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Science literacy and skills of physics education students by developing a project-technology skills learning model

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ABSTRACT

This study aims to develop a learning model that can foster science literacy skills by involving 'the ability to think critically, think creatively, and collaborate skills. Three research questions were asked: i) how to develop learning models to cultivate skills (science literacy, critical thinking, creative thinking, and collaboration); ii) how to validate it; and iii) how critical thinking, creative, and collaboration skills affect science literacy skills. This research uses analysis, design, development, implementation dan evaluation (ADDIE) development design by using validation sheets as data collection instruments: three learning model experts and two lecturers who teach introductory physics courses as practitioners participated in this research. The collected data is analyzed using V-Aiken to determine the level of validity. Overall, the validation results from model development are in the "meet requirements" and "feasible" categories for implementation. The analysis results of the relationship of research variables show that critical thinking, creative thinking, and collaboration directly affect science literacy skills; however, critical thinking and creative thinking skills have a moderate effect on science literacy skills if collaboration skills act as mediation.

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1. INTRODUCTION

Science literacy is one of the assessment indicators conducted by the Program for International Student Assessment (PISA). Science literacy is defined as understanding scientific concepts meaningfully, explaining scientific phenomena, describing them based on scientific evidence, and applying them in everyday life [1]. The science literacy ability of students in Indonesia from the primary and secondary school levels has experienced problems. Based on PISA data in 2022, the average science literacy score of students in Indonesia is 383, while the average science literacy score of all PISA participating countries in 2022 is 485. These results show that the science literacy of students in Indonesia is far below the average of other countries [2]. According to Bangun *et al*. [3], the low science literacy of students in schools in the future will also affect the science literacy ability of college students in universities. One piece of evidence of the impact of low science literacy can be seen from the observations, assignments, and tests conducted on students in the physics education program at PGRI Silampari Lubuklinggau University. The report analysis results show college students' understanding of science literacy, critical thinking, and creative thinking found that only 25% of students were able to provide explanations about scientific phenomena, meaning that most students, or 75%, could not analyze complex data or information, synthesize or evaluate evidence, justify the reasons given from various sources and make a plan or sequence of steps to solve the problem. In addition, journal reading activity is also still low, where it is found that as many as 90% of college students still use references from blogs, WordPress, or high school books. The search for reference sources in the form of scientific works such as journals and research results from the final project (thesis) has yet to be used as the primary reference in doing assignments and adding scientific insight.

The substance of the achievement of undergraduate students in physics education, according to the Indonesian National Qualifications Framework, is expected to have the ability to apply logic, critical thinking, systematic, and innovation in the application of science and technology related to the field of physics [4]. Physics learning emphasizes the importance of the discovery process, where college students must be able to work scientifically in problem-solving, think, be scientific, and communicate well [5]. Therefore, science literacy, critical thinking, and creative and collaboration skills need to be built to meet the demands of the Indonesian National Qualifications Framework set by the government. Several studies have been conducted to critically, creatively, and collaboratively improve thinking skills. Still, they have yet to link it to science literacy skills, for example, research [6], [7]. It is essential to analyze this relationship so that educators get information about the factors that affect science literacy skills. In addition, according to Chua and Islam [8], the project learning form is suitable for cultivating science literacy, critical thinking skills, creativity, and collaboration. Project learning is the primary choice suggested by the government as a learning model in universities. The form of project learning is believed to increase student understanding in exploring science comprehensively by being oriented to the practical side of a scientific concept so that this can improve college students' competence [9]. In addition, the project-based learning model can improve college students' thinking levels. Applying the project-based learning model in the curriculum based on the Indonesian National Qualifications Framework in higher education learning activities is one of the benchmarks of key performance indicators.

The technical philosophy of syntax must be understood by lecturers when implementing project learning models into learning activities. The syntax of the learning model is a general reference to how learning is carried out according to the rules and desired results of the learning model. According to Erdogan and Bozeman [10], project learning has a different syntax because each project learning model discusses initiation from different perspectives depending on the objectives. According to Jalinus *et al*. [11], one of the essential things to achieve learning objectives is to develop instructional strategies or modify learning steps (syntax) as appropriate to achieve the desired learning objectives. According to Puente and Kroesen [12] and Laal [13], developing physics learning models, including instructional strategies (modifying syntax or procedures) as learning stages, can help college students achieve learning objectives. The project learning model that modifies syntax to foster scientific literacy skills by involving college students' critical thinking, creative, and collaborative skills is called the project-technology-skills learning model.

