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# PROBLEM BASED LEARNING AND PROJECT BASED LEARNING IN RELATION TO CREATIVITY AND CRITICAL THINKING TOWARDS THE COMPETENCE OF VOCATIONAL EDUCATION STUDENTS

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**Abstrak**

Pembelajaran Berbasis Masalah (Problem-Based Learning/PBL) dan Pembelajaran Berbasis Proyek (Project-Based Learning/PjBL) merupakan model pembelajaran yang berperan penting dalam mengembangkan keterampilan dan kompetensi peserta didik. Implementasi PBL dan PjBL berdampak pada peningkatan kreativitas dan kemampuan berpikir kritis siswa dalam mencapai kompetensi yang relevan dengan tuntutan zaman. Penelitian ini bertujuan untuk mengkaji hubungan antara kreativitas, berpikir kritis, dan kompetensi siswa dalam pendidikan vokasi melalui pendekatan pembelajaran berbasis masalah dan proyek. Metodologi yang digunakan adalah pendekatan pendekatan kuantitatif dengan jenis penelitian eksplanatori, melibatkan 200 mahasiswa jurusan Pengendalian Lalu Lintas Udara pada pendidikan vokasi penerbangan, yang terdiri dari 70 mahasiswa tingkat akhir, 70 tingkat menengah, dan 60 tingkat awal dari perguruan tinggi penerbangan dengan kompetensi Aerodrome Flight Information Services (AFIS). Instrumen penelitian berupa kuisioner tipe Measures of Typical Performance (MTP) digunakan untuk mengumpulkan tanggapan mahasiswa. Hasil analisis statistik dengan SEM-PLS menunjukkan nilai R-Square sebesar 0,953 atau 95%, yang mengindikasikan adanya hubungan yang signifikan antara kreativitas, berpikir kritis, dan kompetensi mahasiswa dalam bidang pendidikan vokasi.

**Kata Kunci :** Problem-Based Learning (PBL), Project-Based Learning (PjBL), Kreativitas, Berpikir kritis, Kompetensi, Pendidikan Vokasi

***Abstract***

*Problem-Based Learning (PBL) and Project-Based Learning (PjBL) are instructional models that play a crucial role in developing students' skills and competencies. The implementation of PBL and PjBL has an impact on enhancing students' creativity and critical thinking abilities in achieving competencies that are relevant to the demands of the current era. This research aims to examine the relationship between creativity, critical thinking, and students' competencies in the field of vocational education through problem-based and project-based learning approaches. The research methodology employed is a quantitative approach with an exploratory study design. The research participants consist of 200 students majoring in Air Traffic Control in Vocational Aviation Education, comprising 70 final-year students, 70 intermediate-level students, and 60 entry-level students from aviation colleges with competencies in Aerodrome Flight Information Services (AFIS). The research instrument utilized is a questionnaire of the Measures of Typical Performance (MTP) type to gather student responses. The statistical analysis result*

*using SEM-PLS reveal an R-Square value of 0.953 or 95%, indicating a significant relationship between creativity, critical thinking, and students' competencies in the field of vocational education.*
***Keywords**: Problem-Based Learning (PBL), Project-Based Learning (PjBL), Creativity, Critical thinking, Competency, Vocational education*

## INTRODUCTION

Various steps have been taken to improve the performance of university graduates by developing the learning curriculum. According to Nilson (2023), students need to have mature self-awareness in facing learning challenges and integrate attitudes with thinking actions, which enable them to achieve competence and learning goals through professional actions(Nilson, 2023). According to Lorenz Lassnigg's perspective (2017), professional actions in the field of education in the global era are based on competence-based education (Lassnigg, 2017). In the competence-based education (CBE) approach, this methodology focuses on providing the skills required by industries and evaluating students' abilities to perform tasks that align with their capabilities(Koenen et al., 2015).

Compared to conventional curriculum, 21st-century skills are more tangible in nature. Students need to be able to think critically and creatively, possess skills in utilizing information media and technology, as well as be able to work, adapt, and develop themselves into professionals through the use of life skills(Kivunja, 2014)(van Laar et al., 2020). Critical thinking is one of the characteristics or skills of 21st-century learning that needs to be developed, based on research involving 250 researchers from 60 global institutions affiliated with ATC21S (Assessment & Teaching of 21st Century Skills). The implementation of critical thinking in learning refers to a deeper understanding of theories, evidence, and significant issues through scientific approaches and the application of various subjects in real-world contexts(Savery, 2015)(Kivunja & Kuyini, 2017)(Gray, 2021). Critical thinking is a skill that can be acquired through the learning process; therefore, efforts are

required to teach and encourage students to engage in critical thinking by selecting meaningful learning models.

