Phenomenon, 2022, Vol. 12 (No. 1), pp. 120-139
JURNAL PHENOMENON
phenomenon@walisongo.ac.id

Effectiveness of Project Based Learning Integrated STEM in Physics Education (STEM-PJBL)

Roslina[1], Achmad Samsudin[2], Winny Liliawati[3]
[1,2,3]*Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No.229, Isola, Kec. Sukasari, Kota Bandung, Jawa Barat*

Abstract

This study aims to review 36 articles from reputable international journals such as indexed by Scopus, Web of Science (WoS) and SINTA, which explains the Effectiveness of Project Based Learning Integrated STEM in Physics Education. The articles selected for review were the ones published in the last eight years, from 2015 to 2022. The research approach used was a Systematic Literature Review (SLR). This study analyzed the representation of research according to their general characteristics consists of type of publication, year of publication, research approach and educational level. This study also analyzes the effectiveness STEM-PJBL in physics education based on the results of the reviewed research articles. The results show that the use of STEM-PJBL has a positive impact on cognitive, skills and attitude aspects and that STEM-PJBL can be integrated into media or materials teaching such as modularity,worksheet, the implementation of STEM with robots, as well as teacher awareness. So it can be used by teachers as input to apply STEM-PJBL in during physics learning.

Keywords: STEM-PJBL, Physics Education, Systematic Review

Efektivitas Pendekatan STEM Terintegrasi Project Based Learning Dalam Pembelajran Fisika

Abstrak

Penelitian ini bertujuan untuk mereview 36 artikel dari jurnal internasional bereputasi yang terindeks Scopus, Web of Science (WoS) dan SINTA, yang menjelaskan Efektivitas STEM terintergrasi Project Based Learning dalam Pembelajaran Fisika. Artikel yang dipilih untuk direview adalah artikel yang diterbitkan dalam delapan tahun terakhir, dari 2015-2022. Metode yang digunakan adalahSystematic Literature Review (SLR). Penelitian ini menganalisis representasi penelitian menurut karakteristik umumnya yang terdiri dari jenis publikasi, tahun publikasi, pendekatan penelitian dan tingkat pendidikan. Penelitian ini juga menganalisis efektivitasSTEM-PJBL dalam pembelajaran fisika berdasarkan hasil artikel penelitian yang direview. Hasil penelitian menunjukkan bahwa penggunaan STEM-PJBL dalam pembelajaran fisika berdampak positif pada aspek kognitif, keterampilan dan sikap dan bahwa STEM-PJBL dapat diintegrasikan ke dalam media atau bahan ajar seperti modul, lembar kerja siswa, implementasi STEM dengan robot, serta persepsi guru. Sehingga dapat dijadikan sebagai bahan

ISSN: 2088-7868, e-ISSN 2502–5708

masukanguru untuk menerapkan STEM-PJBL dalam pembelajaran fisika.

Kata kunci: STEM-PJBL, Pendidikan Fisika, Studi Literature

INTRODUCTION

The development of science and technology in the era of industrial revolution 4.0 in the 21st century is increasingly unstoppable. This has implications for global challenges and competition in each country. To compensate for this, we are forced to adapt quickly to current developments. So, of course, we need quality human resources. With the existence of quality human resources, it is hoped that each country will be able to compete with other countries. The learning process that allows students to build their own knowledge into a learning concept has attracted attention in the field of education in recent decades. Various types of innovative learning methods and strategies have been continuously adapted, to suit the needs of students throughout their study period, or to anticipate the future the student will face.