2. METHOD

This research design is research and development (R&D), and it uses analysis, design, development, implementation, and evaluation (ADDIE) to develop a learning model, "Project-technology-skills". According to Maison *et al*. [14], the development research procedures of the ADDIE model are: i) conducting preliminary research, ii) planning, iii) developing prototypes of project-technology-skills learning models, iv) validating conceptual experts in model development, and v) testing project-technology-skills learning models and conducting evaluations. This learning model was implemented in 34 college students in the physics education study program at PGRI Silampari Lubuklinggau University, Indonesia. Data collection using validation and observation instruments. Experts and practitioners conducted product design validation tests of the project-technology-skills learning model. At the validation stage, three validators are experts in model development, while the practice is carried out by two lecturers who teach introductory physics courses. The observation instrument measured the influence of critical thinking, creative thinking, and collaboration skills on college students' science literacy skills. The assessment instrument in this study uses a rating scale of 1 to 5 for validation and observation.

Analysis, validation, and evaluation were conducted to determine the feasibility and practicality of the learning model. To assess the level of validity, the collected data is analyzed using the V-Aiken formula [15], which is as (1).

$$V = \frac{\sum S}{n\,(C-1)} \tag{1}$$

Description*:* *V*=Aiken index; *S*=score given by the rater minus the lowest score in the category; R=score given by the rater; *Lo*=lowest assessment score (1); *C*=highest scoring score (5); *n*=number of validators (assessors). Interpretation of validity is done by looking at the results of the value of V; if the criterion is less than 0.4, then it is said that the validity is low; if between 0.4 and 0.8, it is said that the validity is medium, and if it is more than 0.8 it is said to be high validity [16]. Meanwhile, data analysis of college student skills is carried out by measuring the percentage of assessment of critical thinking, creative, collaboration, and science literacy skills using (2).

$$P\ (critical\ thinking,\ creative\ thinking,\ collaborative,\ science\ literacy) = \frac{X}{Y} x100\% \quad (2)$$

Information for P is a percentage of skill. While X is the number of values obtained, and Y is the total number of maximum values. Furthermore, measurements were also made of increasing college student skills results from the first project learning to the last project learning with the normalized gain (N-gain) as in (3).

$$N - gain = \frac{Average\ last\ skill\ score - Average\ first\ skill\ score}{Maximum\ score - Average\ first\ skill\ score} \quad (3)$$

With criteria if N-gain >0.7 high gain index, if 0.7>N-gain>0.3 medium gain index, and if N-gain<0.3. Low gain index. For analysis, the influence of critical thinking, creative thinking, and collaborative thinking skills on science literacy using the structural equation modeling (SEM) method with the help of Smart Partial Least Square 3.0 software (SmartPLS 3.0). SEM measurement with SmartPLS 3.0 software uses the outer and inner models. Evaluation of the measurement model is carried out through confirmatory factor analysis (CFA) analysis by conducting validity tests by looking at the loading factor value of >0.70, average variance extracted (AVE) >0.50, the discriminant validity of the cross-loading value >0.70, and testing the reliability of the composite reliability model >0.70. The inner model evaluation aims to predict the relationship between latent variables by looking at the percentage of variance in R-Square values (R-Square>0.70=strong; 0.25<R-Square<0.50=moderate; and R-Square<0.25=weak). Significance testing is done by looking at whether the total P-value <0.05 in the path coefficients table and testing the effect size by looking at the F-squared value if the effect size value 0.35 has a strong effect if the effect size value is 0.15, the effect size <0.35 has a moderate effect, and if the 0.02 effect size value <0.15 has a weak impact [17]. According to Sarstedt *et al*. [18], the F-square test only applies to the effect of direct efficiency while measuring the effect size of mediation using the upsilon equation (v) as in (4).

$$v\ = \beta^2 MX.\beta^2 YM.X \quad (4)$$

With $\beta^2 MX$ is the square of the path coefficients of influence X on M and $\beta^2 YM.X$ is the square of the path coefficient of effect M on Y. Interpretation of upsilon statistical values *(v)*, namely *v* values <0.01 (low mediation effect), 0.01<*v*<0.075 (moderate mediation effect), and *v*>0.075 (high mediation effect).

