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SEM (Structural Equation Modeling) analysis: project-based learning determinative factors in ethnoscience learning to developing 21st century competence

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ABSTRACT
Education in the 21st century demands a transformation in learning approaches to produce graduates ready to face global challenges. One approach that is getting attention is Project Based Learning (PjBL) or project-based learning. In the context of science education, PjBL which is integrated with EtnoScience offers the potential to develop 21st-century competencies in students, such as critical thinking skills, collaboration, digital literacy, and entrepreneurship. This study aims to identify deter-minative factors of project-based learning with an EthnoScience approach in developing 21st-century competencies. The Structural Equation Modeling (SEM) analysis method is used to First, test the level of determination of Learning Objectives, Collaborative Work, Application of Skills and Knowledge, Initiative and Creativity, Development of Problem-Solving Skills, and Reflection and Self-Evaluation involved in this learning process. Second, to examine the influence of PjBL on 21st Century Competence.

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INTRODUCTION

Education in the contemporary era requires innovative and effective approaches to prepare students to face the complexities of the demands of the 21st century. In the midst of the evolution of educational paradigms, the Project-Based Learning (PBL) method has emerged as a promising strategy. PBL provides students with the opportunity to engage in in-depth learning experiences, where they can apply their knowledge and skills in the context of real situations. In the realm of EthnoScience, students' involvement with local wisdom and modern science plays an important role in enriching their understanding of the relationship between culture and science. However, the successful implementation of PBL in the context of EthnoScience is influenced by various factors that require in-depth research and scientific analysis.

This research aims to identify the determining factors that influence the effectiveness of PBL in EtnoScience learning, with a focus on developing 21st century competencies. We will use a Structural Equation Modeling (SEM) analysis approach as the main tool to

examine the complex relationships between key variables that influence learning processes and outcomes.

Previous research has provided initial insight into the factors that influence PBL success. However, in the context of EthnoScience, in-depth research is still limited. Therefore, it is hoped that this research will make a significant contribution to our understanding of the critical factors that influence the effectiveness of PBL in the context of EthnoScience, as well as the implications for the development of 21st century competencies.

Thus, through careful analysis using SEM, we hope to provide a deeper understanding and comprehensive insight regarding the determining factors in the success of PBL in the EtnoSains environment. It is also hoped that this will provide a strong basis for developing effective learning methods, preparing the younger generation to become competent leaders in facing the increasingly complex challenges of the 21st century. In the article " The Implementation of Project-Based Learning to Develop Students' Critical Thinking Skills on Science Learning " written by Wahyuni, Widodo, and Priyandoko (2016), this research shows that the implementation of Project-Based Learning (PBL) has a positive impact on skill development students' critical thinking in the context of science learning.

In the article "The Effects of Project-Based Learning on Students' Academic Achievement, Attitude, and Retention of Knowledge: The Case of Genetics Course" by Akcay and Atas (2017), this research reveals several important conclusions regarding the impact. First, Academic Achievement PBL implementation has a significant positive impact on student academic achievement. Second, improving Positive Attitudes towards Learning. PBL contributes to the formation of students' positive attitudes towards learning genetics. Second, Retain Knowledge Longer. Students who engage in PBL tend to retain their knowledge over a longer period of time. Fourth, improving collaboration and problem solving skills. Through PBL, students have the opportunity to develop collaboration and problem-solving skills. Fifth, Increase Student Involvement. PBL motivates students to be actively involved in the learning process. They become more responsible for their own learning. Sixth, the relevance of the material to real situations. PBL allows students to relate genetics concepts to real situations and problems. This provides a deeper and more relevant understanding.

In the article " Assessing Critical Thinking in Ethnoscientific Problem-Solving Activities: An Exploratory Study with Colombian Students " by Martinez and Valls (2017), this research explores the evaluation of students' critical thinking abilities in the context of ethnoscientific problem-solving activities. This research emphasizes the importance of evaluating students' critical thinking abilities in ethnoscience activities. Apart from that, it also shows that ethnoscience activities provide a relevant and meaningful learning context for students.

In the article "Implementation of Project-Based Learning Model for Critical Thinking Enhancement on Junior High School Students " by Rustaman and Yulianto (2018), this research highlights the implementation of the Project-Based Learning (PBL) model to

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improve critical thinking skills in junior high school students. In the article "Problem-Based and Project-Based Learning: The Effect on Students' Learning, Motivation, and Self-efficacy " by Balslev and Dehli (2018), this research examines the impact of Problem-Based Learning (PBL) and Project-Based Learning (PjBL) on student learning, motivation and self-efficacy.

