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Learning Cycle-Inquiry Effect on Pre-Service Elementary Teachers' Science Process Skills and Content Knowledge

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Annotation. This study explored the effects of Learning Cycle and Inquiry (LCI) on pre-service teachers' science process skills (SPS) and concept knowledge (CK). The experimental group was taught using the LCI. The positive control group 1 learned using the inquiry, the positive control group 2 learned using the learning cycle-5E, and the negative control group was involved in conventional learning processes. The study results revealed significant differences in the research participants' CK and SPS.

Keywords: *content knowledge, learning cycle-inquiry, science process skills.*

Introduction

Recent global curriculum has focused on developing science-literate students (Akben, 2015; Baptista & Molina-Andrade, 2021). Science-literate students can understand scientific facts and apply science process skills (SPS) to solve science-related problems (OECD, 2017). In different countries, science process skills (SPS) are an integral part of the school curriculum (Shahali et al., 2017; Wu & Wu, 2011). Therefore, students must develop SPS to fully learn and understand science (Hofstein & Lunetta, 2004). In short, modern education should aim to help students master concepts and apply SPS in everyday life. A balanced relationship between SPS and content knowledge (CK) is necessary to create a meaningful learning process (Tan et al., 2022).

Science process skills (SPS) are important because they play a major role in building students' competence and enthusiasm for science and various natural phenomena that occur in daily life (Duran et al., 2011; Erkol & Ugulu, 2014). SPS help students develop higher thinking skills (HOTS), including critical thinking, decision making, and problem solving skills (Koray et al., 2007). SPS enable students at universities to find and develop facts and concepts themselves. Increased SPS ultimately leads to increased content knowledge (Coil et al., 2010).

However, some previous studies have shown that students have poor science process skills (Andriyani et al., 2019; Artayasa et al., 2017; Fadilla et al., 2019; Irwanto et al., 2018). Few students can learn methods of scientific thinking because most classroom instructions are not based on discovery (Gultepe & Kilic, 2015). Traditional teaching methods are no longer sufficient to support the development of students' content knowledge and science process skills (Akben, 2015). Conventional classrooms emphasize non-student-centered activities that fail to encourage students to understand topics and concepts (Idris et al., 2022). Most classroom learning activities only focus on helping students achieve high test scores without encouraging students to actively participate in class (Awelani & Fraser, 2004). Thus, one factor that plays a significant role in underachieving is the quality of instruction (Luera et al., 2005). To find a solution to this challenge, educational researchers conducted various studies. One is applying inquiry and learning cycle (LC) to enhance college students' science process skills and content knowledge.

The inquiry-based learning model has been implemented in the classroom to improve the science process skills of prospective teachers (Artayasa et al., 2017; Imaduddin & Hidayah, 2019; Irwanto et al., 2018). The inquiry-based learning model offers higher education students the opportunity to obtain facts and explanations about natural phenomena, which can help them develop science process skills (Borrull & Valls, 2021). Inquiry involves students' curiosity in developing experimental questions that can enhance their reasoning skills (Gultepe, 2016). In addition, Irwanto et al. (2019) state that inquiry-based learning emphasizes critical thinking and science process skills rather than simply mastering scientific concepts.

On the other hand, the learning cycle (LC) focuses more on promoting content knowledge (Koyunlu Ünlü & Dökme, 2022; Nopparatjamjomras & Nopparatjamjomras, 2020). LC is designed to help teachers move from traditional to student-centered classrooms (Marfilinda et al., 2019). LC helps students understand science concepts, encourages scientific reasoning, engages students in the learning activities (Marek, 2008), and critical thinking (Cahyarini et al., 2016; Suwono et al., 2019, 2023). Ergin et al. (2008) state that the LC-5E model allows students to learn new concepts, understand concepts that are already known in depth, and actively seek information for understanding.