The STEM approach has evolved to meet today's educational needs. STEM approach is an innovation in education that integrates four areas of study, namely Science, Technology, Engineering and Mathematics. STEM was first launched by the National Science Foundation around the 1990s (Boy, 2013). Learning STEM is necessary for students to improve various skills of the 21st century (Schmidt & Fulton, 2016). Many students from different countries believe that STEM can secure their future careers (Tseng et al., 2013). This learning helps students come up with solutions to a problem from many different perspectives. Furthermore, because learning is interdisciplinary, STEM can be taught through a number of learning strategies such as problem-based learning (Lou et al., 2011; Parno et al., 2020), question-based learning (Cedillo, 2018; Yuliati et al., 2018) and project-based learning (e. g Tseng et al., 2013; Capraro & Capraro, 2016; Vogler et al., 2018). Because it integrates four areas of learning or at least two areas of knowledge in one learning process, it is hoped that learning becomes more meaningful and does not create boredom. In this respect, the advantage of STEM over discrete learning is that it can increase interactivity, forming certain experiences for students in building their learning experience (Tofel &Callahan, 2014).

Furthermore, Project Based Learning (PJBL) is a student-centred instructional model that promotes diverse specific skills within the process of creating an authentic

prototype, product or artefact (e.g Bell, 2010; Mihardi et al., 2013; Salmiza et al., 2019). Poject-based learning is a teaching and learning model that encourages students to learn through projects. The project includes research activities that engage students in complex tasks such as design, problem solving, and decision making (Tseng et al., 2013).Students independentlydesign real and feasible products or present their research accomplishments in their spare time(e.g Shi-Jer Lou et al., 2017; Fleming, 2000; Mergendoller & Thomas, 2001). Several studies on STEM education typically integrate the STEM approach with other approaches or learning models. Some examples of such integration include STEM-Project Based Learning (Samsudin, Jamali, Zain, & Ebrahim, 2020; Hanif, Wijaya, Winarno, & Salsabila, 2019). Beside PjBL, learning nowadays need togo with the trend in globalization era, one ofthose is by integrating *Science*, *Technology*, *Engineering,dan Mathematics* (STEM).

PJBL model combined with STEM approach is an innovative step in learning to provide opportunities for students to plan the learning process collaboratively and produce a specific product which can be used as a learning resource (Jauhariyyah et al., 2017). An approved and collaborative PJBL in STEM education to help students develop critical 21st century skills, including creative thinking skills, including creative and innovative thinking are important in developing higher order thinking skills (HOTS) (Barak & Asad, 2012; Hassan & Osman, 2014; Lesseig et al., 2017). In STEM-PJBL,students apply abstract concepts of science and mathematics to an engineeringcontext using technology tools.These opportunities stimulate students to construct their own knowledge and make use of formative feedback that is important in the STEM-PjBL lessons, In addition, because STEM-PjBL includes lots of hands-on activities, communication, and collaboration with peers, it helps students develop positive confidence in their ability to solve physics problems(Han, 2013). Several studies have been done to evaluate the effectiveness of applying STEM-PJBL in education.

The study states that stem PJBL Increase Effectiveness and Encourages Meaningful Learning through Student Direct Investigation (e.g Olivarez, 2012; Tseng et al., 2013; Vega et al., 2013). According to Han et al. (2014) students who have experienced STEM PjBL showed positive attitudes toward learning itself, team communication, and collaborativebehavior (e.g Baran et al., 2021; Dominguez & Jaime, 2010; Rooij, 2009;).It has also been found that by motivating students to solve authentic interdisciplinary

problems, the STEM-PJBL approach helps students solve real-world problems by developing and using problem-solving skills. Their collaborative problem (e.g Kelley & Knowles,2016; Hickey, 2014; Mayer et al., 2012; Bicer &Capraro, 2017; Erdogan et al., 2016; Lee etal., 2019), increases their sense of responsibility (Kellgren et al., 2016), allows them to solve problems from the point of view of a scientist or an engineer (Capraro & Slough, 2013) and thus indirectly develop their skills in scientific processes (Satchwell & Loepp, 2002).