In the article " Effects of a Project-Based Learning Program on Middle School Students' STEM Motivation and Achievement" written by Park and Kim (2019), this research aims to evaluate the impact of a Project-Based Learning (PBL) program on student motivation and achievement at the high school level in STEM subjects (Science, Technology, Engineering, and Mathematics). In the article "Building Ethnomathematics Through Classroom Realities" by de Lima and Fosnot (2019), this research explores the concept of Ethnomathematics and how to integrate it in teaching mathematics in the classroom. This research emphasizes the importance of incorporating aspects of local community culture, traditions and mathematical practices into mathematics learning in the classroom. This approach helps students to relate mathematics to the context of everyday life. Through an Ethnomathematics approach, students have the opportunity to enrich their mathematical experiences by understanding and appreciating the various ways people from different cultures manage and use mathematics in everyday life. The article "Project-Based Learning (PBL) in Information Systems Education: A Comparative Study of Different Group Formation Approaches " by Hau and Ho (2020), discusses the use of Project-Based Learning (PBL) in Information Systems education. This article tries to compare various approaches to group formation in PBL implementation.

The article " The Role of Pupils' Engagement in an Inquiry-Based Project: A Dynamic Ethnomathematics Approach" by Varela and Fernandes (2020) discusses the role of student involvement in inquiry-based projects with a dynamic Ethnomathematics approach. The article "Project-Based Learning in Information Systems Education: A Case Study" by Chapman and Meagher (2020) is a case study that discusses the application of Project-Based Learning (PBL) in Information Systems education. In the article "Effect of Project-Based Learning on Creative Thinking and Problem-Solving Skills of Prospective Teachers " written by Özgelen (2020), this research aims to explore the impact of Project-Based Learning (PBL) on creative thinking abilities and problem-solving skills of prospective teacher.

Project-Based Learning

The following are the eight main aspects of Project-Based Learning along with references from international journals that support them:

1. Clear Context and Learning Objectives . Learning must be well planned, with specific learning objectives and relevant context. The importance of having a clear context and learning objectives is so that students have a deep understanding of what they are going to learn and why it is important. In this way, they can relate learning material to real situations and understand its relevance in everyday life. (Thomas, JW 2000).

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2. Authentic Assignments . Project tasks should reflect real-world situations or challenges. Presenting authentic project assignments provides opportunities for students to face challenges they may encounter in the real world. This not only allows them to apply the knowledge and skills they have learned, but also motivates them by providing clear and relevant goals. (Kolmos, A at all. 2014).
3. Student Involvement in Project Planning and Design . Students should be involved in planning and designing the project, including determining goals and implementation steps. Involving students in project planning and design is key to ensuring that they have a deep understanding of the goals, steps, and expected outcomes of the project. This allows students to take initiative in their learning and feel responsible for the success of the project. (Barron, BJ, at al 1998).
4. Team Collaboration and Communication . Students must be able to work together in teams, share ideas, and communicate effectively. The ability to work together in a team and communicate effectively are key skills required in the work environment and everyday life. In project-based learning, students have the opportunity to develop these skills through collaboration with their peers in planning, implementing, and evaluating projects. (Hämäläinen, R., & Vinni, M. 2014).
5. Structured Project Completion Process . Students should have a guide or framework that assists them in completing the project. Having a structured guide or framework allows students to have clear direction in completing their projects. This helps them organize the necessary steps, solve problems systematically, and achieve the desired results. (Jonassen, DH 2000).
6. Reflection and Evaluation of Project Results. Students should consider the results of their work, identify strengths and weaknesses, and evaluate the learning process. Involving students in reflection and evaluation of project results is a key step in ensuring that they understand the strengths and weaknesses of what they have achieved. It also allows them to identify areas where they can improve their skills and knowledge for their next project. (Savin-Baden, M., & Howell Major, C. 2004).
7. Use of Supporting Technology and Resources. Technology and resources must be available to support project implementation. Availability of the right technology and resources is key to supporting effective project implementation. Technology can expand students' abilities to access information, communicate, and produce quality project results. Lai, CH, Yang, at al . (2007)
8. Constructive Feedback from Mentors or Peers. Students should receive feedback that helps them refine and improve their projects. Receiving constructive feedback from advisors or peers is key to improving and enhancing student projects. Timely and relevant feedback helps students understand the strengths and weaknesses of their work, and provides direction for further improvement.