3. RESULTS AND DISCUSSION

3.1. Analysis of the needs of lecturers and college students

Needs analysis is carried out by making observations, assignments, and tests on students of the physics education study program at PGRI Silampari Lubuklinggau University. The results of the report analysis showed that students' understanding of science literacy, critical thinking, and creative thinking found that only 25% of students were able to provide explanations about scientific phenomena, meaning that most students, or 75%, could not analyze complex data or information, synthesize or evaluate evidence, and make plans or sequences of steps to solve problems. Students argue that the learning activities are challenging to understand because they need direct experience. Students also expect changes in the learning methods carried out.

3.2. Project-technology-skills learning model syntax design

The syntax of the project-technology-skills learning model is the first one: motivation and orientation to the problem. Problem-oriented is an action that refers to a problem to identify the problem, define the problem, and formulate a strategy for solving the problem [19]. In dealing with problems, college students are given motivational interventions that are very important to trigger success in solving problems. The second syntax is project planning (management). According to West [20], college students need to set goals in planning, and achieving goals refers to schedules, budgets, and things needed. The third syntax is science literacy. When a person has adequate scientific literacy in obtaining information, he will use these scientific rules to check the validity of information sources, understand and explain phenomena that occur scientifically, interpret the data obtained, make conclusions based on credible data, and design appropriate solutions [21]. The fourth syntax is open-ended projects. Open-ended project implementation can improve critical and creative thinking skills [22]. Critical thinking is a cognitive process that questions the information in an individual's mind map and allows the restructuring of that information. At the same time, creative thinking is generally defined as the ability to produce something new, original, and effective [23]. According to Kocak *et al*. [24], critical thinking skills are necessary to practice creative thinking; the problem-solving process can be more flexible and faster due to creative and critical thinking skills. The fifth syntax is sharing and positive dependency (collaboration). Collaboration and communication are needed in social activities, especially social interaction at the organization, which aims to accelerate project completion and function to complement each other [25]. Collaboration activities will be maximized if they meet the requirements of collaborative learning, namely positive interdependence in which college students at various levels of performance work together in small groups towards a common goal [26]. The sixth syntax is monitoring. Monitoring project implementation to review progress towards achieving the program is essential. The seventh syntax is to create a product or produce an answer to a problem. The eighth syntax is formative and summative evaluation. Formative evaluation is carried out at each stage of the process or at the time of implementation, starting from the problem orientation to the stage of product results. A summative evaluation is carried out after the project's implementation is completed. Evaluation determines the size of the excess and deficiency of project implementation [27].

3.3. Model development results

The “Project-technology-skills” learning model refers to constructivism, behaviorism, and cognitive learning theories. Theory serves as a basis for drawing up the steps of learning activities. The results of developing the “Project-technology-skills” learning model with eight syntaxes are described in Figure 1.