Furthermore, related studies show that teaching with the help of STEM-PJBL positively affects students' creativity and attitude towards science learning (Tseng et al., 2013), motivation (Siew et al., 2015) and their learning outcomes (Çevik & Abdioğlu, 2018; Lou et al. 2014; Nurtanto et al., 2020). Thus, through the integration of PJBL and STEM approaches, students can transfer knowledge between the four disciplines through the projects they have undertaken. In this way, meaningful learning occurs, positively influencing students' attitudes and increasing their likelihood of choosing STEM careers for their future careers (Tseng et al., 2013). Studies of systematic literature review (meta-analysis) relating to the STEM-PJBL have also been published by several researchers previously.Amelia&Santoso, 2020 in their literature review research, aimed tooverview the ProjectBased Learning integrated STEM and describe the 21st century skills in Project Based Learning integrated STEM onscience subject. Furthermore,Diana et al., 2020 also aimed toexplore theeffectiveness aspects of implementing PJBL learning model in STEM education.Maharani et al., 2021 conducted a meta-analysis of articles relating toanalyze research trends related to PJBL-STEM topics in 2016-2020 through bibliometric analysis withthe Scopus database. Based on the statements regarding the application of STEM-PJBL, this article encourages the writing of this article to further examine the effectiveness of the integrated STEM Project Based Learning approach in learning physics. The study aimed to review 36 articles from reputable international journals related to the effectiveness of STEM-PJBL. Articles reviewed were published from 2015 to 2022. The research questions determined in this study is the following:

- How is the representation of research according to their general characteristics ?
- How is the effectiveness of STEM-PJBL in physics education ?

RESEARCH METHODS

The research method used is a systematic review of the literature. Systematic

literature review is the review of research literature using systematic and unambiguous accounting methods. The systematic review aims to obtain clear, coherent and accountable methods. A systematic literature review was conducted focusing on answering specific research questions(Nanang et al., 2020; Gough et al., 2017).

The data used is secondary data from articles related to research. Researchers selected 36 reputable international journals from 2015 to 2022. A summary of the selected journals for review can be seen in Table 1.

Table 1. Summary of Selected Journals for Review

Name of journal	f	Indexed By
Journal of Turkish Science Education	2	Scopus
Asia Pacific Journal of Educators and Education	1	Scopus
Journal of Nusantara Studies-Jonus	1	WoS
Solid State Technology	2	Scopus
Jurnal Pendidikan IPA Indonesia	2	Scopus
Pegem Eğitim ve Öğretim Dergisi	1	Scopus
EURASIA Journal of Mathematics Science and Technology Education	2	Scopus
Journal of Agricultural Education and Extension	1	Scopus
International Journal of STEM Education	1	Scopus
SpringerPlus	1	Scopus
Education Sciences	1	Scopus
Participatory Educational Research (PER)	1	Scopus
Italienisch		Scopus
International Journal of Advanced Research in Engineering and Technology (IJARET)	1	Scopus
Journal of Research in Innovative Teaching & Learning	1	Scopus
Jurnal Penelitian Pendidikan IPA	2	Sinta
Journal of Science Learning	3	Sinta
Momentum: Physics Education Journal	1	Sinta
Jurnal Kependidikan: Penelitian Inovasi Pembelajaran	1	Sinta
JIPF (Jurnal Ilmu Pendidikan Fisika)	1	Sinta
JHSS (Journal of Humanities and Social Studies)	2	Sinta
JTK: Jurnal Tadris Kimiya	1	Sinta
International Journal of Educational Science and Research (IJESR)	1	Copernicus
International Journal of Progressive Sciences and Technologies (IJPSAT)	1	Copernicus
Elementary Education in Theory and Practice	1	Copernicus
International Journal of English Literature and Social Sciences	1	Copernicus
International Journal of STEM Education for Sustainability	1	J-Gate
IMPULSE: Journal of Research and Innovation in Physics Education	1	J-Gate

Based on table 1, it is explained that the articles selected for review consist of 28

reputable international journals, which consist of 14 journals indexed by Scopus, 1 journal Web of Science (WoS), 7 journals indexed by Sinta, 4 journals indexed by Copernicus, and 2 journals indexed by J-Gate. Therefore, the researcher concludes that the articles selected for review are quality and accountable articles.

