Classroom Action Research (CAR) model by Kemmis & McTaggart and conducted in three cycles. Each cycle consisted of plan, act, observe, and reflect. Each cycle informs and leads the next learning process to improve the preservice teachers' scientific literacy. The spiral Classroom Action Research model by Kemmis & McTaggart was described as follows.

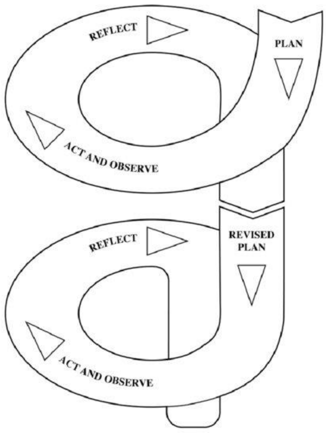

Figure 1. Classroom Action Research model by Kemmis & McTaggart

Planning

Researchers designed the learning plan by implementing flipped problem-based learning integrated with e-campus. Then the researchers prepared the learning materials, student observation sheet, and student scientific literacy test.

Action

Lecturer applied the syntax of flipped problem-based learning integrated with e-campus. The learning process was done synchronously and asynchronously. At the pre-class stage, the lecturer delivered the learning objectives and instructions through the agenda on the e-campus. Then lecturer uploaded the learning materials and student worksheet a week before the in-class activity. Students downloaded them, studied the above learning materials, and analyzed the problems on their own time. They also can use the discussion room on e-campus to discuss the problems collaboratively. At the "in class" stage (done synchronously assisted by zoom meeting), the lecturer reintroduced the problems and guide the students to present their work and compare it with others. Lecturer also guides the student to the final summarization. In the post-class stage (done asynchronously), students worked on their post-test.

Observation

The action stage by implementing flipped problem-based learning integrated with e-campus was followed by the observation process using an observation sheet. To observe the asynchronous learning was carried out by observing the student's activities recorded on the e-campus. While synchronous learning activities can be observed through the learning process using a video conference platform.

Reflection

This stage was an activity to evaluate the learning process by implementing flipped problem-based learning integrated with e-campus based on both the observation results and the increase in students' scientific literacy. The data regarding both the observation results and the increase in students' scientific literacy were analyzed to decide what to do in the further cycle planning.

This research planning was done based on the student's scientific literacy pre-test and a pre-semi-structured interview with the students at the beginning of the semester. This helped the researchers to explore the students' perceptions regarding online learning and the issues as the basic idea of this research. The action phase of the cycle was planned for 3 cycles and each cycle consisted of 2 periods of meetings.

The subjects of this study were the pre-service teacher in Elementary Teacher Education Programs in class 19 C1. The data collected from 32 pre-service teachers were categorized into qualitative and quantitative data. The qualitative data were obtained by observation and interview and the quantitative data were obtained by scientific literacy testing and observation. Data collection was performed using observations, interviews, and tests. The data was validated by triangulation of technique and analyzed according to the qualitative analysis technique of Milles & Huberman consisting of data reduction, data display, conclusion, and verification. The successful research was indicated by 85% both of observation results and students' scientific literacy testing results.

RESULT AND DISCUSSION

Learning Activity

The flipped classroom was a blended learning model that combines synchronous and asynchronous learning activities. Synchronous activities were face-to-face learning activities together between teachers and students using a video conference platform. While asynchronous activities were indirect learning where students learn independently. Flipped-classroom consisted of three stages, namely pre-class, in-class, and out-of-class. At the pre-class stage, students carry out asynchronous learning activities, distributed teaching materials such as e-modules or learning videos, and student worksheets through the learning content feature "Materi" given a week before the face-to-face learning begins. Then, students discussed the problems taken from the uploaded student worksheet and analyzed them to find out how to solve the problems collaboratively using the discussion room feature "diskusi" at e-campus features. In the discussion room, students can upload links, pictures, or documents regarding to the problems. Students prepared the discussion results in their own PowerPoint to be explained in face-to-face learning. The second stage was in-class where students and teachers conduct face-to-face online learning with video conference features, zoom meetings. In this stage, students presented their work and discussed the problems to compare the steps to solve other problems and find out which steps to solve the problem were most appropriate. Then, both lecturer and students discussed the unresolved questions and provided material reinforcement from previous asynchronous learning. The last stage, out of class was an asynchronous stage to measure and evaluate the achievement of learning objectives. The assessment process was carried out by utilizing the exam feature "Ujian" on the e-campus.