This research discusses the performance of the combined Learning Cycle and Inquiry later known as the Learning Cycle-Inquiry (LCI). Several references describe the similarity of the inquiry phases and cycles of LC. LC is one of the most suitable models to combine with inquiry (Eroğlu & Bektaş, 2022). LC was developed based on a scientific inquiry approach (Koyunlu Ünlü & Dökme, 2022). Guided inquiry activities provide opportunities for students to address alternative conceptions (Garcia I Grau et al., 2021). The difference between the two is that the initial phase of LC suggests starting with an inductive approach, whereas the initial phase of inquiry suggests a deductive approach. However, induction and deduction can coexist and complement each other in the inquiry process (Pedaste et al., 2015). This study assessed college students' science process skills before and after the implementation of LCI-based learning. It also explored the effectiveness of the LCI learning model in increasing the students' content knowledge. It is hoped that the results of this study can guide faculty and university curriculum designers to combine inquiry learning and the learning cycle to teach science to prospective elementary school teachers.

Method

Research Questions

The present study was conducted to explore the effects of Learning Cycle and Inquiry (LCI) on college students' science process skills and content knowledge. Specifically, this study attempted to answer the following questions: 1. Are there any statistically significant differences in science process skills between LCI students and non-LCI students? 1. Are there any statistically significant differences in content knowledge between LCI and non-LCI students?

Context of the Study

The Department of Elementary School Teacher Education (ESTE) is part of the Indonesian national education system responsible for preparing and developing quality teacher resources. Elementary school is a fundamental level of education. It lies the foundation for a higher level of formal schooling. Therefore, the ESTE study program must produce teachers with extensive content knowledge, strong investigative skills, a strong learner spirit, and an adequate ability to apply learning methods or practices to improve learning quality.

The ESTE department applies a spiral development approach to material development to ensure systematic learning. One of the materials considered relevant and presented in the form of courses is the basic concepts of natural science, which is the context we wanted to explore. Since inquiry-based learning and learning cycle (LC) were implemented in science courses for science teachers (physics, chemistry, and biology), we were interested in combining learning cycle and inquiry and examining its effectiveness in basic science courses.

Design of the Study

The present study employed a pretest-post-test nonequivalent control group design (Creswell, 2014). Learning Cycle-Inquiry (LCI) was applied to improve college students' science process skills and content knowledge in a science basic course. The course lasted 16 weeks. Four freshman groups studying science were used as participants. All groups received the same lesson topics, namely the relationship between living things and the environment, the reproduction of living things, the organ system of the human body, and the importance of a healthy lifestyle. However, the topics were delivered using different instructions. In the experimental group, instruction was based on the LCI model. There were two positive control groups and one negative control group. To learn the topics, the positive control group 1 used the Inquiry learning phases, the positive control group 2 used the learning cycle (LC) 5E learning phases. In contrast, the negative control group used the conventional methods of learning.

Participants

Four (4) groups of freshmen from a university in East Java, Indonesia, participated in this study. The total number of the students was 82 students. They were enrolled in a basic science course. The four groups of participants consisted of the LCI group (23 students), the Inquiry group (23 students), the Learning Cycle-5E group (18 students), and the Conventional group (18 students). The four classes had a homogeneous variance and normal data distribution, confirmed by the Levene's Test for Equality of Variances and the One-sample Kolmogorov-Smirnov test (p-value>0.05). All students agreed to be involved in this research from start to finish. Thus, their involvement was voluntary and without coercion.

Instrumentation

Test for science process skills (SPS)

The participants' science process skills were assessed using five essay questions that refer to five indicators: formulating hypotheses, identifying variables, designing experiments/ investigations/ observations, interpreting data, and drawing a conclusion (making an inference). A lecturer with science education expertise evaluated the face validity and content validity of the test. The test items were revised based on the expert recommendations. The revised items were then used in a field tryout. The field tryout was conducted with sophomore students to establish the validity and reliability of the test. Test validity was tested using Pearson Correlation. The results showed that only item number 5 had an insignificant p-value.

Meanwhile, the reliability test results revealed a Cronbach's alpha value of 0.80, indicating a high reliability level. The invalid test items were revised. All study groups used the revised test items in the pre-test and post-test. Below is an example of an empirically and theoretically valid science process skills test.

Indicator: identifying variables

Question Number 2: Vita wants to do a simple study on "the effect of an organic fertilizer type on the growth of red bean sprouts". From the research title, determine:

a. the research variables;

b. the formulation of the problems or the relationship between the research variables;

c. the research hypothesis.

