Library Progress International
Vol.44, No.3, Jul-Dec 2024: P. 90-96

Print version ISSN 0970 1052
Online version ISSN 2320 317X

Original Article

Available online at www.bpasjournals.com

An Implementation of Project-Based Learning (PBL) Teaching Model in Improving Early Child's Critical Thinking Skill

Natalina Purba[1], Rohdearni Wati Sipayung[2], Rahmawati Rahmawati[3], Beslina Afriani Siagian[4], Herman Herman[5*], Christina Natalina Saragi[6], Endang Fatmawati[7]

[1,5]Universitas HKBP Nommensen Pematangsiantar, Pematangsiantar, Indonesia
[2]Universitas Simalungun, Pematangsiantar, Indonesia
[3]Universitas Prima Indonesia, Medan, Indonesia
[4,6]Universitas HKBP Nommensen, Medan, Indonesia
[7]Universitas Diponegoro, Semarang, Indonesia
*Corresponding email: herman@uhnp.ac.id

How to cite this article: Natalina Purba, Rohdearni Wati Sipayung, Rahmawati Rahmawati, Beslina Afriani Siagian, Herman Herman, Christina Natalina Saragi and Endang Fatmawati (2024). An Implementation of Project-Based Learning (PBL) Teaching Model in Improving Early Child's Critical Thinking Skill. 44(3), Library Progress International, 90-96

ABSTRACT

The aim of this research is to investigate the impact of implementing a project-based learning teaching model on the enhancement of critical thinking skills among early childhood students. The study seeks to assess the specific influence of project-based learning on the development of critical thinking abilities in young learners. This study employed a structured process to gauge the influence of project-based learning on the critical thinking abilities of young children. The research plan comprised a pre-test and post-test model to measure the efficacy of the educational model. Information was gathered through observation of the kids' actions during project-based learning tasks and group discussions. Moreover, the study made use of qualitative data analysis techniques to interpret the observed behaviors and their association with critical thinking skills. The participants in the study were chosen from classes I A, I B, and I C using a purposive sampling technique. The research examined the effectiveness of Project Based Learning (PBL) in enhancing students' critical thinking skills in their learning. The implications of project-based learning (PBL) for teaching practices and curriculum development in early childhood education are significant, and research findings suggest that it can effectively enhance critical thinking skills among young learners. Additionally, involving parents in supporting and extending thinking skills into the home environment has been shown to be effective in reinforcing critical and creative thinking abilities among young children.

Keywords: Early child, critical thinking skill, PBL, teaching model

1. Introduction

The introduction section of the study aims to provide a comprehensive overview of the research and its objectives. It sets the stage for the entire study by presenting the background and rationale for the chosen topic. Furthermore, it outlines the specific objectives and explains the significance of the study, emphasizing its potential impact on the field of early childhood education (Yazidah et al., 2017). The study focuses on the development of critical thinking abilities in early childhood education through the implementation of project-based learning. This teaching model emphasizes the cultivation of critical thinking skills in students and aims to address the need for effective strategies to enhance critical thinking abilities in young learners.

Additionally, the introduction section highlights the significance of the study in the context of early childhood education, emphasizing the potential impact of the project-based learning teaching model on the improvement of critical thinking skills in young children. The section serves to provide a clear understanding of the research objectives and the

importance of the study in the field of early childhood education (Hasmadi et al., 2018; Herman et al., 2024). The study aims to introduce a Project Approach in early childhood education, particularly in rural preschools, to enhance critical thinking abilities and foster creativity and innovative thinking in young children. The integration of project-based learning in early childhood education is expected to have a positive impact on children's motivation, active involvement in learning, and the quality of their work, thus laying the groundwork for further academic development.

Project-based learning (PBL) has gained attention as an effective teaching model for early childhood education due to its ability to foster critical thinking skills and active involvement in learning (Claussen, 2017). The rationale for implementing PBL in early childhood education stems from the need to address existing gaps in traditional teaching methods, particularly in rural preschools where teachers may lack formal training in early childhood education (Hasmadi et al., 2018). The Project Approach, a key component of PBL, enables teachers to guide children through in-depth studies of real-world topics, fostering inquiry learning, teamwork, and communication skills.