Critical thinking lacks meaning without individual growth in knowledge, intelligence, and thinking abilities.(J. M. Spector & Ma, 2019). Self-awareness, confronting beliefs, and emotion management are motivational factors in the integrated intellectual process during learning(Medley et al., 2010)(Drigas et al., 2020). There are numerous factors influencing learning behaviors, and some of these factors can have a positive impact when combined together(Morton et al., 2016)(Otto & Pensini, 2017)(Kahu & Nelson, 2018). Creativity in problem-solving may not be directly taught but through habituation processes integrated into student learning and practice(Snyder & Snyder, 2008)(Yazar Soyadı, 2015)(Herro & Quigley, 2017). By making certain modifications to these models, the decision-making process indirectly plays a role in enhancing engagement in learning.

Problem-Based Learning (PBL) and Project-Based Learning (PjBL) are two learning approaches that can be integrated into the 21st-century learning curriculum to significantly enhance the quality of education. Integrating PBL and PjBL into the 21st-century learning curriculum can greatly improve the quality of education. Through PBL, students are actively engaged in addressing real-world problems and developing critical thinking skills. Meanwhile, PjBL provides opportunities for students to engage in relevant real-life projects, integrating cross-disciplinary knowledge and fostering creativity. With the integration of PBL and PjBL, students become the focal point of learning, actively engage, work in teams, and connect their learning to the real world, thus preparing them with relevant skills and understanding to face future challenges.

In vocational education, the application of PBL and PjBL can significantly contribute to achieving critical thinking and creativity(Nilsook et al., 2021)(Muhammad et al., 2021). Through PBL, vocational students are exposed to real-world problems that are relevant to their field of expertise. This encourages

them to think critically in analyzing, evaluating, and seeking the best solutions. Additionally, PjBL provides opportunities for students to engage in projects that require them to utilize practical knowledge and skills to create innovative and creative solutions. By involving vocational students in PBL and PjBL, they can develop the critical thinking abilities necessary to overcome workplace challenges while honing their creativity to generate solutions aligned with industry needs (Vogler et al., 2018). This enables them to become competent professionals ready to meet the demands of an evolving work environment.

Considering the advantages of Problem-Based Learning (PBL) and Project-Based Learning (PjBL), these learning models can be the appropriate solution for educators in implementing Competency-Based Education (CBE) for Vocational Education students, with aviation vocational education students used as respondents in this study. PBL and PjBL can enhance collaboration skills, critical thinking, complex problem-solving, learning transfer, and creative learning, which contribute to the development of vocational education students' competencies.

Based on the aforementioned context, this research aims to explore the direct and indirect relationships between critical thinking, creativity, and vocational education students' competencies using PBL and PjBL. The development of this model is expected to be utilized as an evaluation system for integrated learning models in the curriculum and assist students in developing content mastery through authentic experiences.

## RESEARCH METHODOLOGY

This research design employs a quantitative approach with an explanatory research type(Jain, 2021). This method was chosen to validate and test the measurement model of the research variables. The creativity variable uses the FFOE model (Fluency, Flexibility, Originality, Elaboration) with 8 indicators(Nadeem et al., 2012), and the critical thinking variable uses the FRISCO model (Focus, Reason, Inference, Situation, Clarity, Overview) with 11 indicators(Djumanova, 2021). The

competency variable uses the Standard model (Knowledge, Skills, and Attitudes) with 15 indicators.

The research respondents consisted of 200 purposively selected students in Aviation Vocational Education, including 70 final-year students, 70 intermediate-level students, and 60 entry-level students with competencies in Aerodrome Flight Information Services (AFIS) from Aviation Vocational Schools in Indonesia. The implementation of PBL and PjBL was carried out using Air Traffic Control training simulator facilities(Fothergill et al., 2009)(Updegrove & Jafer, 2017), following the learning mechanisms as shown in Figure 1 and Figure 2. Students are presented with concrete problems, search for solutions, and work on projects in teams to solve the problems. The skills that are nurtured through PBL and PjBL extend beyond the acquisition of knowledge and include abilities such as effective communication and presentation, efficient organization and time management, proficient problem-solving, self-assessment and reflection, active participation in group work, leadership qualities, and critical thinking(Chang & Tseng, 2009)(Habók & Nagy, 2016)(Kolmos et al., 2020)(Caeiro-Rodriguez et al., 2021).