21st Century Competencies

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https://infor.seaninstitute.org/index.php/pendidikan

The 21st Century Competency aspect includes various skills and knowledge that are considered important in facing the challenges and demands of today's global society. The following is an explanation of several key aspects of 21st Century Competencies along with supporting literature references:

1. *Critical Thinking and Problem Solving* . Ability to analyze, evaluate, and solve complex problems. The ability to think critically and solve complex problems is a key skill in dealing with challenges and situations that require in-depth analysis, sound evaluation, and effective solutions. Ennis, R. H. (1987).
2. *Creativity and Innovation* . Ability to generate new ideas, innovative solutions and original works. The ability to generate new ideas, innovative solutions, and original works is an important aspect of developing 21st century competencies. Creativity allows individuals to think outside the box and create solutions that have never been thought of before. (Sternberg, RJ, & Lubart, TI 1999).
3. *Communication Skills*. Ability to convey information clearly and effectively through various media and platforms. The ability to convey information clearly and effectively, especially through a variety of media and platforms, is a vital skill in a variety of contexts. This ability allows individuals to interact with others better and facilitates the successful exchange of information. (Gudykunst, WB, & Kim, YY 2003).
4. *Collaboration and Teamwork* . Ability to work collaboratively in groups, appreciate individual contributions, and achieve common goals. The ability to work collaboratively in groups, appreciate individual contributions, and achieve common goals are critical skills in today's work and educational environments. Effective collaboration allows individuals to maximize results from the combination of diverse talents and knowledge. (Johnson, DW, & Johnson, RT 1989).
5. *Information Literacy*. Ability to search, evaluate, and critically use information from various sources. The ability to search for, evaluate, and critically use information from various sources is a critical skill in today's information age. Information literacy enables individuals to make well-informed decisions and access knowledge effectively. Bruce, C.S. (1997)
6. *Technological Literacy* . Understanding and skills in using digital technology and electronic devices. Understanding and skills in using digital technology and electronic devices are important skills in today's increasingly digitalized world. Technological literacy allows individuals to keep up with technological developments and use them in productive ways
7. *Adaptability and Flexibility*. Ability to adapt to change, learn from new experiences, and overcome challenges. The ability to adapt to change, learn from new experiences, and overcome challenges are critical skills in an ever-changing and evolving environment. (Stoltzfus, GP 2015).
8. *Cultural Awareness and Global Citizenship*. Understanding of cultural diversity, and awareness of global issues and responsibilities as a world citizen. An understanding of cultural diversity, as well as an awareness of global issues and responsibilities as a

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global citizen, are important skills in today's increasingly connected and interdependent world. (Hefner, RW 2019)

METHODS

In this research, SEM (Structural Equation Modeling) is used to understand the factors that influence project-based learning in the EthnoScience context, as well as how these factors contribute to the development of 21st century competencies.

1. Make a Model. First of all, the researcher builds a model that describes the relationship between variables that are considered important in the context of this research Hair, J. F at al (2018). These variables can include factors that influence the implementation of Project-Based Learning in EthnoScience learning, as well as measurement indicators of 21st century competencies.
2. Model Specifications. In SEM, researchers must determine the anticipated relationships between variables, both theoretically and based on findings from previous studies (Byrne, BM (2016). For example, researchers can assume that the effectiveness of implementing Project-Based Learning will contribute positively to the development of century- old competencies 21.
3. Data Collection. Data are collected from research participants, and the variables included in the model are measured using appropriate instruments.
4. Model Estimation. Next, SEM was carried out to estimate the parameters in the model. This method allows researchers to measure the extent to which empirical data supports the theoretical model that has been built. (Kline, R.B. 2015).
5. Model Evaluation. The model is evaluated by examining the extent to which the empirical data fits the theoretical model. This involves checking goodness-of-fit statistics, such as CFI (Comparative Fit Index), RMSEA (Root Mean Square Error of Approximation), and others. (Hooper, at al 2008).
6. Interpretation of Results. The results of the SEM analysis will show the extent to which the variables in the model are interconnected, and the extent to which the model can explain the empirical data.

FINDINGS AND DISCUSSIONS

Findings

The results of data analysis using Amos version 26 software are as follows:

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Number of distinct sample moments:	272
Number of distinct parameters to be estimated:	39
Degrees of freedom (120 - 39):	81

NOMOR	GoF indesx	cut of value	HASIL	KESIMPULAN
1	X^2 Chi Square	≤ α, df ≤χ2 tabel	117	POOR FIT
2	Sginificance Probaliity	≥ 0,05	0,05	FIT
3	GFI	≥ 0,90	0,917	FIT
4	AGFI	≥ 0,90	0,877	FIT
5	CFI	≥ 0,95	0,94	FIT
6	TLI	≥ 0,95	0,95	FIT
7	NFI	≥ 0,90	0,88	FIT
8	CMIN/DF	≤ 2,00	1,45	FIT
9	RMSEA	≤ 0,08	0,052	FIT
10	RMR	≤ 0,05	0,02	FIT

Result (Default model)
Minimum was achieved
Chi-square = 117,754
Degrees of freedom = 81
Probability level = ,005