By implementing the Project Approach, teachers can prepare children to become young investigators, actively involved in their own learning and motivated to produce high-quality work. Furthermore, project work provides a context for children to apply their academic skills in purposeful ways, ultimately supporting their continued learning process. This shift towards PBL in early childhood education not only benefits students by fostering critical thinking skills but also revitalizes educators and increases community involvement in the learning process.

2. Literature Review

The literature on project-based learning (PBL) in early childhood education emphasizes its positive impact on students' learning experiences and educators' professional development. (Claussen, 2017) highlights that PBL not only enhances school climate and student motivation but also revitalizes teachers as partners in the learning process. The approach fosters inquiry-based learning, empowering children to take charge of their own education and nurturing a lifelong love for learning. Additionally, (Merritt et al., 2017; Purba et al., 2024) underscore the significance of PBL in promoting student engagement, self-regulated learning, and conceptual understanding across various subjects, including science, mathematics, and technology. These insights collectively emphasize the multifaceted benefits of implementing PBL in early childhood education, aligning with the growing emphasis on holistic skill development and student-centered pedagogy. (Al-Bahadli et al., 2023; Ansari et al., 2023)

Conceptual Framework of Project-based Learning

Project-based learning (PBL) is underpinned by a robust conceptual framework that emphasizes inquiry learning, teamwork, and communication as essential components for early childhood development (Hasmadi et al., 2018). PBL, often referred to as the Project Approach, involves guiding children through in-depth studies of real-world topics, thereby enabling them to produce high-quality work and fostering their motivation. The projects within PBL are extended investigations of phenomena in the children's environment, providing a context for the application of academic skills and the acquisition of basic concepts and skills to support their continued learning process in primary school. This approach not only supports students' learning but also revitalizes educators, increases student motivation, and enhances teachers' beliefs in their ability to reach students at varying levels (Claussen, 2017).

The theoretical foundations of the implementation of project-based learning (PBL) in early childhood education are rooted in constructivist principles, aligning closely with the PBL approach. Constructivism emphasizes the active construction of knowledge through real-world problem-solving and inquiry-based learning, which resonates with the essence of PBL. As noted by (Cash, 2017) , effective project-based instruction utilizes content to connect with real-world issues and solutions, fostering collaboration and the application of technology. This approach is underpinned by constructivist learning theory, emphasizing the importance of students' active involvement in their learning process. (Neo & Fadilla, 2024)

Furthermore, (Claussen, 2017) emphasizes that project work in early childhood education supports students' learning, revitalizes educators, and enhances school climate and student motivation. It also encourages inquiry and research, nurturing children's autonomy in learning and fostering a lifelong love for learning. These insights underscore the theoretical alignment between constructivism and PBL, highlighting the potential impact of PBL on early childhood critical thinking skills. (Zakariya, 2020)

Constructivism and Project-based Learning

Constructivism is a key theoretical framework that underpins project-based learning (PBL) in early childhood education. According to Claussen (Claussen, 2017), project work in PBL aligns with the constructivist approach by

empowering young learners to take charge of their own learning, fostering their love for learning, and promoting inquiry and investigation. The principles of constructivism, as highlighted by Dewey and Kilpatrick, emphasize active and experiential learning, where children engage in hands-on activities, make choices, and work collaboratively in a democratic classroom setting (Sari & Astuti, 2018). This approach encourages children to actively express and explore materials, discover cause-and-effect relationships through direct experiences, and develop both individual and group contextual works. By integrating constructivist principles into PBL, educators can effectively enhance children's critical thinking skills and overall learning experiences. (Zhao et al., 2023)

3. Methodology

The methodology section of this study involved a structured approach to assess the impact of project-based learning on early childhood critical thinking skills. The research design included a pre-test and post-test model to measure the effectiveness of the teaching model. Data was collected through observation of the children's behavior during project-based learning activities and class discussions. Additionally, the study utilized qualitative data analysis techniques to interpret the observed behaviors and their relation to critical thinking skills (Novianti, 2018; Fadhil et al., 2021; Rony et al., 2024)

The research design was guided by the need to understand how project-based learning influences early childhood critical thinking. The study's objectives were to recognize the impact of project-based learning on critical thinking skills and to describe the process of how critical thinking skills improved through the implementation of the teaching model. The participants in the study were early childhood students, and the data collection methods focused on capturing their engagement and critical thinking behaviors during project-based learning activities.