This study was conducted from January 2022 to April 2023. Data collection techniques involve questionnaires (typical performance measurement, MTP) and interviews. The typical performance measurement is designed to reveal individual tendencies in reactions or behaviors in specific situations(P. E. Spector & Fox, 2002)(Donaldson & Grant-Vallone, 2002). Data analysis techniques employ multiple linear regression supported by Structural Equation Modeling Partial Least Square (SEM-PLS)(J. F. Hair et al., 2014)(Lowry & Gaskin, 2014)(J. Hair & Alamer, 2022). The analysis is conducted on latent variables to obtain values or measures based on observed indicators. The latent variables are divided into two based on

their functions: exogenous variables (critical thinking and creativity) and endogenous variables (competency).

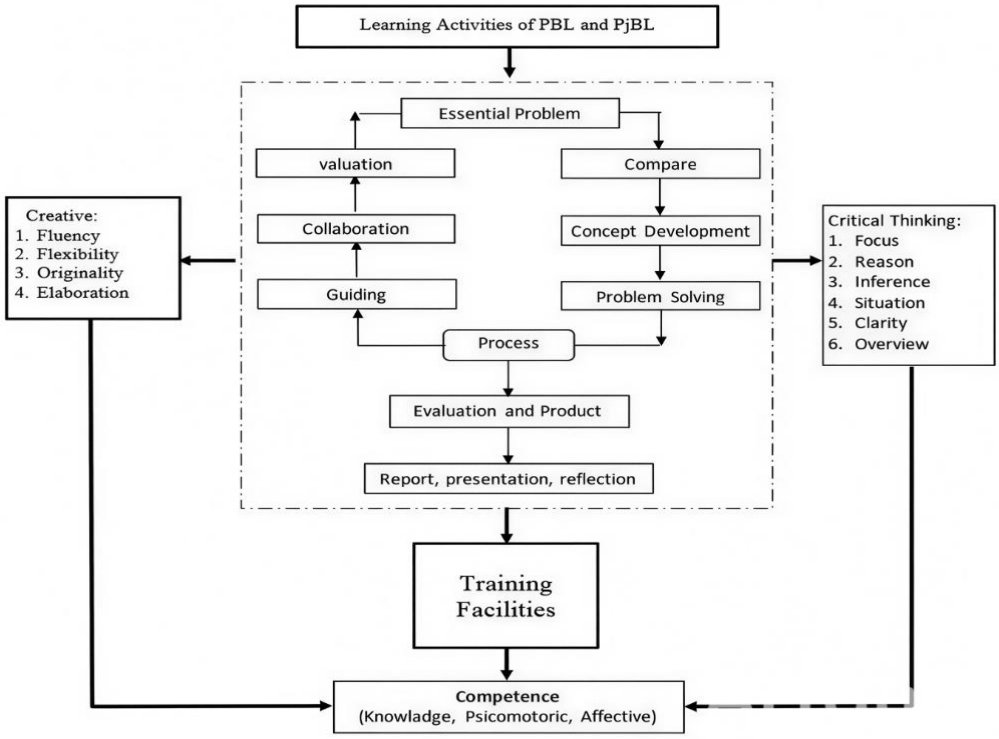


**Figure 1.** Mechanisms Of The Pbl And PjBL Learning Proce

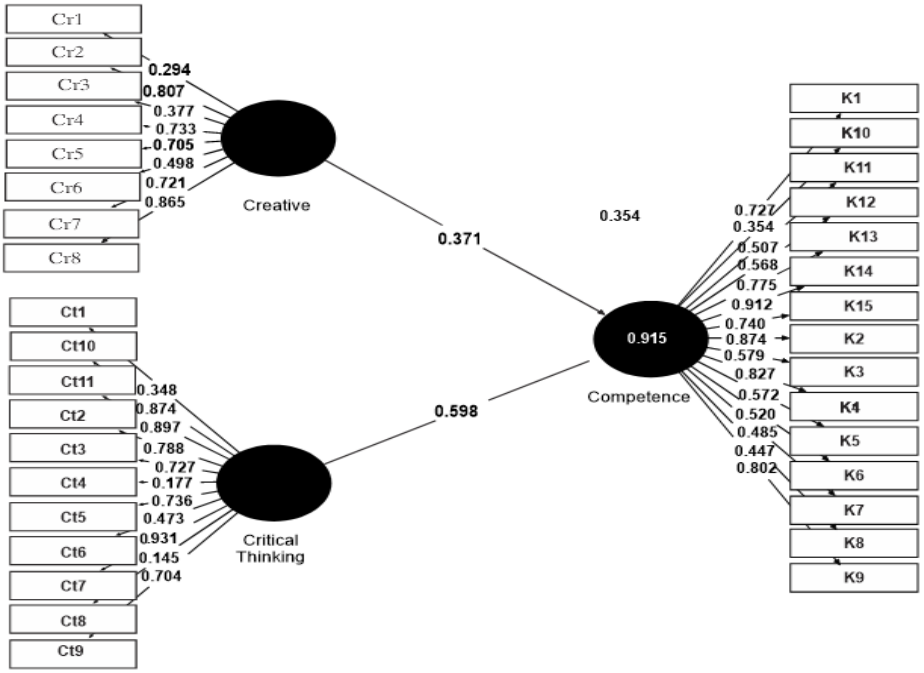


**Figure 2.** The Results Of Construct Analysis Testing Using Smart Pls

## RESEARCH METHODOLOGY

### Creativity and Critical Thinking in PBL Learning

In the context of Problem-Based Learning (PBL) in vocational education, creativity and critical thinking play crucial roles. Here is a further elaboration on these two aspects in PBL learning in vocational education:

1. Creativity in PBL: In PBL learning, creativity involves students' ability to generate new ideas, create innovative solutions, and think beyond conventional boundaries(Gallagher, 2015). In vocational settings, creativity is important in designing creative solutions to technical problems or complex real-world situations. In PBL, students are presented with challenges or projects that represent real-life situations they need to solve. Through this approach, students are encouraged to think creatively, develop unique solutions, and generate new ideas that are relevant to the vocational context they are learning. Creativity also plays a role in designing presentations or final products that depict their solutions innovatively.
2. Critical Thinking in PBL: Critical thinking in PBL focuses on students' ability to analyze deeply, evaluate, and solve problems in a logical and rational manner(Ulger, 2018). In the context of vocational education, critical thinking becomes essential in facing technical challenges and complex problems. In PBL learning, students are invited to engage in situational analysis, identify problems, gather and evaluate relevant information, and formulate the best solutions based on logical reasoning. Critical thinking also involves students' ability to evaluate the decisions and solutions they have made and consider the implications and consequences of those solutions within the vocational context.