This study analyzes the representativeness of the research based on their general characteristics and the effectiveness of project-based learning Integrating STEM in physics education. Data were collected and interpreted in the form of tables and figures, and then analyzed descriptively. Data analysis results in numbers or percentages. In the discussion, the authors explained the relationship between the results of this study and the results of previous studies. In addition, the results of the discussion will explain the strengths and weaknesses of implementations related to integrated STEM project-based learning in physics education.

The authors adapted the research procedure from the Winarno et al., 2020 studies, which explained that there are several stages used in the literature review research. The stages of the review process can be seen in Figure 1

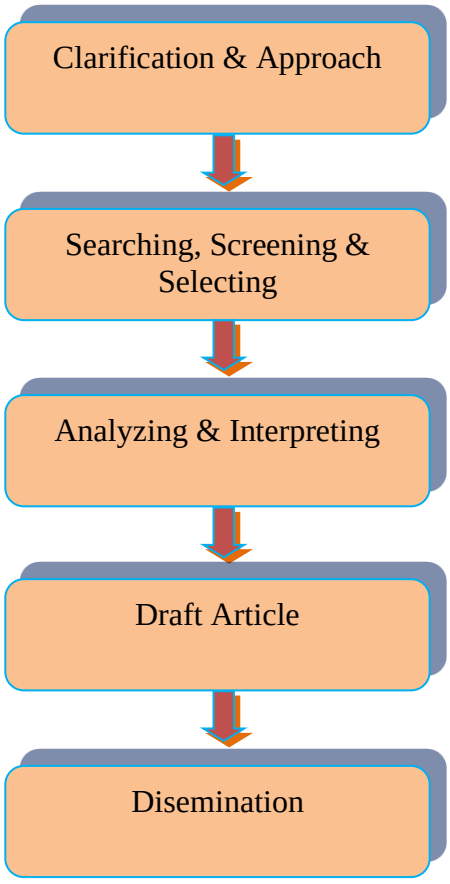

Figure 1. Stages of the Review Process

The stages of the research procedure are as follows:

a. Clarification & Approach

   In the clarification and approach stages, the authors explored the rationale for reviewing articles related to the effectiveness of project-based learning Integrating STEM in physics education, then determined research questions, article criteria, and formed the research framework.

b. Searching, Screening & Selecting

   In the searching, screening, and selection stages, the researcher looked for articles that explained the effectiveness of the Project Based Learning-based STEM approach in physics education. The search for journals was done through Google Scholar that met the criteria according to the researcher. Then the researcher screened and validated other researchers to ensure that the selected articles matched the criteria. To ensure the quality of the articles reviewed, the authors only select articles from reputable international journals. The researcher used keywords such as "STEM Project", "STEM Project Based Learning" and "Physics Education" and other keywords. As a result, the authors found two hundred articles related to STEM-PJBL in physics education. However, the authors decided that only 40 articles were selected for review.Researchers selected 14 journals indexed by Scopus, 1 journal Web of Science (WoS), 7 journals indexed by Sinta, 4 journals indexed by Copernicus, and 2 journals indexed by J-Gate.

c. Analyzing & Interpreting

   In the analyzing and interpreting phase, the authors analyzed the representation of the characteristics of the study. The results of the data analysis were then described using tables and figures. Also, we discuss and interpret the results obtained

d. Draft Article

   The results of the data analysis were made to be a draft article. Thereafter, the authors adjusted the article draft with the intended journal template.

e. Disemination

   In the final stage, the articles that have been made will then be sent to reputable journals for publication.

RESULTS AND DISCUSSION

In this study, the representation of research according to its general characteristics including type of publication, year of publication, research approach and education level. The results of this study have been published in journals, yearbooks, books, theses or other journals. The representation of the study by publication type can be seen in Table2.