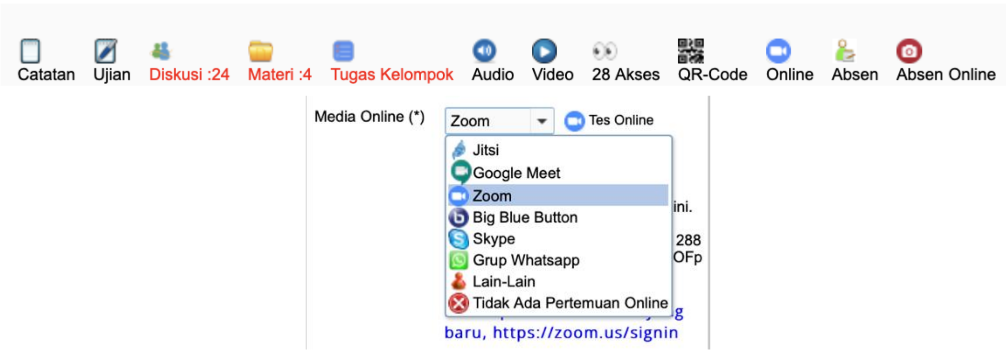

Figure 2. The e-campus features

E-campus has many features to support the learning process such as learning notes, exams, a discussion room, learning content for various formats (documents, links, audio, and video), tasks, an integrated online learning platform (jitsi, google meet, zoom meeting, skype, big blue button, skype, and WhatsApp group), and absence feature. These features need to be used and optimized to improve learning achievement. One way to optimize these features in the learning process was to combine them with innovative learning models. In this research, e-campus was supported with flipped problem-based learning models. Flipped problem-based learning was a combination of the flipped classroom and problem-based learning. The flipped classroom was a kind of blended learning model that combined synchronous and asynchronous learning activities to create a meaningful dan joyful learning (Dziuban et al., 2018). While the problem-based learning model was student-centered learning using contextual problems that activated student participation in learning experiences and formed students to become flexible thinkers in the problem-solving (Damayanti et al., 2020; Muyassaroh & Nurpadilah, 2021). Blending flipped classrooms and problem-based learning has been widely researched and has a positive impact on the learning process (Çakıroğlu & Öztürk, 2017; Chis et al., 2018; Mudhofir, 2021; Tawfik & Lilly, 2015). It is also considered appropriate for developing the scientific literacy (Paristiowati et al., 2019). The implementation of flipped problem-based learning models used in research, both in the first phase (learning in the classroom) and in the second phase (learning outside the classroom) refers to the syntax of problem-based learning models. The syntaxs of problem-based learning according to Arends (2012) are problem orientation, learning organization, guiding an individual or group investigation, developing and presenting the students' works, and analyzing and evaluating the problem-solving process. The stages of the implementation of Flipped-Problem Based Learning integrated with e-campus pelita bangsa are described in the following chart:

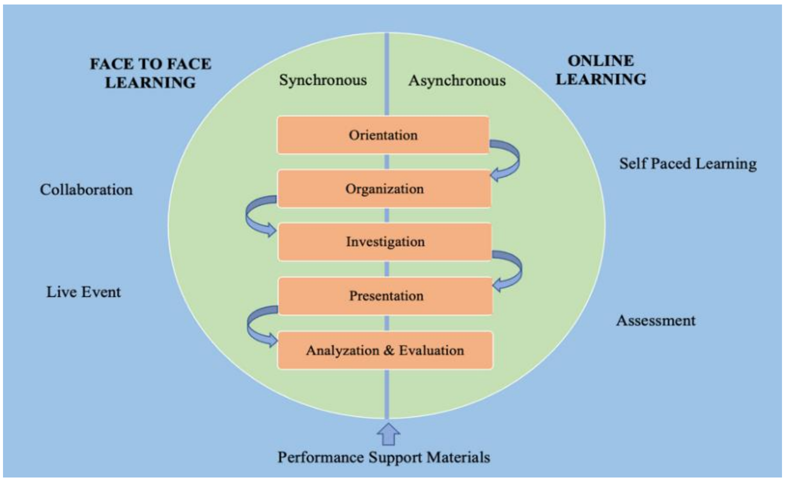

Figure 3. The Implementation of Flipped Problem-Based Learning integrated with e-campus adapted from Ramadhani et al., (2019)

The description of each step of the implementation flipped-Problem Based Learning integrated with e-campus in detail can be seen in table 1. The data regarding observation results of the implementation of flipped problem-based learning integrated with e-campus are presented in the following table 2.