Below is a table that can explain the relationship between creativity and critical thinking in PBL learning in vocational education.

**Table 1.** Exploring the Relationship Between Creativity and Critical Thinking in Problem-Based Learning in Vocational Education

| Aspect | Creativity | Critical Thinking |
|---|---|---|
| Definition | The ability to generate new ideas and innovative solutions in a vocational context | The ability to analyze, evaluate, and solve problems through logical reasoning |
| Role | 1. Designing creative solutions for technical problems<br>2. Generating new ideas relevant to the vocational context | 1. Analyzing situations and problems in-depth<br>2. Identifying the best solutions based on logical reasoning |
| Objective | 1. Developing out-of-the-box thinking skills<br>2. Enhancing skills in generating innovative solutions | 1. Developing strong analytical abilities<br>2. Improving decision-making based on rational thinking |
| Process | 1. Encouraging creative thinking through brainstorming, modeling, and idea exploration<br>2. Stimulating experimentation and new discoveries | 1. Involving in-depth analysis of situations and problems<br>2. Encouraging critical evaluation of relevant information |
| Outcome | 1. Unique and innovative solutions<br>2. Creative ideas relevant to the vocational context | 1. Effective and logical problem-solving<br>2. Decision-making based on critical thinking |
| Benefits | 1. Ability to address technical challenges with creative solutions<br>2. Readiness to face changes and innovation in the workplace | 1. Ability to analyze problems with critical and rational thinking<br>2. More effective decision-making in a vocational context |

The table above provides an overview of the interrelationship between creativity and critical thinking in PBL learning in vocational education. It includes definitions, roles, objectives, processes, expected outcomes, and benefits that

students can gain from developing these two aspects. The table helps visualize how creativity and critical thinking complement each other and are essential in developing vocational competence through PBL.