The test takers might score between 0-4 for Question No. 2. The criteria for each score are: 0 for "no variable was identified", 1 for "the identified variables were wrong:, 2 for "can only identify one of them, the independent or dependent variable", 3 for "can identify all variables correctly, but cannot manipulate the variables", and 4 for "can identify and manipulate all variables correctly".

Test for content knowledge (CK)

The participants' content knowledge was assessed using nine essay questions that refer to four subtopics taught in the basic science course. The test belonged to a higher-order thinking test which measured the participants' abilities to analyze (C4), evaluate (C5), and create (C6). The difficulty of the test items was based on the revised Blooms taxonomy. This test was validated by a science lecturer and tried out to a group of sophomores. The face and content validity tests showed that five questions were invalid (p-value > 0.05) and needed minor revisions. The reliability test showed high reliability (a Cronbach's alpha value of 0.85). The following contains an example of an empirically and theoretically valid content knowledge test.

Indicator 1: the relationship between living things and the environment (C4-Analyzing)

Question Number 1: Humans hunt birds for their uniqueness and their usefulness as food. Birds have a vital role in the balance of a tree ecosystem.

a. Name the biotic and abiotic components in a tree ecosystem! Give one example of the relationship between biotic components influenced by abiotic components in the tree ecosystem!

b. Draw the tree ecosystem food web!

c. Explain the position of birds in the tree ecosystem organization level and if there is continuous hunting, what will happen to the balance of the tree ecosystem?

Data Collection Procedure

First, we sent a letter to the department head of the ESTE department at the target university. The head of the study program recommended that we meet the lecturer in charge of the basic science course. We then communicated informally by telephone to discuss informed consent with the lecturer. After obtaining consent, four classes were determined based on the results of the equivalence test on the students' GPA. We randomly selected one student group as the experimental class and the other three as control groups. Two weeks before conducting the treatment, participants were acclimatized to get used to the learning atmosphere of the LCI model, the exam, and the 5E learning cycle. The acclimation session was given to the students to prepare them to use the models, allowing the lessons to be better managed and the learning process to be more effective. In the first and sixteenth weeks of the course, all participants completed the same pre- and post-test on scientific process skills and content knowledge. The collected data was then statistically evaluated.

The Learning Cycle-Inquiry (LCI) Implementation

Learning Cycle-Inquiry (LCI) is a combination of two learning models, namely Learning Cycle (LC) 5E developed by Bybee (Bybee et al., 2006) and Inquiry proposed by Llewellyn (Llewellyn, 2012). The LCI learning process begins by creating a condition that prepares students to participate in learning. This stage involves students connecting past and present experiences and organizing their thoughts to achieve learning goals. Then, LCI encourages students to explore interesting subjects and seek problems from a phenomenon. LCI facilitates students to find ideas that increase understanding to solve a problem. Learning in the LCI classroom involves students learning to interpret the meaning of a phenomenon, problem, data, or other information. The LCI model includes activities that can increase student motivation, strengthen their scientific process skills, and critical thinking through inquiry activities and reasoning. Finally, in the LCI classroom, students conduct elaboration and assessment of the implemented learning activities. Table 1 maps the LCI syntax in detail.

Table 1
LCI Syntax

Syntax	Description	Learning Activities
Orienting students to the process of learning	Creates a condition in which students are prepared to learn. Introduces students to the objectives and stages of learning. Motivates students through apperception activities. Prepares students for group.	Students are divided into groups of 2 or 3. Encourages students to think by asking "Have you ever grown sprouts? How did you do it?"
Exploring knowledge	Provides students with the opportunity to engage in the learning process, by letting them explore an interesting object or situation. Asks and stimulates students to identify and formulate the problem.	Students determine the problem that is going to be investigated, for example "Can the growth media affect the germination of long bean seeds?" then identify the dependent variable of the research, for example "the number of leaves" and the independent of the research, for example "growth media".