Table 1. The Syntax of Flipped-Problem Based Learning Integrated with E-campus

Syntax	Procedures	Student Activities
Asynchronous	Problem Orientation	Students understand the details of the problems to be discussed. The problems are taken from the uploaded student worksheet on the e-campus. Then, students analyze and find out how to solve the problems.
	Learning Organization	Students solve the problems by finding out several problems that are similar or similar to the problems being analyzed. In this step, students can categorize the details of the problems discussed.
	Individual or group investigation	After students classify the details of the problem, students can investigate the problem in groups or individually.
Synchronous	Development and Presentation	Students can develop and present the results of problem discussions using a video conference platform. In this step, students can compare the steps to solve other problems and find out which steps to solve the problem are most appropriate.
Asynchronous	Problem Solving Analyzation and Evaluation	Students can conduct analysis to reflect and evaluate the results of investigations regarding the solution to the problem being discussed. Students can conclude correct and appropriate problem solving.

Table 2. The observation Result of The Implementation Flipped-Problem Based Learning Integrated with E-campus

Procedures	Average Scores		
	Cycle I	Cycle II	Cycle III
Problem Orientation	4,19	4,24	4,67
Learning Organization	4,08	4,33	4,75
Individual or group investigation	3,67	4,11	4,67
Development and Presentation	4,11	4,33	4,78
Problem Solving Analyzation and Evaluation	3,94	4,56	4,78
Sum	20,00	21,57	23,64
Average	4,00	4,31	4,73
Percentage	80,00%	86,29%	94,56%

The increase in the observation results in each cycle with the application of Flipped-Problem Based Learning Integrated with E-campus is presented as follows:

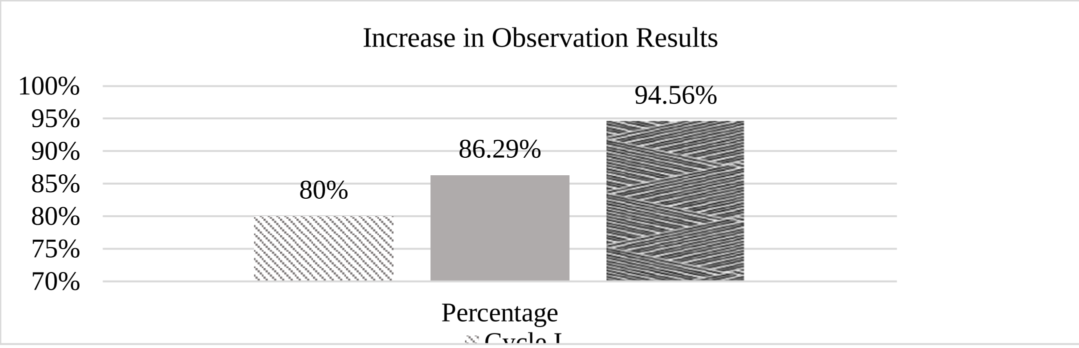

Figure 4. Increase in Observation Results

E-campus was a learning management system that helps the implementation of flipped-problem-based learning with synchronous and asynchronous learning processes. To observe asynchronous learning was carried out by observing activities recorded on the e-Campus. Then, the synchronous stage through face-to-face learning was observed through the learning process using a video conference platform, zoom meeting. The results of the observations showed an increasing trend in each cycle by 80% in the first cycle, increased to 86,29% in the second cycle, and reached 94,56% in the third cycle. At first, both lecturers and students were still in the adaptation. The lecturer still faced many issues and had to explain every step repeatedly. Lecturer had to guide and take the lead role in directing the students to the next steps. Students seem to lack confidence and there was little effort in preparing the presentation. They read their notes during the presentation and were reluctant about sharing their arguments. But then, in the second cycle, this condition was getting better. Both students and lecturers started to enjoy the learning by implementing flipped problem-based learning integrated with e-campus, although there were several learning activities need to be improved. In the third cycle, the lecturer created an interactive atmosphere by organizing the students and getting the students involved. The lecturer was also quite good at guiding the student's investigation. The lecturer facilitated the students develop and present the investigation result and performed well in guiding the students to analyze the problem-solving. Some students were enthusiastic and felt more confident to present their discussion results. Students were able to carry out the lecturer's instructions. Both lecturer and students enjoyed the learning process.