In combination, creativity and critical thinking in PBL learning in vocational education provide opportunities for students to develop analytical, problem-solving, and reflective thinking skills relevant to the workplace. They are encouraged to view problems from various perspectives, explore alternative solutions, and make effective decisions based on critical and innovative thinking. This lays a strong foundation for students to develop their vocational competencies and become professionals ready to face the challenges of an ever-evolving work environment.

**Creativity and Critical Thinking in PjBL Learning**

In the context of Project-Based Learning (PjBL) in vocational education, creativity and critical thinking also play a significant role. Here is a further elaboration on these two aspects in PjBL learning in vocational education:

1. Creativity in PjBL: In PjBL, creativity involves students' ability to generate new ideas, develop innovative solutions, and come up with creative concepts within the context of the project being undertaken. In vocational learning, students are presented with project tasks that represent real-world challenges they need to complete. Through the PjBL approach, students are given the freedom to explore creative ideas, design original solutions, and produce products or presentations that showcase their creativity in problem-solving or achieving project goals (Siew et al., 2015)(Remijan, 2017)(Chistyakov et al., 2023). Creativity also encourages students to think beyond conventional boundaries, integrate cross-disciplinary knowledge, and demonstrate innovation in project implementation.
2. Critical Thinking in PjBL: Critical thinking in PjBL involves students' ability to analyze, evaluate, and solve problems logically and rationally within the

context of the project being undertaken(Abidin et al., 2020)(Sari & Prasetyo, 2021). Students are invited to conduct in-depth analysis of relevant information, identify potential problems that may arise, and formulate the best solutions based on critical thinking. Critical thinking also involves students' ability to consider the implications and consequences of the decisions or solutions they make and evaluate the quality and effectiveness of the solutions generated. In vocational learning, critical thinking becomes essential in facing technical challenges and real-world problems encountered in projects, enabling students to make appropriate decisions and design effective solutions.

Here is a table explaining the relationship between creativity and critical thinking in PjBL learning in vocational education.

**Table 2.** The Relationship Between Creativity and Critical Thinking in PjBL in Vocational Education

| Aspects | Creativity | Critical Thinking |
|---|---|---|
| Definition | The ability to generate new ideas and innovative solutions | The ability to analyze, evaluate, and solve problems logically |
| Role | Designing original and innovative solutions | Conducting in-depth analysis of information |
| | Generating creative ideas relevant to the project | Identifying potential problems and formulating best solutions |
| Objective | Developing creative thinking skills | Enhancing critical thinking abilities |
| | Encouraging innovative problem-solving | Improving rational decision-making |
| Process | Encouraging exploration of creative ideas | Analyzing information and evaluating its relevance |
| | Fostering innovative approaches in project execution | Applying logical and rational thinking in problem-solving |

| | | |
|---|---|---|
| Outcome | Unique and innovative project solutions | Effective problem-solving outcomes |
| | Creative ideas applicable to vocational context | Well-reasoned and logical decision-making |
| Benefits | Enhanced problem-solving and innovative skills | Improved analytical thinking and decision-making |
| | Readiness to tackle complex vocational challenges | Capacity for effective problem resolution |

The table above provides an overview of the interrelationship between creativity and critical thinking in PjBL learning in vocational education. It includes definitions, roles, objectives, processes, expected outcomes, and benefits that students can gain from developing these two aspects. The table helps visualize how creativity and critical thinking complement each other and are essential in developing students' vocational competencies through PjBL.

In combination, creativity and critical thinking in PjBL learning in vocational education allow students to develop complex and in-depth thinking skills. Students are encouraged to think creatively in generating innovative solutions and designing products or presentations that showcase their creativity. On the other hand, critical thinking helps students analyze deeply, evaluate critically, and solve problems with logical and rational thinking. Through the development of creativity and critical thinking skills in PjBL, students can acquire profound vocational competencies, enhance their problem-solving abilities, and be prepared to meet the demands of an increasingly complex work environment.

## THE RESULTS OF VARIABLE TESTING

In analyzing the relationship between Creativity and critical thinking towards student competence using the PBL and PjBL approaches, the testing of measurement models and estimation of standard variable values is necessary. The

construct validity and reliability should be tested first. Construct validity can be examined by looking at the values of outer loadings (factor loadings) and Average Variance Extracted (AVE) for each indicator within the construct. If the outer loading value is ≥ 0.7 and AVE is ≥ 0.5, the indicators are considered valid. On the other hand, construct reliability can be tested by examining the value of Composite Reliability (composite reliability) ≥ 0.7 and Cronbach's Alpha ≥ 0.7 (Şimşek & Noyan, 2013). If all these criteria are met, the measurement model is considered suitable for use.