Table 2. Representation of Research According to The Type of Publications

No	Type of Publications	f	(%)
1	Journal	36	100
2	Proceeding	0	0
3	Book atau Thesis	0	0
Total		40	100

Table 2 explains that the type of publication selected for review was drawn from 260 articles. The researchers did not use publications in yearbooks, books, theses, or the like so that the articles selected for review were of high quality. It can also be concluded that based on the data, the articles selected for review are 100% from international journals. The year of publication was determined by seeing the year of the published article in a journal. Representation of research based on the year of publication can be seen in Figure 2.

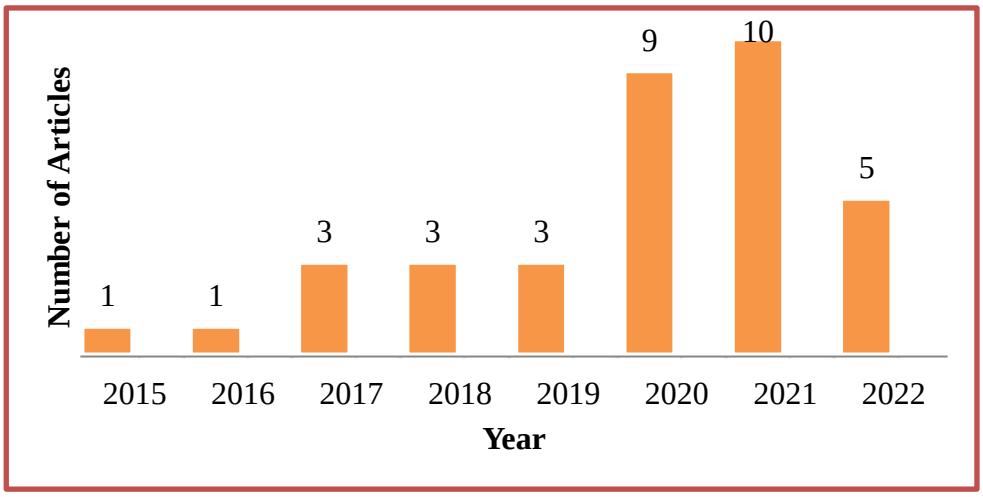

Figure2. Representation of Research-Based on the Year of Publication

Figure 2 explains that the selected articles related to the effectiveness of the STEM approach based on Project Based Learning (STEM-PJBL) in physics education from 2015 to 2022. The 36 articles selected for review consisted of 1 article (2015), 1 article (2016), 3 articles (2017), 3 articles (2018), 3 articles (2019), 9 articles (2020), 10 articles (2021)

and 5 articles (2022). The most reviewed articles were 10 articles published in 2021. The least reviewed articles were those published in 2015 and 2016 with 1 article each. Based on these data, it can be concluded that the articles selected for review are those published in the last eight years. This shows that the articles reviewed are up to date, so the results of this study can be used by stakeholders related to physics education or further researchers. Research approaches used in studies include qualitative, quantitative, mixed or other methods. A summary of the research approach of the 40 articles selected for review can be found in Table 3.

Table 3. Representations of Research Based on the Research Approach

No	Research Approach	f	Persentase
1	Quantitatif	24	67
2	Qualitatif	4	11
3	Mixed Methods	8	22
Total		36	100 %

Based on Table 3, it shows that the most widely used research approach is quantitative with 24 articles (67%), while the least used research approach is qualitative method with 4 articles (11%). Based on these data, it is concluded that the research approach used for research related to STEM-PJBL in physics learning consists of quantitative, mixed, and qualitative methods. The determination of the educational level in this study can be seen from research participants. Representation of research based on the educational level can be seen in table 4.