A. Research Design

The research design employed in this study draws on the project-based learning (PBL) model to investigate its impact on early childhood critical thinking skills. The approach encompasses several key elements outlined in the literature. First, the formulation of interview sheets initiates learning with essential questions, providing students with assignments to engage in activities. Moreover, the PBL model is shown to develop multiple intelligences, enhance knowledge systems, knowledge domains, and metacognition. The second step involves designing project-solving steps and project implementation, emphasizing the need for clear problem definition, making assumptions, and potential improvements. Additionally, the facilitation and monitoring of teachers during project completion support students' creative thinking abilities, particularly in terms of fluency. Furthermore, activities such as proposal development train students to generate varied and novel ideas. The PBL approach also includes project presentation and evaluation, thereby providing a comprehensive framework for the study (Antika & Nawawi, 2017). (Ndia et al., 2020; Shekh-Abed, 2024)

B. Participants

The participants in the study were selected from classes I A, I B, and I C using a purposive sampling technique. The research focused on the effectiveness of the Project Based Learning (PBL) model in improving students' critical thinking skills in the context of learning. The independent variable in the study was the active and confident application of the PBL model, while the dependent variable was the students' critical thinking skills. The results indicated that 94% of the students (29 out of 31) achieved completeness in their ability to think critically when exposed to the PBL model. Additionally, there were observed differences in the average critical thinking ability between classes that applied the PBL model and those that used conventional learning models (Indratno, Joko S & Purnomo, 2018). This sheds light on the specific sample population and the criteria for their selection, providing valuable insights into the study's participant demographics.

C. Data Collection Methods

The data collection methods for this research involved a systematic approach to gather information relevant to the research goals (Judijanto et al., 2024; Rakhmyta et al., 2024). The inquiry-based teaching method was selected as the independent variable to promote critical thinking skills among EFL students, aligning with the research objectives to recognize how this method improves critical thinking skills and its impact on the teaching process (Novianti, 2018). The research utilized tools such as formative written tests, observer observations, and student worksheets to gather both quantitative and qualitative data. The data collected from these methods were then analyzed using descriptive statistics and qualitative analysis to ensure the validity and objectivity of the findings (Irawati, 2011; Munthe et al., 2024).

D. Data Analysis Techniques

Data analysis in the context of the implementation of project-based learning teaching model involves several key techniques. The study by Novianti (2018) on improving critical thinking skills through inquiry-based teaching provides valuable insights into the process of enhancing students' critical thinking abilities. In the current research, the data analysis techniques encompass the assessment of students' critical thinking skills before and after the implementation of project-based learning. This involves quantitative analysis to measure the impact of the teaching model on critical thinking, as well as qualitative analysis to gain a deeper understanding of the students' cognitive development. Additionally, the study incorporates the use of comparative analysis to evaluate the effectiveness of project-based learning in comparison to traditional teaching methods, contributing to a comprehensive examination of the collected data.

Results and Discussion

The results of the research indicate a significant improvement in early children's critical thinking skills following the implementation of the project-based learning teaching model. Both quantitative and qualitative analyses revealed a notable enhancement in critical thinking abilities among the participants. The findings align with previous studies that have demonstrated the positive impact of project-based learning on critical thinking skills (Cash, 2017). Moreover, the present study's outcomes contribute to the existing body of knowledge by specifically focusing on the early childhood context, highlighting the effectiveness of project-based learning in fostering critical thinking skills at a young age. The results underscore the value of integrating project-based learning into early childhood education to cultivate essential cognitive abilities in young learners.

Quantitative analysis of the research findings on the implementation of project-based learning in early childhood education reveals compelling insights. In a study conducted by Paranduri (2018) , it was found that students who received project-based learning demonstrated high mathematical critical thinking abilities and medium enhancement in critical thinking skills. Additionally, their mathematical disposition showed improvement, particularly for those in the low category. Similarly, a study by Indratno et al. (2018) highlighted the effectiveness of the Project Based Learning model in enhancing students' critical thinking skills. The research indicated that students' critical thinking abilities significantly improved when exposed to the Project Based Learning model compared to conventional learning approaches. These quantitative findings underscore the positive impact of project-based learning on early childhood critical thinking skills, emphasizing its potential as an effective teaching model.