**Table 3.** Validity and Reliability Testing of The Creativity Indicators

| Variable | Indicator | β | Validity | AVE | CR | CA | Statement |
|---|---|---|---|---|---|---|---|
| Creativity | CR-1 | 0.294 | Invalid | 0.711 | 0.885 | 0.842 | Valid and Reliable |
| | CR-2 | 0.807 | Valid | | | | |
| | CR-3 | 0.377 | Invalid | | | | |
| | CR-4 | 0.733 | Valid | | | | |
| | CR-5 | 0.705 | Valid | | | | |
| | CR-6 | 0.498 | Invalid | | | | |
| | CR-7 | 0.721 | Valid | | | | |
| | CR-8 | 0.865 | Valid | | | | |

Indicator testing is an initial step in construct analysis aimed at evaluating the validity of variables before conducting reliability testing. The results of the analysis of the creativity variable indicators are shown in Table 3.

Based on the table, indicators CR-1, CR-3, and CR-6 of the creativity variable have outer loading values ≤ 0.7, indicating invalidity, although the AVE values are ≥ 0.5. Therefore, these indicators need to be removed from the measurement model. Furthermore, the results of the reliability test show that the CR and CA values are ≥ 0.7, indicating adequate reliability.

Next, validity testing measurements were conducted on the critical thinking indicator, as shown in Table 4. From the results of the validity testing measurements, it was found that 5 indicators of the critical thinking variable need to be removed: C-T1, C-T4, C-T6, C-T8, and C-T11. These indicators have outer loading values ≤ 0.7, indicating that these 5 indicators are not valid and should be removed from the construct measurement. Meanwhile, the results of the reliability test show that the Composite Reliability (CR) and Cronbach's Alpha (CA) values are ≥ 0.7, indicating good reliability.

**Table 4.** Validity and Reliability Testing of The Critical Thinking Indicators

| Variable | Indicator | β | Validity | AVE | CR | CA | Statement |
|---|---|---|---|---|---|---|---|
| Critical thinking | C-T 1 | 0.347 | Invalid | 0.645 | 0.923 | 0.889 | Valid and Reliable |
| | C-T 2 | 0.788 | Valid | | | | |
| | C-T 3 | 0.727 | Valid | | | | |
| | C-T 4 | 0.174 | Invalid | | | | |
| | C-T 5 | 0.736 | Valid | | | | |
| | C-T 6 | 0.472 | Invalid | | | | |
| | C-T 7 | 0.931 | Valid | | | | |
| | C-T 8 | 0.142 | Invalid | | | | |
| | C-T 9 | 0.704 | Valid | | | | |
| | C-T 10 | 0.874 | Valid | | | | |
| | C-T 11 | 0.340 | Invalid | | | | |

The results of the SmartPLS analysis for the Competence variable indicate that the competence indicators, as a whole, can be considered valid and reliable based on Table 5. However, there are 8 indicators that need to be removed as they are deemed invalid. These indicators are K-3, K-5, K-6, K-7, K-8, K-10, K-11, and K-12. Although the AVE values are ≥ 0.5 and the Composite Reliability (CR) and Cronbach's Alpha (CA) values are ≥ 0.7, these indicators do not meet the validity criteria to be included in the measurement model with loading values ≤ 0.7. Therefore, these indicators should be excluded from the measurement model.

**Table 5.** Validity and Reliability Testing of The Competence Indicators

| Variable | Indicator | β | Validity | AVE | CR | CA | Statement |
|---|---|---|---|---|---|---|---|
| Competence | K-1 | 0.727 | Valid | 0.734 | 0.939 | 0.925 | Valid and Reliable |
| | K-2 | 0.874 | Valid | | | | |
| | K-3 | 0.576 | Invalid | | | | |
| | K-4 | 0.827 | Valid | | | | |
| | K-5 | 0.573 | Invalid | | | | |
| | K-6 | 0.510 | Invalid | | | | |
| | K-7 | 0485 | Invalid | | | | |
| | K-8 | 0.446 | Invalid | | | | |
| | K-9 | 0.802 | Valid | | | | |
| | K-10 | 0.334 | Invalid | | | | |
| | K-11 | 0.506 | Invalid | | | | |
| | K-12 | 0.567 | Invalid | | | | |
| | K-13 | 0.775 | Valid | | | | |
| | K-14 | 0.912 | Valid | | | | |
| | K-15 | 0.740 | Valid | | | | |

After conducting construct validity and reliability analyses, and ensuring the necessary assumptions are met, the next step is to perform a model fit test or structural model test. According to Manteiga and Crujeiras (2013), the model fit test can be categorized as follows(González-Manteiga et al., 2013):

a. GoF < 0.5 indicates a weak model,

b. 0.5 < GoF < 0.75 indicates a moderate model,

c. GoF > 0.75 indicates a good model.