Syntax	Description	Learning Activities
Formulating hypotheses	Asks students to think about the temporary solution to the problem.	Students formulate a temporary assumption to solve the problem, for example "The growth media may affect the germination of the long bean seeds".
Explaining	Students design an investigation Students do investigation activities to collect information to test the hypothesis (for example, via observation, experiment, practicum, reading, or discussion).	Students establish the investigation schedule, tool and material, and procedure.
Analyzing and interpreting data	Students determine the acceptable answer to the problem based on the collected data or information. Students develop skills in explaining meaning of a problem, an issue, data, or other information.	Students analyze data and present it in the form of tables or images of "the length of the long bean sprout stem (in cm)" and "the number of leaves".
Drawing a conclusion	Students conclude and describes the investigation findings based on the analysis results and data interpretation.	Students conclude by stating that "the growth media affect the germination of long bean seeds".
Elaborating	Students do activities that strengthen and elaborate the concepts received from learning. The activities relate to the application of concepts in everyday life.	Students elaborate the concept of growth by assuming that external factors, such as nutrients in the soil and fertilization can influence the growth of long bean seeds.
Evaluating	Students evaluate the learning process and reflect on their progress in acquiring knowledge during the learning process.	Students reflect on problems and insights obtained during the learning process.

Data analysis

Data analysis was performed using descriptive and inferential statistics. Descriptive statistics was used to obtain the mean (M) of the pre- and post-test scores and the standard deviation (SD) of the scores. In addition, inferential statistics was used to analyze covariance (ANCOVA) with the pretest score as the covariate. ANCOVA was run to examine the difference in science process skills and content knowledge between the experimental and control groups. The LSD test was conducted because ANCOVA showed a p-value smaller than 0.05 (significant).

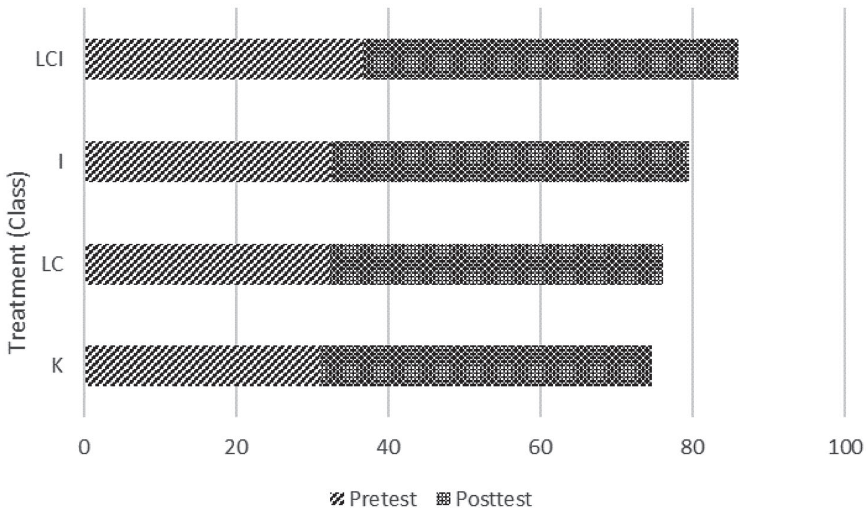
Findings

Science process skills

Based on the actual means of participants' science process skills (Figure 1), the LCI group performed better than the other groups in the pretest, with a mean of 36.81 (SD= 2.53). Meanwhile, the Inquiry and LC groups obtained mean scores of 32.57 (SD = 2.61) and 32.38 (SD = 3.23), respectively. Conversely, the conventional group achieved slightly less than the Inquiry and LC groups, namely 31.08 (SD = 3.33). In the post-test, the LCI group achieved a mean score of 86.02 (SD = 2.84) and is therefore better than the other groups. There was no significant difference between the Inquiry, LC, and conventional groups regarding post-test score. The scores achieved by the groups were 79.46 (SD = 2.60), 76.13 (SD = 3.09), and 74.61 (SD = 3.30), respectively.