Table 4. Representations of Research Based on the Educational Level

Participants	Educational Level	f	Persentase
Student	Kindergarten school	1	2.8
	Elementary School	0	
	Junior high school	11	30,5
	Senior High School	16	44,4
	Vocational School	2	5,5
	University	4	11,11
Teacher	kindergarten school	0	
	Elementary School	0	
	Junior high school	0	
	Senior High School	0	
	Vocational School	0	
	University	2	5,5
Total		36	100 %

Table 4 shows participants in studies related to the effectiveness of STEM-PJBL in physics education. They consist of students, teachers, and others. Most studies used participants from high school students with a total of 16 articles (44.4%), while very few studies used participants from vocational high school students with a total of 2 articles (5,5%) and participants from elementary school students did not. There are articles on related studies. For participation using participants from university teachers with a total of 2 articles (5.5%), and there are no articles on related studies at the education level of kindergarten, elementary school, junior high school, high school, and vocational high school. Based on these data, it can be concluded that the implementation of research using the effectiveness of STEM-PJBL in physics eduaction for teacher participation is still very limited at all levels of the university level.

In this study, the effectiveness of STEM-PJBL in physics learning is divided by author, article title and article results. The effectiveness of STEM-PJBL in physics education can be seen in table 5.

Table 5. Effectiveness of STEM-PJBL in Physics Education

Authors	Title	Results
Jamali et al., 2020	The Effect of STEM Project Based Learning on Self-Efficacy among High-School Physics Students	STEM-PJBL improve students' self-efficacy to solve physics problem. Also, the study proposes a guideline for future research.
Saleh et al., 2020	STEM Project-Based Approach In Enhancing Conceptual Understanding and Inventive Thingking Skills Among Secondary School Studenst	Project-based approach, was found effective in enhancing conceptual understanding and inventive thinking skills among secondary school students
Jr & Sulaiman, 2020	The Effectiveness of Integrated STEM-PBL Physics Module on Students' Beliefs about Physics and Learning Physics	Integrated STEM-PBL physics module intervention resulted in a positive shift in beliefs about physics and learning physics and traditional approach showed no influence on students' beliefs about physics and learning physics
Purwaningsih et al., 2020	The Effect of STEM-PjBL and Discovery Learning on Improving Student' Problem-Solving Skills of The Impulse and Momentum Topic	STEM-PjBL has a significant positive effect on improving students' problem solving skills rather than discovery learning
Çevik, 2018	Impacts of the Project Based (PBL) Science, Technology, Engineering and Mathematics (STEM) Education on Academic	STEM-PJBL improved significantly student academic achievement in the furniture design course and developed career interests in a positive direction.

	Achievement and Career Interests of Vocational High School Students	
Samsudin et al., 2018	Phyisics Achievement in STEM Project Based Learning (PjBL): A GENDER STUDY	This study confirmed that STEM-PjBL can better foster students' problem solving skill to reach higher level of achievements in physics mechanic test. There were not any differences in performance of girls and boys in the high school
Lou et al., 2017	A Study of Creativity in CaC2 Steamship-derived STEM Project-based Learning	STEM project-based learning can further develop the affective domain of creativity, including adventurousness, curiosity, imagination and challenge.
Vela et al., 2020	Improving perceptions of STEM careers through informal learning environments	There was no significant change in students' dispositions toward each individual STEM field, there was a statistically significant improvement of students' perceptions of STEM careers.
Jr & Sulaiman, 2020	The Development of Integrated STEM-PBL Physics Module for Learning Classical Mechanics in Secondary Education	Integrated STEM-PBL physics module showed the module had excellent face validity and content validity.
Syukri et al., 2021	Development of a PjBL Model Learning Program Plan based on a STEM Approach to Improve Students' Science Process Skills	The RPP project-based learning model based on the STEM approach is feasible to be used to improve students' science process skills in a dynamic fluid material.
Hanif et al., 2019	Enhancing Students' Creativity through STEM Project-Based Learning	STEM project-based learning give a good impact on students' creativity.
Jason D & Timothy, 2021	The Effect of Authenticity on Project-Based Learning: A Quasi-Experimental Study of STEM Integration in Agriculture	This study suggest that the stimulation of interest in the learning process, and increases in achievement, occur using projects with, what could be labeled as, medium levels of authenticity.
(Kartini et al., 2021)	Promoting Student's Problem-Solving Skills through STEM Project-Based Learning in Earth Layer and Disasters Topic	STEM Project-Based Learning is recommended to improve students' Problem-Solving Skills since they can use their integrated knowledge to solve a real-world problem
Afriana et al., 2016	Project Based Learning Integrated to STEM to Enhance Elementary School's Students Scientific Literacy	Project based learning integrated with STEM was significantly enhance students' scientific literacy skill in air pollution concept.
Siew et al., 2015	The perceptions of pre-service and in-service teachers regarding a project-based STEM approach	STEM professional development workshops can provide insights into the support required for teachers to adopt