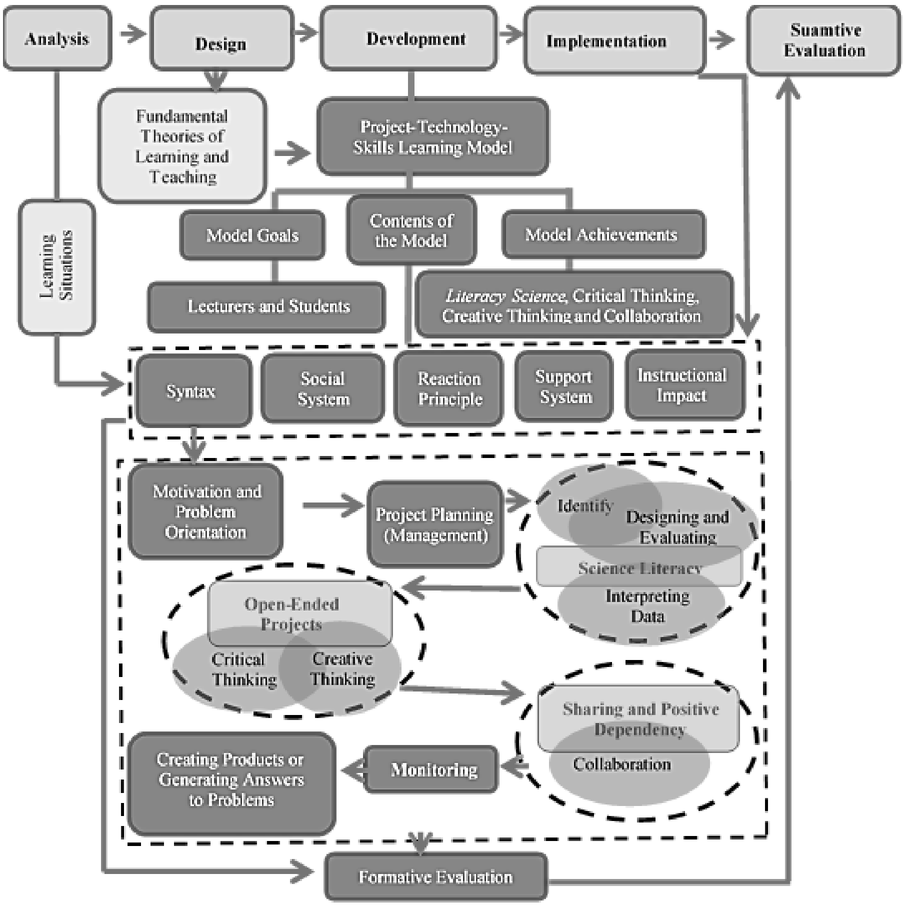

Figure 1. Results of the development of the project-technology-skills learning model

The project-technology-skills learning model consists of three aspects, namely: i) project: learning based on projects designed to explore students’ critical and creative thinking skills in solving problems and innovation through open-ended (technology and reference); ii) technology: technology can help make learning with projects more effective and efficient, and integrating it into the learning environment can improve literacy, science, critical thinking, creative thinking, and collaboration skills; and iii) skills: the results obtained from project learning include skills needed to succeed in the 21st century, such as science literacy skills for college students and the ability to think critically and creatively when solving problems by collaborating.

3.4. Social system in project-technology-skills learning model

The social system is the process of learning activities of lecturers and students. This learning activity is expected to improve college student competence. The social system or learning activities between lecturers and students can be seen in Table 1.

Table 1. A social system in the project-technology-skills learning model

Activities	Lecturer activities	Student activities
Introductory activities	Unveiling 1. Lecturers start the lecture with greetings and prayers with students. Phase 1: Motivation and problem orientation 2. Lecturers convey problems and competencies that must be achieved by analyzing facts, phenomena, or problem issues related to learning material. 3. Lecturers motivate students and encourage them to collaborate in solving problems.	Unveiling 1. College students pray together to open lectures. 2. College students confirm attendance. Phase 1: Motivation and problem orientation. 3. College students understand the problems and competencies that must be achieved by analyzing facts, phenomena, or problem issues related to learning material. 4. After getting motivated, college students collaborate in solving problems.
Presentation of core activities:	4. The lecturer directs each group to follow the guidelines of the project-technology-skills learning model book. 5. Lecturers monitor the activities of each group and assess through observation sheets (especially phase 2 to phase 7) Phase 6: Monitoring 6. Lecturers assist students in finding solutions when students face problems (the role of lecturers as monitoring and facilitators). Phase 7: Creating a product or producing an answer to a problem 7. Lecturers provide opportunities for group representatives, with the team's help, to present project and product-making results or provide findings or answers to problems from topics or learning materials.	Phase 2: Project planning (management). 5. College Students begin to plan project implementation strategies. 6. Each group begins to create or organize the schedule and distribution of group members' tasks. Phase 3: Using science literacy (identifying, evaluating, and interpreting data). 7. All group members identify related issues discussed from various sources (journals, books, and internet). 8. All members collect the results of the identification obtained, discuss or analyze the problem, and propose several alternative appropriate solutions. 9. The group evaluates the various data obtained to form a project to find scientific evidence. Phase 4: Open-ended project implementation (critical and creative thinking). 10. Open-ended projects trigger college students' critical and creative thinking skills. 11. Each group can have a different form of project from another group but with the same problem focus. 12. Project differences occur due to the information obtained and the group's decision to choose the project form. 13. The difference in project form is also influenced by mastery of technology, especially software and learning applications. Phase 5: Sharing and positive dependency (collaboration and communication) 14. After college students divide the tasks in phase II, the tasks carried out by each affect the group's success in completing the project (positive dependence). 15. To speed up project completion, each individual can work on the same or different tasks depending on the number of groups. 16. Each individual in the group can communicate the results of their work to the group regarding the results or findings of the problems faced to be discussed together (sharing). 17. The group leader monitors his members' work to ensure that it conforms to the group's goals (leadership). Phase 6: Monitoring. 18. When students face problems, lecturers can help through discussion and consultation. In this case, lecturers help students find solutions (the role of lecturers as monitors and facilitators). Phase 7: Creating a product or producing an answer to a problem 19. Group representatives present project results.
Closing activities	Phase 8: Evaluation. 8. Lecturers conduct evaluation and reflection by strengthening students' understanding of the material discussed.	Phase 8: Evaluation. 20. Students evaluate and reflect on the reinforcement provided by lecturers.