Figure 1

The Actual Mean of Participants' Pretest and Post-Test on Science Process Skills



Note. LCI = Learning Cycle-Inquiry, I = Inquiry, LC = Leaning Cycle, K = Conventional

The inferential statistics ANCOVA was run to confirm the difference in participants' performance in science process skills, using pretest scores as covariates. The ANCOVA results proved that the research treatment influenced the increase in participants' science process skills. Table 2 records the ANCOVA results showing that each research treatment affected participants' science process skills significantly differently. Therefore, an LSD test was conducted to examine which learning model could significantly affect participants' science process skills.

Table 2

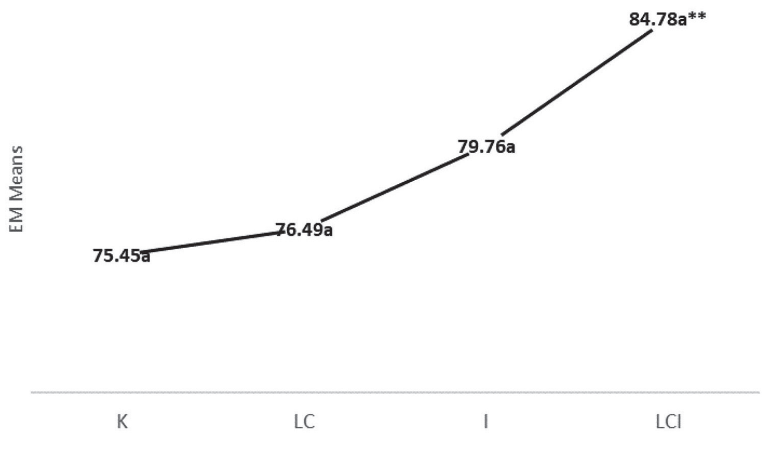
The ANCOVA Results of Participants' Science Process Skills

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	2658.308	1	2658.308	277.300	.000
	Error	421.049	43.921	9.586		
Pretest	Hypothesis	85.929	1	85.929	11.247	.001
	Error	588.290	77	7.640		
Group	Hypothesis	721.295	3	240.432	31.470	.000
	Error	588.290	77	7.640		

The LSD test results indicated that the LCI model had the most significant effect on participants' science process skills, compared to the other learning models (i.e., Inquiry, Learning Cycle, and Conventional). Therefore, the LCI model increased participants' science process skills more effectively than the Inquiry, Learning Cycle, and Conventional models. Furthermore, the results also proved that the LC and Inquiry models enhanced participants' science process skills more significantly than the conventional model. As shown by the estimated marginal means (EM), participants studied with the LCI model performed better on science process skills (mean 84.78) than participants studied with the inquiry, the learning cycle, or the conventional models (mean 79.76, 76.49 and 75.45) (Figure 2). These findings indicate that the LCI model had the best potential to improve students' science process skills.

Figure 2

The Estimated Marginal Means (EM) of Participants' Posttest on Science Process Skills



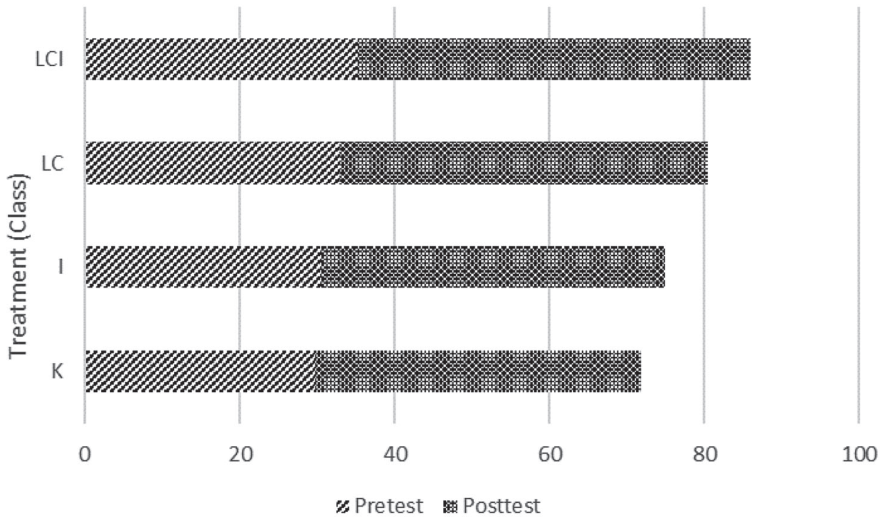
Note. a = covariates appearing in this model are evaluated at pre-test = 33.39; 95% CI.
** = significantly different from other groups (p < 0.01)
LCI = Learning Cycle-Inquiry, I = Inquiry, LC = Leaning Cycle, K = Conventional