Qualitative analysis in the context of project-based learning involves a comprehensive examination of non-numeric data to gain a deeper understanding of the impact of this teaching model on early childhood critical thinking skills. (Cash, 2017) emphasizes the importance of qualitative data in providing valuable insights into the effectiveness of project-based learning. It is suggested that future studies should consider employing qualitative methods to analyze student perceptions, as this would complement the quantitative findings and contribute to a more comprehensive understanding of the impact of project-based learning on critical thinking skills. Additionally, highlights the potential for qualitative analysis to explore the impact of project-based learning on specific demographic groups, such as low-achieving and minority students, providing a more nuanced understanding of the effects of this teaching approach.

Discussion

The findings of the research indicate that the implementation of project-based learning has a significant impact on early childhood education, particularly in enhancing critical thinking skills. This aligns with the work of (Yazidah et al., 2017), who emphasize the importance of training and developing critical thinking abilities, especially through models of learning such as the inquiry training model. Their study highlights the potential of inquiry-based teaching to foster reflective thinking, which is essential for the development of critical thinking skills. Furthermore, Novianti (2018) underscores the potential of inquiry-based teaching in promoting critical thinking and stimulating a higher-order thinking atmosphere in learning. The study's focus on improving students' critical thinking skills through an inquiry-based approach resonates with the implications of the current research, shedding light on the effectiveness of such methods in enhancing critical thinking skills in early childhood education. In conclusion, the discussion of the research findings underscores the significance of project-based learning and inquiry-based teaching models in nurturing critical thinking skills in early childhood education. The implications of this study extend to educational practices, emphasizing the potential of these teaching approaches to improve critical thinking abilities among young learners.

The interpretation of the research findings reveals valuable insights into the effectiveness of project-based learning (PBL) in enhancing early childhood critical thinking skills. (Novianti, 2018) emphasizes the significance of

inquiry-based teaching in improving students' critical thinking skills, highlighting its potential to stimulate higher-order thinking. This aligns with the implications of the present study, which demonstrates the positive impact of PBL on students' critical thinking abilities. Similarly, the study by (Isnur Indratno et al., 2018) underscores the effectiveness of the Project Based Learning model in improving students' critical thinking skills, as evidenced by the significant differences in critical thinking abilities between classes that applied PBL and those that used conventional learning models. These findings underscore the potential of PBL as a pedagogical approach to foster critical thinking skills in early childhood education.

The research findings presented in this section align with the overarching goal of understanding the implications and applications of the project-based learning teaching model in early childhood education. Both studies contribute to the growing body of evidence supporting the positive impact of inquiry-based and project-based learning on students' critical thinking skills, thereby emphasizing the potential of these pedagogical approaches in shaping effective teaching and learning practices in early childhood education.

Implications for Early Childhood Education

The implementation of project-based learning (PBL) in early childhood education has significant implications for teaching practices and curriculum development. Research findings suggest that PBL can effectively enhance critical thinking skills among young learners. This teaching model emphasizes the development of students' critical thinking abilities, aligning with the indicators of critical thinking proposed by Ennis and Skemp (Yazidah et al., 2017). PBL provides students with the opportunity to engage in disciplined inquiry, fostering the process of reflective thinking, which is essential for the enhancement of critical thinking skills. While previous studies have focused on inquiry-based teaching models in different educational contexts, the implications for early childhood education are particularly promising, as they offer a structured yet flexible approach to nurturing critical thinking abilities in young learners (Novianti, 2018).

Conclusion and Recommendations

The implementation of a project-based learning teaching model has demonstrated promising results in enhancing early children's critical thinking skills. The findings of this study underscore the potential of project-based learning in fostering higher-order thinking abilities among young learners. As a result, it is recommended that educators and policymakers consider integrating project-based learning approaches into early childhood education curricula to cultivate and enhance critical thinking skills from an early age (Novianti, 2018). Furthermore, the involvement of parents in supporting and extending thinking skills into the home environment has shown to be effective in reinforcing critical and creative thinking abilities among young children. Therefore, it is recommended that educators collaborate with parents to create a mutually supportive partnership aimed at promoting critical and creative thinking skills outside the classroom, thus further enhancing the impact of project-based learning on early childhood development (Burke, 1992).

Hence, a comprehensive summary of the research findings related to the impact of project-based learning on critical thinking skills is presented. The study by Cash (2017) focused on the implementation of project-based instruction and its potential to improve students' critical thinking skills (Cash, 2017). The study defined critical thinking as the development of higher-order thinking skills, including analyzing, evaluating, and creating, as per the revised Bloom’s taxonomy. The research employed an open-ended, medium-structured essay based on the document-based question to measure critical thinking improvement. The findings suggested that project-based instruction has the potential to enhance students' critical thinking abilities, as evidenced by the significant gains in critical thinking improvement observed in the study.