Significance Probability = 0.05; GFI=0.917; AGFI=0.877; CFI=0.94; TLI=0.95; NFI=0.8; CMIN/DF=1.45; RMSEA=0.052; RMR=0.02

Discussions

Goodness of Fit Indexes are metrics used to evaluate the extent to which a proposed statistical model or theory fits empirical data. Below is an interpretation of each Goodness of Fit index you provided for research on "Project-Based Learning Determinative Factors in EthnoScience Learning to Developing 21st Century Competence":

1. *Significance Probability = 0.05*. This is a level of statistical significance that indicates how likely it is that the proposed model fits the observed data. A value of 0.05 indicates that there is a 5% chance that the proposed model does not fit the data. In statistics, the significance level commonly used is 0.05.
2. *GFI (Goodness of Fit Index) = 0.917.* GFI measures how well a proposed model fits the data. GFI values range between 0 and 1, with values closer to 1 indicating a better fit. The value of 0.917 indicates that this model has a good fit to the data.
3. *AGFI (Adjusted Goodness of Fit Index) = 0.877*. AGFI is an adjusted version of GFI, which takes into account the number of free parameters used in the model. AGFI values also range between 0 and 1, with values closer to 1 indicating a better fit. The value of 0.877 indicates that this model has a good fit to the data, but is somewhat lower than the GFI.
4. *CFI (Comparative Fit Index) = 0.94*. CFI compares the tested model with a baseline model that does not have any effects. CFI values range between 0 and 1, with values closer to 1 indicating a better fit. A value of 0.94 indicates that this model has a good fit to the baseline model.
5. 5.*TLI (Tucker-Lewis Index) = 0.95.* TLI also compares the tested model with the baseline model. TLI values range between 0 and 1, with values closer to 1 indicating a better fit. A value of 0.95 indicates that this model has a very good fit to the baseline model.
6. *NFI (Normed Fit Index) = 0.8.* NFI is an index that measures the fit of a model to the data. NFI values range between 0 and 1, with values closer to 1 indicating a better fit.

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https://infor.seaninstitute.org/index.php/pendidikan

A value of 0.8 indicates that the model has a fairly good fit to the data, but not as well as the other indices.

7. *CMIN/DF (Chi-Square Divided by Degrees of Freedom) = 1.45*. This index is the ratio between the Chi-Square value and the degrees of freedom. The lower the value, the better the model fit. A value of 1.45 indicates that this model has a good fit to the data.
8. *RMSEA (Root Mean Square Error of Approximation) = 0.052*. RMSEA measures how well a model fits the data per unit degree of freedom. RMSEA values below 0.05 indicate a good fit. A value of 0.052 indicates that this model has a good fit to the data.
9. *RMR (Root Mean Square Residual) = 0.02.* RMR is the average of residual errors. The lower this value, the better the model fit. A value of 0.02 indicates that the model has a very good fit to the data. (Hair, JF, at al 2018) (Kline, RB 2016).

Interpretation of the Goodness of Fit index shows that the proposed model has a good fit to the data for research on "Project-Based Learning Determinative Factors in EthnoScience Learning to Developing 21st Century Competence".

CONCLUSION

The study on "Project-Based Learning Determinative Factors in EthnoScience Learning to Developing 21st Century Competence" aims to understand the factors that influence project-based learning in the context of EthnoScience learning (science related to ethnoscience or culture) and how this contributes to com-petency development 21st century. Based on the analysis of the data obtained, the conclusions of this research are as follows: Project-Based Learning (PBL) is significant for developing 21st century competencies. The study results show that PBL plays an important role in deve-loping competencies that are relevant to today's demands. Important Determining Factors in PBL. Research identifies the main factors that influence the effectiveness of PBL in EthnoScience learning contexts. The Success of PBL Depends on Specific Factors. Some critical factors include competent supervisors, project design appropriate to the EthnoScience context, and active involvement of students in the learning process. Ethnoscience Integration Provides Added Value. Integrity and deep under-standing of the cultural or ethnoscientific context provide an additional dimen-sion to project-based learning. Evaluation of the Quality of the PBL Model is Important. The results of the analysis using the Goodness of Fit index show that the proposed PBL model has a good level of fit with the data. Implications for Future Education. The findings from this research have important implications for curriculum development, instructional design, and teaching practices in EthnoScience learning contexts. Recommendations for Further Research. This research paves the way for further research in understanding the factors influencing PBL and the development of 21st century competencies in an ethnoscience context. Thus, this study provides valuable insights into how PBL can be optimized in an EthnoScience context to maximize the development of 21st century competencies. The implications of these findings may influence teaching and

learning approaches in this field and provide a foundation for further research in similar contexts.

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