Increase in Scientific Literacy

The implementation of flipped problem-based learning integrated with e-campus can improve the scientific literacy of elementary preservice teachers in natural science subjects. The scientific literacy instrument was developed by elaborating the dimensions of scientific literacy consisting of content, context, and process. The lattice arrangement also paid attention to the cognitive domain implementation (C3), analysis/synthesis (C4), and evaluation (C5) with a focus on the dimension of conceptual knowledge. The scientific literacy indicators used in this research refer to Gormally et al., (2012) as shown in the following table.

Table 3. The Scientific Literacy Indicators

Scientific Literacy Indicators	Sub Indicators
Identifying scientific issues	Identifying valid scientific arguments
	Evaluating the validity of a knowledge source
	Evaluating the use of scientific information
Utilizing scientific evidence	Analyzing graphical data representation
	Interpreting the data graphically
	Solving problems using quantitative abilities
Explaining phenomena scientifically	Using scientific knowledge appropriately
	Understanding the elements in research design
	Making predictions/give reasons appropriately

Table 4. Increase in Scientific Literacy

Procedures	Percentage		
	Cycle I	**Cycle II**	**Cycle III**
Identifying scientific issues	54.17	77.08	88,54
Utilizing scientific evidence	61.98	81.77	87.50
Explaining phenomena scientifically	57.29	72.40	88.02
AVERAGE	57.81	77.08	88.02

The scientific literacy testing results showed an increase in the average percentage in each cycle from 57.81% in the first cycle, to 77.08% in the second cycle, and became 88.02% in the third cycle. The average score of the three indicators was not much different. However, the percentage increase in each cycle was quite significant. The increase in scientific literacy testing results on each indicator is presented as follows.

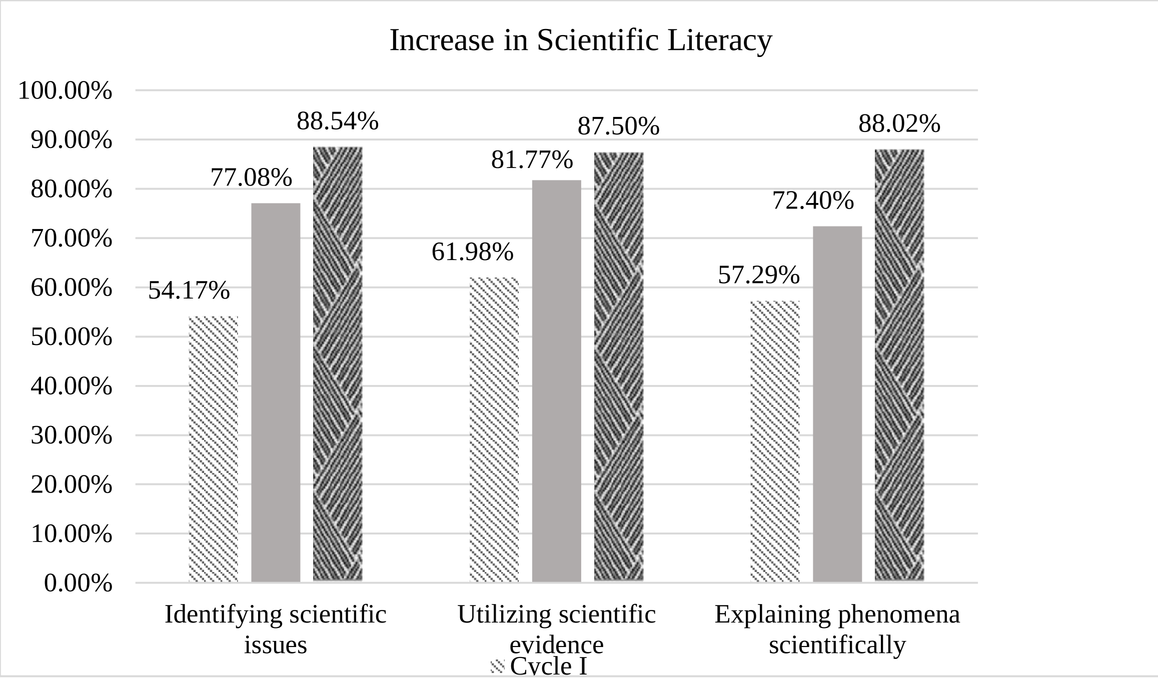

Figure 5. Increase in Scientific Literacy

Based on the graph above, can be seen that the implementation of flipped-problem-based learning integrated with e-campus improved the elementary preservice teacher' scientific literacy on all indicators in each cycle. In the first indicator, "identifying scientific issues", the percentage score increased by 54.17% in the first cycle, to 77.08% in the second cycle, and became 88.54% in the third cycle. The percentage score in the "Utilizing scientific evidence" indicator increased by 61.98% in the first cycle, to 81.77% in the second cycle, and became 87.50% in the third cycle. Meanwhile, in the "explaining phenomena scientifically" indicator 57.29% in the first cycle increased to 72.40% in the second cycle and reach 88.02% in the third cycle.