Content Knowledge

Figure 3 shows that the LCI group performed better than the other groups in the pretest with a mean score of 35.35 (SD = 2.87). Then the LC group achieved a mean score of 32.92 (SD = 3.08), followed by the Inquiry and conventional groups with mean scores of 30.62 (SD = 3.03) and 29.77 (SD = 3.22), respectively. In the post-test, the LCI group obtained a mean score of 86.02 (SD = 2.84) and is thus above the mean scores of the other groups. The LC group reported a mean score of 80.51 (SD = 3.13) for the posttest. Meanwhile, the Inquiry (mean = 74.95; SD = 4.79) and conventional groups (mean = 71.80; SD = 5.58) had lower mean scores than those of the LCI and LC groups.

Figure 3

The Estimated Marginal Means (EM) of Participants' Posttest on Content Knowledge



Note. LCI = Learning Cycle-Inquiry, I = Inquiry, LC = Leaning Cycle, K = Conventional

The inferential statistics ANCOVA was run to confirm the difference in participants' performance in content knowledge, using pretest scores as covariates. The ANCOVA results proved that the research treatment influenced the increase in participants' content knowledge. Table 3 records the ANCOVA results showing that each research treatment affected participants' content knowledge significantly differently. Therefore, an LSD test was conducted to examine which learning model could significantly affect participants' content knowledge.

Table 3

The ANCOVA Results of Participants' Content Knowledge

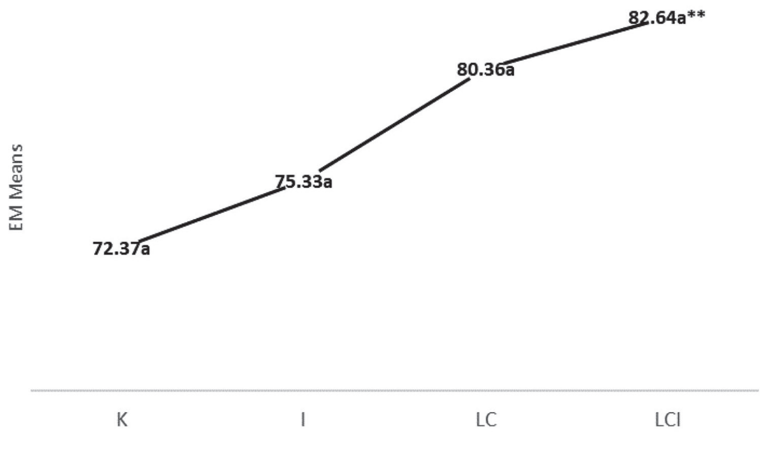
Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	3414.290	1	3414.290	135.120	.000
	Error	1751.225	69.305	25.269		
Pretest	Hypothesis	38.157	1	38.157	1.684	.198
	Error	1744.415	77	22.655		
Group	Hypothesis	876.689	3	292.230	12.899	.000
	Error	1744.415	77	22.655		

An analysis of covariance (ANCOVA) was performed to confirm the difference in participants' performance on content knowledge. The ANCOVA results in Table 3 show a score of 0.000 for the significance of the model, proving that the implementation of different learning models significantly affected participants' content knowledge. In other words, four learning models had different potentials for influencing students' knowledge growth. Therefore, an LSD test was carried out.

As shown by the estimated marginal means (EM), participants studied with the LCI and LC models had similar performance on science process skills (mean 82.64 and 80.36, respectively). However, the content knowledge of students from the Inquiry (75.33) and conventional (72.37) groups was lower than the participants in the LCI and LC groups (Figure 4). These findings indicate that the LCI model had the best potential to improve students' science process skills.