References

Al-Bahadli, K. H., Al-Obaydi, L. H., & Pikhart, M. (2023). The Impact of the Online Project-Based Learning on Students' Communication, Engagement, Motivation, and Academic Achievement. *PSYCHOLINGUISTICS, 33(2), 217-237*. https://doi.org/10.31470/2309-1797-2023-33-2-217-237

Antika, R. N. & Nawawi, S. (2017). The Effect of Project Based Learning Model in Seminar Course to Student's Creative Thinking Skills. *Jurnal Pendidikan Biologi Indonesia, 3(1),72-79*. DOI: 10.22219/jpbi.v3i1.3905

Ansari, B. I., Junaidi, J., Maulina, S., Herman, H., Kamaruddin, I., Rahman, A., & Saputra, N. (2023). Blended-Learning Training and Evaluation: A Qualitative Study. *Journal of Intercultural Communication, 23(4), 155–164*. https://doi.org/10.36923/jicc.v23i4.201

Burke, M. M. (1992). Building a Home for Thinking Transfer. *Critical and Creative Thinking Capstones Collection. 35*. https://scholarworks.umb.edu/cct_capstone/35

Cash, C. E. (2017). *The Impact of Project-Based Learning On Critical Thinking In A United States History Classroom*. (Doctoral dissertation). Retrieved from https://scholarcommons.sc.edu/etd/4093

Claussen, D. (2017). *A Review of Literature: Project Based Learning in Early Childhood. Master's Theses & Capstone Projects*. NWCommons: Northwestern College, Iowa. Available at: https://nwcommons.nwciowa.edu/cgi/viewcontent.cgi?article=1057&context=education_masters

Fadhil, M., Kasli, E., Halim, A., Evendi, Mursal, & Yusrizal (2021). Impact of Project Based Learning on Creative Thinking Skills and Student Learning Outcomes. *Journal of Physics: Conference Series, 1940*. DOI:10.1088/1742-6596/1940/1/012114

Hasmadi, H., Mazeni, I., Jameyah, S., & Mohd Azuri, S. (2018). Young Investigator - Towards Creativity and Innovative Mind Through Inquiry Learning Using Qualitative Study. *Advanced Science Letters, 24 (1). pp. 411-412*.

Herman, H., Purba, R., Purba, N., Fatmawati, E., Saputra, N., and Thao, N. V. (2024). Investigating the bilingual acquisition of language acquired by an early aged child from social psychology: A case study. *Revista Iberoamericana de Psicologia del Ejercicio y el Deporte, 19(2), 202-207*. Retrieved from: https://www.riped-online.com/articles/investigating-the-bilingual-acquisition-of-language-acquired-by-an-early-aged-child-from-social-psychology-a-case-study-107034.html

Ihsan, I. (2019). Pengaruh model pembelajaran problem based learning terhadap peningkatan keterampilan berpikir kritis siswa kelas X IPS SMA N 1 Suralaga tahun pelajaran 2018/2019. *Media Bina Ilmiah, 14(4)*. DOI: https://doi.org/10.33758/mbi.v14i4.357

Indratno, S. I., Joko S, I., & Purnomo, E. A. (2018). Efektivitas model pembelajaran project based learning terhadap kemampuan berpikir kritis materi bangun ruang kelas VIII. *Prosiding Seminar Nasional & Internasional*. Available at: https://jurnal.unimus.ac.id/index.php/psn12012010/article/view/4256

Irawati, I. (2011). Improving Students Ability In Critical Thinking By Using Problem-Based Learning Method at MAN 8 Jakarta. *Seminar Nasional FMIPA-UT*. Available at: https://repository.ut.ac.id/2453/

Judijanto, L., Sitompul, M. S., Herman, H., Manihuruk, L. M. E., Fatmawati, E., Munthe, M. V. R., Batubara, J., Saputra, N. (2024). Students' Perception on the Use of English Pop Song in Improving the Skill of Pronunciation. *Studies in Media and Communication, 12(3), 218-230*. DOI: https://doi.org/10.11114/smc.v12i3.7004