3.5. Product validation results and feasibility of project-technology-skills learning model

The support system in the project-technology-skills learning model includes all materials, means, and supporters of the learning model that three experts and two practitioners have validated. The experts consisted of 1 lecturer from the Department of Physics Education, Faculty of Natural Sciences Education, Yogyakarta State University, Indonesia, and two lecturers from the Master of Physics Education, Faculty of Postgraduate, Universitas Ahmad Dahlan, Yogyakarta, Indonesia. Meanwhile, two lecturers (teaching team) who taught Basic Physics courses at PGRI Silampari Lubuklinggau University, South Sumatra Province, Indonesia, become assessed and practitioners. First, experts validate the feasibility of the product from the aspects of supporting theory and learning syntax. Then, the learning model is validated again by practitioners regarding the feasibility of its application in fundamental physics learning. The results of the validation can be seen in Figure 2.

Based on Figure 2, the comprehensive development and validation process of the models developed in this study has been shown to meet the criteria of effectiveness and practicality. It confirms that the development used in this study has succeeded in producing a procedural learning model that can potentially improve college students' critical thinking, creative thinking, collaboration, and science literacy skills. This can be seen from the overall score of Aiken V above 0.4. That is, the assessment results from experts and practitioners are enough to be used as a reference in field testing on a broader scale.