Figure 4

The Estimated Marginal Means (EM) of Participants' Posttest on Content Knowledge



Note. a = covariates appearing in this model are evaluated at pre-test = 32.37; 95% CI.
** = significantly different from other groups (p <0.01)
LCI = Learning Cycle-Inquiry, I = Inquiry, LC = Leaning Cycle, K = Conventional

The LSD test results indicated that the LCI model differed significantly from the Inquiry and Conventional models yet had similar effects with the LC model in enhancing participants' content knowledge. Therefore, it was concluded that the LCI and LC models were more effective than the inquiry and conventional models in improving students' content knowledge. This finding suggests that the LCI and LC models had the same potential to improve college students' content knowledge.

Discussion

The present study aimed to investigate the effect of the LCI learning model on college students' science process skills (SPS) and content knowledge (CK). College students involved in this study came from the department of elementary school teacher education (ESTE). When this study was conducted, the students were enrolled in a basic science course at the target university. College students must develop SPS and CK to achieve scientific literacy (Sjöström & Eilks, 2018). Learning Cycle-Inquiry (LCI), as a combination of inquiry and LC, is expected to be the best alternative learning model for improving student performance in science compared to implementing the two models separately or traditional learning.

The main finding of this study was that students exposed to LCI experienced a more significant increase in SPS and CK than students exposed to inquiry, LC, and conventional models. This result is supported by the high EM score obtained by LCI. In other words, the LCI learning model has proven high effectiveness in improving students' SPS and CK. There are several reasons why LCI has the highest effectiveness. *First*, experiential activities in the LCI classroom emphasize student independence. In the LCI class, students are trained to design experiments, collect data, and draw conclusions without much help from the instructor (Teig et al., 2018). This series of activities requires students to interact with each other to more easily achieve common learning goals (Mende et al., 2021). Group experiments conducted by LCI students allow discovery (Rannastu et al., 2019) and knowledge construction (Jerrim et al., 2019).

Second, before elaborating, students make generalizations or valid conclusions based on the experimental results. This stage allows students to draw on relevant contextual information and modify their understanding of the phenomena they have studied (Teo & Goh, 2019). Further, inference skills require higher cognitive processes than just remembering information. These skills are relevant to CK and inquiry activities, and are an integral component of SPS (National Research Council, 2011).

Third, in the elaboration phase, students are not only asked to carry out ongoing investigative activities, but are also invited to conduct small experiments accompanied by various questions to strengthen understanding. Asking questions is a constructivist learning method (Crogman & Trebeau Crogman, 2016). Questions asked in LCI classes can encourage students to think critically (Thompson, 2018) and help them strengthen understanding (Aguilera & Perales-Palacios, 2020; Salmon & Barrera, 2021). Thus, students can strengthen concepts during the elaboration phase by extending and applying facts to real situations and new contexts (Llewellyn, 2012).

Another advantage of LCI learning is that students can measure their abilities and knowledge at the evaluation stage. This activity can help students improve their work to be ready for further learning. LCI students tend to be more prepared to learn material because they have read more resources needed to supplement their knowledge. In addition, evaluation activities are an important aspect of problem-solving and investigation activities (Arends, 2011). In conclusion, LCI can familiarize students with using SPS to solve problems (Tai et al., 2018).

LCI does not only emphasize cognitive processes, but also involves students in mental activities (Jack, 2017). Complex learning stages in LCI can help students find complete knowledge to minimize errors in understanding the material being studied. Students who experience each process of acquiring knowledge themselves will find it easier to remember the concepts learned (Hanuscin & Lee, 2008).

The SPS measurement results indicated that students exposed to the inquiry model had EM scores almost the same as LCI students. However, from the CK aspect, students exposed to LC have almost t2he same content knowledge scores as LCI. This result is because inquiry-based learning emphasizes designing and conducting experiments. The syntax of the inquiry model can foster students' SPS (Artayasa et al., 2017; Imaduddin & Hidayah, 2019; Irwanto et al., 2018). Meanwhile, students with LC are more focused on developing CK (Koyunlu Ünlü & Dökme, 2022; Nopparatjamjomras & Nopparatjamjomras, 2020) through activities to solve questions that are described in worksheets.