Merritt, J., Lee, M. Y., Rillero, P., & Kinach, B. M. (2017). Problem-Based Learning in K–8 Mathematics and Science Education: A Literature Review. *Interdisciplinary Journal of Problem-Based Learning, 11(2)*. https://doi.org/10.7771/1541-5015.1674

Munthe, B., Bangun, B., Niswa, K., Sihombing, P. S. R., Shaumiwaty, S., Aritonang, U. E., & Herman, H. (2024). Investigating the implementation of politeness strategies in conveying of God's word from the Bible. *Research Journal in Advanced Humanities, 5(3)*. https://doi.org/10.58256/3m1qah20

Ndia, L., Solihatin, E., & Syahrial, Z. (2020). The Effect of Learning Models and Multiple Intelligences on Mathematics Achievement. *International Journal of Instruction, 13(2), 285-302*. https://eric.ed.gov/?id=EJ1249085

Neo, M. & Fadilla, A. N. (2024). Enhancing student project-based learning experiences within a constructivist learning environment. *EDULEARN24 Proceedings, 1159-1164*. doi: 10.21125/edulearn.2024.0394

Novianti, A. (2018). *Improving EFL students' critical thinking skills through inquiry-based teaching*. S-2 thesis. Bandung: Universitas Pendidikan Indonesia

Paranduri, I. H. (2018). Penerapan Model Pembelajaran Project Based Learning terhadap Peningkatan Kemampuan Berpikir Kritis dan Disposisi Matematis Siswa. *Jurnal Kajian Pendidikan Matematika, 3(2)*. DOI: http://dx.doi.org/10.30998/jkpm.v3i2.2771

Purba, N., Sirait, J., Syathroh, I. L., Sitompul, H. T., Purba, E., Br. Situmorang, N. M., Herman, H. and Fatmawati, E. (2024). Functional Systemic Role Analysis (FSRA) on Early Childhood in the Development of Vocabulary: Insights from Indonesia. *International Journal of Religion*, *5*(3), 322-330. https://doi.org/10.61707/3ymj6v90

Rakhmyta, Y. A., Shaumiwaty, S., Sipayung, R. W., Fatmawati, E., Nainggolan, S. G., Herman, H., & Sitanggang A. (2024). Political Debates and the Power of Textuality: Analyzing the First Debate of Indonesia Presidential Candidates' Election in 2023 from a Systemic Functional Linguistics Perspective. *EVOLUTIONARY STUDIES IN IMAGINATIVE CULTURE*, 8.1., 270–279. https://doi.org/10.70082/esic/8.1.18

Rony, Z. T., Wijaya, I. M. S., Nababan, D., Julyanthry, J., Silalahi, M., Ganiem, L. M., Judijanto, L., Herman, H., and Saputra, N. (2024). Analyzing the Impact of Human Resources Competence and Work Motivation on Employee

Performance: A Statistical Perspective. *Journal of Statistics Applications & Probability, 13(2), 787-793*. DOI: 10.18576/jsap/130216

Sari, A. Y. & Astuti, R. D. (2018). Implementasi pembelajaran project based learning untuk anak usia dini. *Jurnal Motorik, 1(1)*. DOI: https://doi.org/10.31090/paudmotoric.v1i1.547

Shekh-Abed, A. (2024). Metacognitive self-knowledge and cognitive skills in project-based learning of high school electronics students. *European Journal of Engineering Education, 1–16*. https://doi.org/10.1080/03043797.2024.2374479

Yazidah, I., Irawan, E. B., & Sulandra, I M. (2017). The Development of Inquiry-based Teaching Model to Enhance Critical Thinking Abilities on Circles in Junior High School. *International Conference on Education, Número: ICE 201 Parte: 0, 440 - 448*. Available at: https://xjournals.com/collections/articles/Article?qt=zuyq0i8G98gwIct1PoPJIq8CLlJoF9pPN5WFlE4FtGhvs56VD9i8s+EhvV1/fB34

Zakariya, Y. F. (2020). Effects of school climate and teacher self-efficacy on job satisfaction of mostly STEM teachers: a structural multigroup invariance approach. *IJ STEM Ed 7, 10*. https://doi.org/10.1186/s40594-020-00209-4

Zhao, L., Zhao, B. & Li, C. (2023). Alignment analysis of teaching–learning-assessment within the classroom: how teachers implement project-based learning under the curriculum standards. *Discip Interdscip Sci Educ Res 5, 13*. https://doi.org/10.1186/s43031-023-00078-1