After removing invalid or inadequate indicators, the results of the model fit test indicate an R2 value of 0.953. The average communalities for the creativity and critical thinking variables are 0.7662 and 0.7933, respectively, resulting in an average of 0.7797. Furthermore, the calculation of Goodness of Fit (GoF) yielded the following results:

$G_0F = \sqrt{\overline{c_0 mx} R^2}$
= (0.7797 x 0.953)

= 0.7430

Based on the calculation, a GoF value of 0.743 indicates that the model falls into the "Good" category. Therefore, the structural relationship between creativity and critical thinking towards competence is depicted in Figure 3.

Figure 3. GOF (Structure Model The Goodness Of Fit)

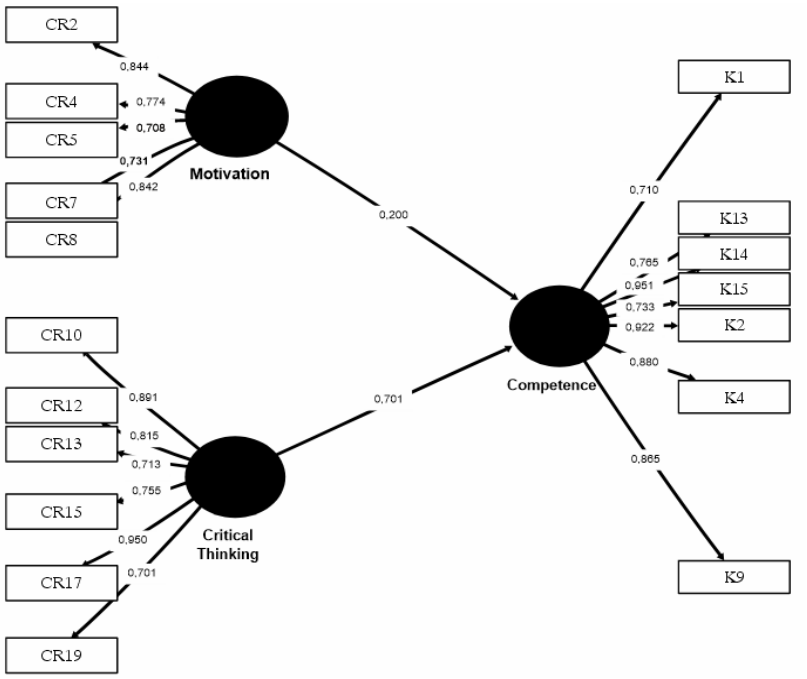


**Table 6.** The Results of Discriminant Validity Analysis

| | Critical Thinking | Competence | Creativity |
|---|---|---|---|
| **Critical Thinking** | 0.946 | | |
| **Competence** | 0.824 | 0.963 | |
| **Creativity** | 0.843 | 0.794 | 0.878 |

To ensure the distinction between the latent constructs and other variables, a discriminant validity test was conducted using the Fornell-Larcker Criterion(Henseler et al., 2015). The results of the discriminant validity test, as shown in Table 6, indicate that the loadings on the intended construct are higher than the loadings on other constructs. The hypothetical model has demonstrated a good fit, thus it is deemed suitable for further research on the relationship between creativity and critical thinking with student competence in vocational education.

Based on the statistical analysis using SEM-PLS, an R-Square value (reliability indicator) of 0.935 or 93% was obtained for competence, indicating that creativity and critical thinking have a positive and significant influence on student competence. Previous studies conducted by Cargas et al. (2017) and Yang and Wu (2012) have also discussed the relationship between creativity in the form of work behavior and critical thinking knowledge in influencing students' academic achievement in completing tasks or assignments during the learning process(Yang & Wu, 2012)(Cargas et al., 2017).