Meanwhile, the conventional model is considered the least effective for increasing students' SPS and CK because this learning model does not require students to explore their skills in depth. Prayitono et al. (Prayitno et al., 2017) explain that conventional learning methods often force learners to memorize the knowledge they receive. Therefore, during conventional teaching, students do not experience knowledge discovery through investigations of the phenomena around them. In addition, their SPS is also difficult to develop.

Conclusion

There was a significant difference in science process skills (SPS) between students in the LCI class and those in the I, LC, and K groups. Significant differences in content knowledge (CK) were also found between students in LCI and those in the I and K groups. This finding suggests that LCI offers more opportunities for students to practice and improve their SPS. In addition, teachers can use LCI as an effective teaching-learning intervention to promote CK. The LCI learning model can positively and effectively affect students' SPS and CK on basic science concepts. Based on these findings, faculty should not only focus on CK but also strive to develop SPS.

Suggestion

Faculty should modify the LC worksheet to include investigation steps. LCI creates a student-centered classroom environment, improves collaboration, and promotes student engagement. However, before implementing LCI in the classroom, faculty must hold a session to present this model at the beginning of learning to familiarize students with the steps and learning activities in LCI. Also, for the sake of time efficiency, lecturers must clearly explain the learning steps at the beginning of the lesson. Some students have little initial knowledge and tend to be slow to explore their knowledge and complete the worksheets given. To overcome this, lecturers must instruct students to maximize group collaboration to create an atmosphere of active discussion and positive interaction.

Limitation

Although the results of this study provide valuable information through establishing three unbiased control groups, some limitations must be recognized. *First*, this study focused on measuring participants' initial and final academic performance using a test instrument that could not examine changes in student abilities from time to time from multiple perspectives. Future research will need to perform a variety of measurements with more than one type of instrument, for example, by using a self-report questionnaire. This instrument can better portray the profile of students' and teachers' scientific process skills and content knowledge. *Second*, future research must also consider the students' background, including the type of institution they study at. Thus, a comparative analysis of SPS and CK can be related to school type, gender, and geographic location. Such an analysis will provide more comprehensive insights to help researchers and policy makers see the implications of creating a new learning model by combining some learning models, such as LCI. *Third*, the impact of LCI may not be limited to SPS and CK in basic science but may extend to other skills and disciplines. In the future, research may consider other variables such as problem solving, critical thinking, and learning motivation to expand the effect of LCI on student skills.

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Mokymosi ciklo-tyrimo poveikis būsimųjų pradinių klasių mokytojų mokslo proceso įgūdžiams ir turinio žinioms

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Santrauka

Šiame tyrime nagrinėjamas mokymosi ciklo-tyrimo (angl. *Learning Cycle and Inquiry*, LCI) poveikis būsimųjų pradinių klasių mokytojų mokslo proceso įgūdžiams ir turinio žinioms. Vieno semestro metu šiame tyrime dalyvavo keturios studentų grupės. Eksperimentinė grupė (23 studentai) buvo mokoma taikant LCI modelį. Pozityvioji kontrolinė grupė (Nr. 1; 23 mokiniai) mokėsi taikant tyrimo metodą, kita pozityvioji kontrolinė grupė (Nr. 2; 18 mokinių) mokėsi taikant mokymosi ciklo-5E modelį, o negatyvioji kontrolinė grupė (18 mokinių) dalyvavo įprastiniuose mokymosi procesuose. Šiame tyrime naudotas prieš tyrimą ir po tyrimo atliktas testas buvo patikrintas ekspertų. Tyrimo rezultatai atskleidė statistiškai reikšmingus tyrimo dalyvių turinio žinių ir mokslo proceso įgūdžių skirtumus. Mokymosi ciklo-tyrimo derinys gali vienu metu skatinti studentų mokslo proceso įgūdžius ir pagerinti jų akademinius rezultatus. Mokytojams patartina naudoti mokymosi ciklo-tyrimo intervenciją mokymosi procese.

Esminiai žodžiai: *turinio žinios, mokymosi ciklas-tyrimas, gamtos mokslų proceso įgūdžiai.*

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