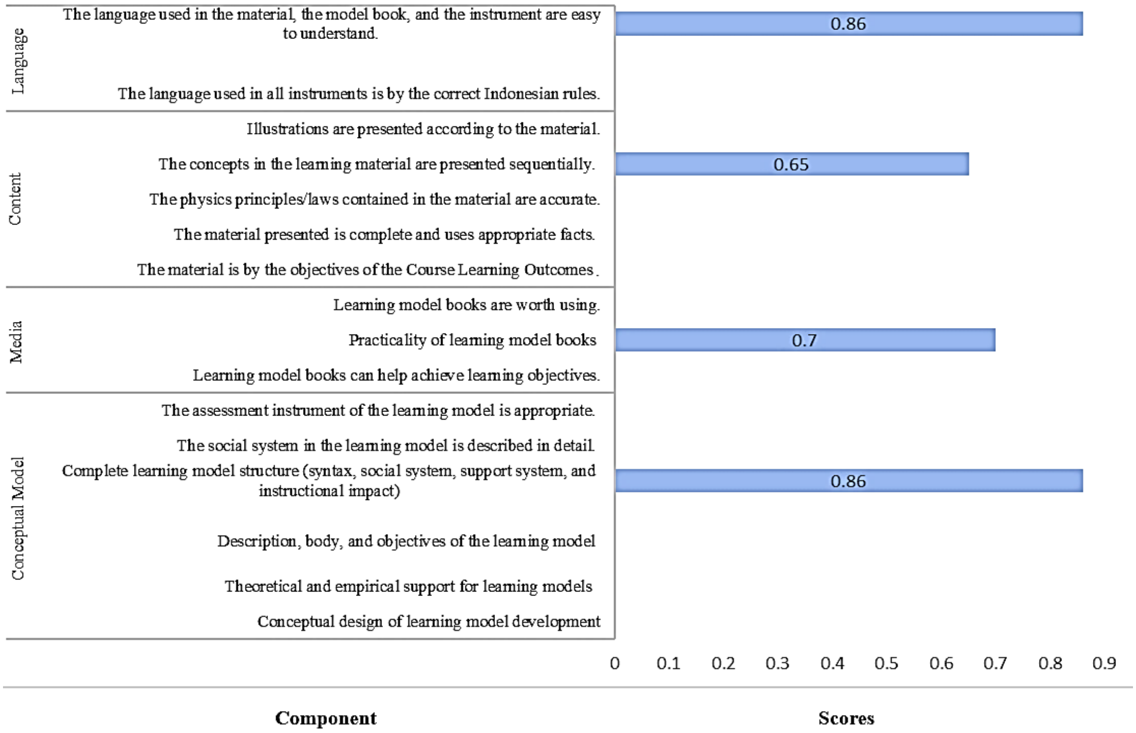

Figure 2. V-Aiken score from expert validation assessment results

3.6. The influence of critical thinking, creative thinking, and collaboration skills on science literacy skills

In classroom learning activities, student activities in carrying out projects are assessed with observation instruments that researchers have specially made. The (2) was used to analyze skill measurement (critical thinking, creativity, collaboration, and science literacy), and the results are shown in Table 2. Thus, the analysis results show that implementing the project-technology-skills learning model contributes significantly to improving college students' critical thinking, creative thinking, collaboration, and science literacy skills. Success analysis is carried out by measuring the magnitude of the impact of skill improvement generated by implementing the project-technology-skills learning model on college student skills. From Table 2, it is evident that the implementation of the project-technology-skills learning model can improve students' skills quite well; this can be seen in the comparison of the average value of each project by calculating the resulting N-gain value. The resulting N-gain values are 0.42, 0.38, 0.37, and 0.51. The theoretical framework for determining the impact of critical thinking, creative, and collaboration skills on science literacy skills is described in Figure 3.

Table 2. Results of students' critical thinking, creative thinking, collaboration, and science literacy skills

Teaching	Critical thinking	Creative thinking	Collaboration	Science literacy skills
1	75.06	75.59	76.76	75.29
2	85.47	84.76	85.35	87.96
N-gain	0.42	0.38	0.37	0.51

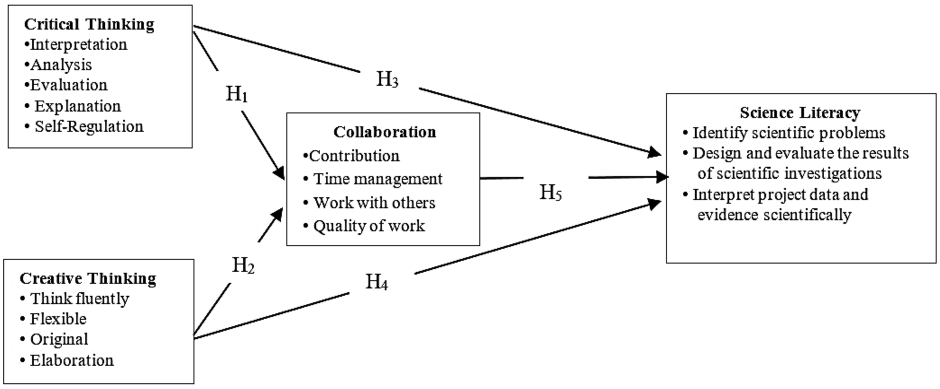

Figure 3. The theoretical framework for determining the impact of critical thinking, creative, and collaboration skills on science literacy skills

Based on the theoretical framework above, the research hypothesis proposed is:
- Hypothesis 1 (H1). Critical thinking skills affect collaboration skills.
- Hypothesis 2 (H2). Creative thinking skills affect collaboration skills.
- Hypothesis 3 (H3). Critical thinking ability affects science literacy skills.
- Hypothesis 4 (H4). Creative skills affect science literacy skills.
- Hypothesis 5 (H5). Collaboration skills affect science literacy skills.
- Hypothesis 6 (H6). Critical thinking skills affect science literacy through collaboration skills as an intervening variable.
- Hypothesis 7 (H7). Creative skills affect science literacy through collaboration skills as an intervening variable.

For analysis, the influence of critical thinking, creative thinking, and collaborative thinking skills on science literacy using the structural equation modeling (SEM) method with SmartPLS 3.0 and obtained the results of confirmatory factor analysis (CFA) analysis of the loading factor value of >0.70, average variance extracted (AVE) >0.50, discriminant validity of the cross-loading value >0.70, and reliability testing of the composite reliability model >0.70. All meet the complete testing for Outer models. The analysis results of the influence of critical thinking, creative thinking, and collaboration skills on science literacy using SmartPLS 3.0 software are in Tables 3-6, and Figure 4.

Table 3. Path coefficients between variables critical thinking, creative thinking, and collaboration skills towards science literacy

Collaboration skills	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P-values
Collaboration skills->science literacy	0.337	0.318	0.078	4.322	0.000
Creative thinking->collaboration skills	0.440	0.379	0.162	2.716	0.010
Creative thinking->science literacy	0.309	0.331	0.066	4.712	0.000
Critical thinking->collaboration skills	0.528	0.586	0.162	3.254	0.003
Critical thinking->science literacy	0.367	0.365	0.056	6.504	0.000

Table 4. The effect size between variables of critical thinking skills, creative, and collaboration skills on science literacy skills (direct effect)