In the first cycle, the scientific literacy testing results showed that the lowest student's scientific literacy ability was in "identifying scientific issues" reaching 54.12% besides 61.98% in the "Utilizing scientific evidence" indicator and 57.29% in "explaining phenomena scientifically". Students still have difficulty in identifying various scientific issues and phenomena presented by the lecturer due to the lack of the student's scientific knowledge. The students came from various educational backgrounds and not all students came from science majors. The completion target of teaching materials forced students to accept science concepts that may not be fully understood. This made some science concepts understood by misconception or just memorized which in the end the concept was easy to forget. Students explained the concept correctly but faced difficulties analyzing the problems using the concept. There were still many students who have misconceptions about a science concept. In the second cycle the highest student's scientific literacy ability was in the "Utilizing scientific evidence" indicator reached 81.77% then proceed with "identifying scientific issues" indicator reached 77.08% and the "explaining phenomena scientifically" indicator reached 72.40%. In this second cycle, students felt more comfortable in identifying scientific issues because these issues were taken by choosing problems that were familiar and close to students' lives. This research was stopped until the third cycle because the students' scientific literacy testing results in the third cycle had reached the targeted research performance indicators of 85% with the first indicator "identifying scientific issues" reaching 88.54%, the second indicator "Utilizing scientific evidence" reached 87.50% and the last indicator, "explaining phenomena scientifically" reached 88.02%.

The key to success in using the flipped-problem-based learning model was encouraging students to be more active in applying new information to various contexts creatively (Capone et al., 2017). The PBL stages helped students to develop claims, sources of evidence, and demonstrate reasoning (Laksmi et al., 2021). By implementing problem-based learning students were trained to think critically and creatively solve problems in everyday life (Fakhriyah, 2014; Kardoyo et al., 2020; Robayani et al., 2018) as critical thinking and problem solving were the basic competence to master scientific literacy (Rouf et al., 2021). Science learning should be more emphasis activity on science process skills and reduce memorizing of concept (Rusilowati et al., 2016). The implementation of flipped problem-based learning also emphasized students' skills and mastery of technology, as well as trained students' independence in finding solutions to problem-solving (Ozdamli & Asiksoy, 2016). Learning by implementing flipped classrooms was able to create a pleasant, conductive, and meaningful atmosphere (Wijanarko & Ganeswara, 2021), flexible, effective, and efficient learning process without being limited by space and time (Cai et al., 2022; Suhendri & Andriyani, 2019), and also improved the student's motivation, learning outcomes, and independence (Garza, 2014; Uzunboylu & Karagozlu, 2015). The advantages of combining these two learning models were also supported by the Learning Management System (LMS) excellences. Using LMS in the learning process facilitated student and lecturer interactions and sharing of learning content (Raza et al., 2021), provided effective ways of learning process (Alomari et al., 2020), and also provided various multimedia resources and individual tracking activities of students' development (Kraleva et al., 2020). The Learning Management System, e-campus supported the implementation of flipped problem-based learning with various management features that facilitate the implementation of the synchronous and asynchronous learning process. This was very supportive to create learning settings that can improve scientific literacy viewed from the scientific literacy indicators that have been described before. Thus, based on the results of the research that has been carried out by researchers as well as previous studies, showed that the implementation of flipped problem-based learning integrated with e-campus can improve elementary preservice teachers' scientific literacy.

CONCLUSION

The implementation of flipped problem-based learning integrated with the e-campus was carried out synchronously and asynchronously with the assistance of the LMS e-campus and carried out through the problem-based learning syntax (1) problem orientation, (2) learning organization, (3) individual or group investigation, (4) development and presentation, (5) and problem-solving analyzation and evaluation. The first, second, third, and fifth Syntax were implemented asynchronously on the e-campus by utilizing various features of learning materials, assignments, and exams. while the presentation activities in the fourth syntax were carried out synchronously through the video conference zoom meeting feature integrated into the e-campus. Combining flipped classrooms and problem-based learning can optimize the learning process by taking advantage of both learning models and complementing each other to minimize weaknesses. This is also supported by the advantages of technology to make the learning process more effective and efficient. So, implementing flipped problem-based learning integrated with the e-campus improved the elementary preservice teachers' scientific literacy.

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