The relationship between the exogenous and endogenous variables in the constructed model can be seen in Table 7

**Table 7.** The Results of Discriminant Validity Analysis

| | Original Sample (O) | Sample Mean (M) | Standart Deviation | T Statistic | P Values |
|---|---|---|---|---|---|
| Critical Thinking → Competence | 0.779 | 0.789 | 0.045 | 19.475 | 0.000 |
| Creativity → Competence | 0.218 | 0.215 | 0.053 | 4.845 | 0.000 |

The results of the analysis of the relationship between the exogenous and endogenous variables can be seen in Table 5 and can be explained as follows:

a. The Path value (original sample) between critical thinking and competence has a positive value of 0.779, with a calculated T-value of 19.475 and a probability of 0.000. This finding indicates a significant positive influence of critical thinking on the competence of vocational education students. The result can be interpreted based on the fact that the calculated T-value ≥ the critical T-value (19.475 ≥ 1.96) or the P-value ≤ the significance level (0.000 ≤ 0.05), which indicates the rejection of the null hypothesis (Ho).
b. The Path value (original sample) between creativity and competence also shows a positive influence with a value of 0.218. The calculated T-value is

4.773, and the probability is 0.000, confirming that creativity significantly contributes to the improvement of vocational education students' competence. In this context, the results show that the calculated T-value ≥ the critical T-value (4.773 ≥ 1.96) and the P-value ≤ the significance level (0.000 ≤ 0.05), resulting in the rejection of Ho.

Within this set of findings, the analysis also reveals that the largest indicator of competence (K14) has a weight of 0.951. This indicates that students demonstrate better abilities and skills in solving Air Traffic Control Technical Skills problems. Indicator K14 has a significant influence on overall competence. This finding suggests that in the context of vocational education, students have developed competencies relevant to their field of study, especially in technical skills related to air traffic control.

Furthermore, this research highlights the importance of using PBL (Problem-Based Learning) and PjBL (Project-Based Learning) models supported by training facilities such as the ATC Simulator. These learning approaches provide contextual learning experiences, where students engage in real-world situations and are exposed to problems and challenges relevant to their field of study. Through problem-solving in real projects, students can develop their critical thinking and creativity skills and enhance their ability to solve complex problems(Kopzhassarova et al., 2016). This approach also helps students to connect theoretical knowledge with more authentic and real-world contexts(Alismail & McGuire, 2015)(Anggraeni & Suratno, 2021).

Overall, these findings indicate a positive relationship between creativity and critical thinking in influencing student competence. The regression coefficient analysis confirms that critical thinking is a significant predictor of competence. This means that students' ability to think critically contributes significantly to the development of their competence. Additionally, these findings also emphasize that creativity and critical thinking are interconnected and inseparable in achieving

students' success in developing their competence through problem-solving and real projects.

## CONCLUSION

Based on the conducted analysis, it can be concluded that the average and outer loadings of the indicators in each variable tend to be high. This indicates that the learning process using the PBL (Problem-Based Learning) and PjBL (Project-Based Learning) approaches has been effective. The results also indicate a significant positive correlation between the studied variables, as evidenced by the GoF (Goodness of Fit) value of 0.743, which can be categorized as "Good".

The development of this learning model can be used as an evaluation system for integrating PBL and PjBL into the curriculum. The integration of these learning approaches is crucial in the context of Vocational Education as it encourages students to think critically in understanding and mastering the learning materials through authentic experiences. Moreover, this approach can enhance students' creativity in problem-solving and generating new ideas.

By adopting this integrated learning model, it is expected that the competence of vocational education students can be effectively improved. The PBL and PjBL approaches not only help students gain a deeper understanding of the learning content but also train them to apply their knowledge and skills in real-life contexts. Thus, this learning model contributes positively to students' cognitive development and creativity, preparing them to face the demands of an increasingly complex job market.

## LIMITTATION AND FUTURE WORK

It should be noted that this study has several limitations. First, we conducted this survey with 200 students in Aviation Vocational Education, specializing in Air Traffic Control with AFIS competency, from Aviation Vocational Schools in

Indonesia. To draw more comprehensive conclusions, it would be beneficial to conduct similar research in other fields such as Engineering, Medicine, Military, Civil Engineering, or other vocational education fields with a larger number of participants from different levels (e.g., secondary and higher education).

Second, future research in this field should include other variables that are also related to the role of PBL and PjBL-based learning, such as motivation or collaboration, to provide additional insights. Therefore, it is crucial to identify and study all factors that influence students' competencies in vocational education.

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