Variables	Collaboration skills	Creative thinking	Critical thinking	Science literacy
Collaboration skills	-	-	-	0.878
Creative thinking	0.215	-	-	0.674
Critical thinking	0.311	-	-	0.881
Science literacy	-	-	-	

Table 5. Specific indirect effects

Collaboration skills	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T Statistics (|O/STDEV|)	P-values
Creative thinking->collaboration skills->science literacy	0.148	0.139	0.058	2.566	0.015
Critical thinking->collaboration skills->science literacy	0.178	0.176	0.078	2.291	0.028

Table 6. Upsilon (v)

Collaboration skills	$\beta^2 MX$	$\beta^2 YM.X$	Upsilon (v)	Type of mediation
Critical thinking->collaboration skills->science literacy	0.528^2	0.337^2	0.032	Moderate
Creative thinking->collaboration skills->science literacy	0.440^2	0.337^2	0.022	Moderate

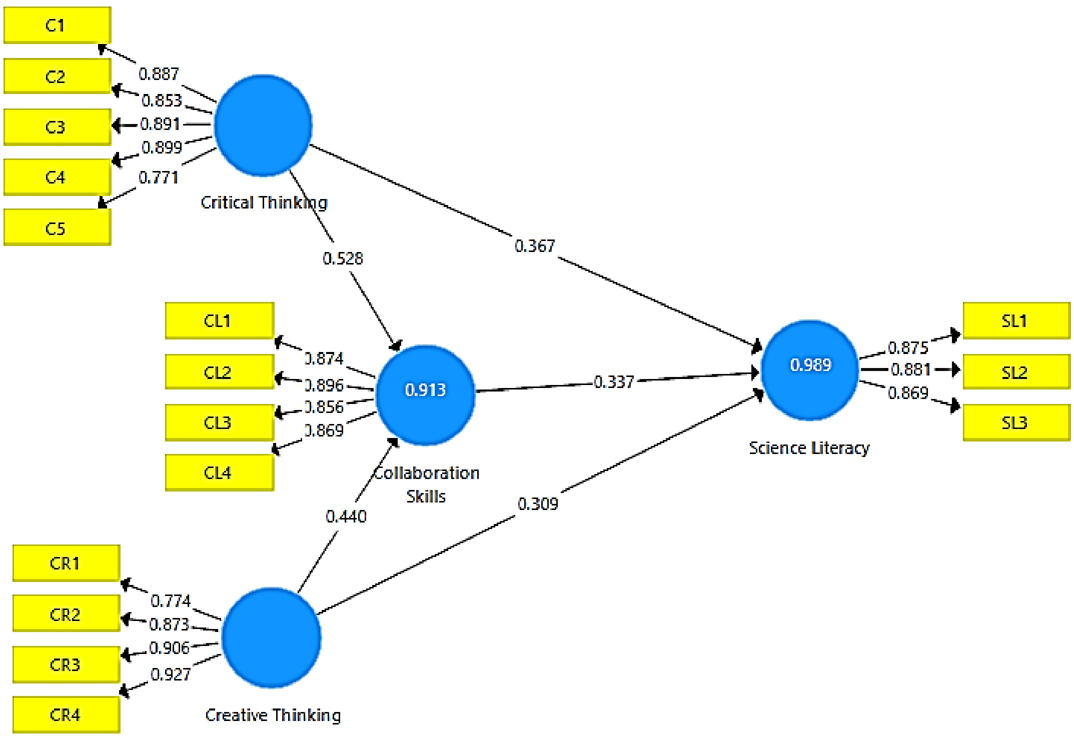

Figure 4. The partial least square-structural equation modelling (PLS-SEM) model

3.7. Discussion

This study develops a project-technology-skills learning model to improve college students' critical thinking, creative thinking, collaboration, and science literacy skills. As a result, college students' critical thinking, creative thinking, collaboration, and science literacy skills have an average final score above 80 and have pretty good index N-gains. According to Estuhono [28], if the skill value is above 75, then the abilities possessed by students are excellent. This confirms that the development carried out in this study has succeeded in producing a procedural learning model that has the potential to improve college students' critical thinking, creative thinking, collaboration, and science literacy skills after going through a comprehensive development and validation process. The results of the analysis of the influence of critical thinking, creative thinking, and collaboration skills on science literacy using SmartPLS 3.0 software, as well as the results obtained in Figure 4 and Tables 3-6, can be concluded as follows.

- In Figure 4, the R square value is 0.913 for collaboration and 0.989 for science literacy. This means that the influence of critical thinking and creative thinking skills on collaboration skills is very strong, at 91.3%, and the influence of critical thinking, creative, and collaboration skills on science literacy, at 98.9%, is also very strong. The rest is influenced by other factors.

- Critical thinking skills have a significant influence on collaboration skills. As seen in Table 3 the P-value<0.05, meaning that H1 is accepted. The magnitude of the direct impact of critical thinking skills on collaboration skills from the f-square value in Table 4, which is 0.311, means that critical thinking skills have a “strong” influence. As Cohen stated, if the f-square value>0.35, it strongly affects the affected variables [29].
- Creative thinking skills have a significant influence on collaboration skills. As seen in Table 3 the P-value<0.05, meaning that H2 is accepted. The magnitude of the direct impact of creative thinking skills on collaboration skills from the f-square value in Table 4, which is 0.215, means that innovative thinking skills have a “moderate” influence. As Cohen stated, if the value is in the range of 0.15, < f-square <0.35, then it has a moderate impact.
- Critical thinking skills have a significant influence on science literacy skills. As seen in Table 3 the P-value<0.05, meaning that H3 is accepted. The magnitude of the direct impact of critical thinking skills on science literacy skills from the f-square value in Table 3, which is 0.881, means that critical thinking skills have a “strong” influence and strongly affect the affected variables. This aligns with [30] opinion that critical thinking skills are closely related to science literacy skills. Critical thinking skills have great potential to support science literacy, primarily through applying techniques or classroom activities based on essential criteria of thinking and principles.
- Creative thinking skills have a significant influence on science literacy skills. As seen in Table 3 the P-value<0.05, meaning that H4 is accepted. The magnitude of the direct impact of creative thinking skills on science literacy skills from the f-square value in Table 4, which is 0.674, means that critical thinking skills have a “strong” influence and strongly affect the affected variables. This study’s results align with the opinion of [31] that science literacy is a creative product (idea) made by scientists from scientific theories that emerge from creativity and through the empirical testing stage, so the two variables have a positive and close relationship.
- Collaboration skills have a significant influence on science literacy skills. As seen in Table 3 the P-value<0.05, meaning that H5 is accepted. The magnitude of the direct impact of collaboration skills on science literacy skills from the f-square value in Table 4, which is 0.674, means that collaboration skills have a “strong” influence and strongly affect the affected variables.
- In the sixth hypothesis test (H6), it was found that the variable of critical thinking skills affects science literacy ability through collaboration skills as an intervening variable, meaning that H6 is accepted. This parameter exists in Table 5 of specific indirect effects with a P-value of <0.05. In measuring the magnitude of the mediation effect, upsilon analysis (v) is used and does not use the value of f-square. According to Sarstedt *et al*. [18], the f-square test only applies to direct effects while measuring mediation using the upsilon equation (v). From the calculation of upsilon in Table 6, a result of 0.032 or in the range of $0.01<v<0.075$, meaning that it has a moderate mediating effect [32]. The results of the upsilon test show that critical thinking skills have a positive and significant impact on science literacy directly but have an insignificant impact through collaboration skills as an intervening variable. Shows that collaboration cannot mediate critical skills to affect science literacy skills to the maximum; one of the reasons is that the collaboration interaction time is only short.
- In the seventh hypothesis test (H7), it was found that the variable of creative thinking skills affects science literacy ability through collaboration skills as an intervening variable, meaning that H7 is accepted. This parameter exists in Table 5 of specific indirect effects with a P-value of <0.05. From the calculation of upsilon in Table 6, a result of 0.022 or in the range of $0.01<v<0.075$, meaning that it has a moderate mediating effect. The results of the upsilon test show that creative thinking skills have a positive and significant impact on science literacy directly but have an insignificant impact through collaboration skills as an intervening variable. Shows that collaboration cannot mediate creative skills to affect science literacy skills to the maximum; one of the reasons is also because the collaboration interaction time is only short.

4. CONCLUSION

Science literacy skills include understanding scientific concepts meaningfully, explaining scientific phenomena, describing them based on scientific evidence, and applying them in everyday life. These skills are essential for university students. The comprehensive development and validation process of the models developed in this study has already the criteria of effectiveness and practicality. The development used in this study has succeeded in producing a procedural learning model that can improve college students’ critical thinking, creative thinking, collaboration, and science literacy skills. Analyzing the influence of critical thinking, creative thinking, and collaborative skills on science literacy skills is essential because it will provide information to educators about factors that can influence the improvement of science literacy skills.

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