	to teaching science	innovative, effective, project-based STEM approaches to teaching science in their schools.
Zulirfan & Yennita, 2022	Feasibility test of STEM at Home Prototype Kit as Science Project-Based Learning Media for Junior High School students	The STEM at Home Project Kit and Worksheet are valid and practically used in science learning, especially on the topic of Simple Machine
Yulkifli et al., 2022	Development of physics e-module based on integrated project-based learning model with Ethno-STEM approach on smartphones for senior high school students	Physics E-Module based on an integrated project-based learning model with the Ethno-STEM approach on smartphones for class XI high school students who meet valid, practical, and effective criteria..
Anon & Chalwatchatuphon, 2018	The Effects of Using STEM Project-Based Learning Activities on Evironmental Problem- Solving Ability of Upper Secondary School Students in Bangkok Metropolis	The STEM project activity to enhance student's ability in environmental problem-solving based on real environmental problems in students' community in all level of student's performance.
Lin et al., 2018	The Effectiveness of Using 3D Printing Technology in STEM Project-Based Learning Activities	There is an increase in students in the engineering design process, namely at the modeling and feasibility analysis stages, and students still think a little about decision making and communication.
Azis, 2021	Effectiveness of E-Module Based on Integrated Project Based Learning Model Ethno-STEM Approach on Smartphones for Student Senior High School Grade XI	E-Module based on an integrated project based learning model with the Ethno-STEM approach is in the effective category of attitude, knowledge, and skill competencies.
Haryadi & Pujiastuti, 2022	Enhancing Pre-service Physics Teachers' Higher-Order Thinking Skills Through STEM PjBL Model	Learning using STEM-PjBL Model could improve higher-order thinking skills more than Direct Instruction Learning
Tyas et al., 2021	Need Analysis for the Development of STEM-PjBL Physics Teaching Materials to Improve Students' Problem Solving Ability in the 21st Century	Study indicate that students need supporting teaching materials in the form of learning media accompanied by pictures and videos equipped with a learning model that can improve students' ability to solve problems, namely STEM-PjBLbased E-module.
Lin et al., 2021	Effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers' engineering design thinking	The effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers' engineering design thinking.

Baran et al., 2021	The Influence of Project-Based STEM (PjbL-STEM) Applications on the Development of 21st-Century Skills	The activities had positive effects on many of their 21st-century skills such as communication, and collaboration, problem-solving, creativity, critical thinking, responsibility, environmental awareness, and information-technology literacy.
Thongsri & Susilowati, 2021	Analysis Dimensions of Creativity in STEM Integrated Project-Based Learning	This research is to train the creativity of prospective teacher students through project creation by integrating STEM fi elds that combine cognitive, aff ective, and psychomotor abilities by exploring the problems that exist in their neighborhood.
Saefullah et al., 2021	Implementation of PjBL STEM to Improve Students' Creative Thinking Skills On Static Fluid Topic	The application of PJBL-STEM can improve students' creative thinking skills in the static fluid topic (Pascal law).
Gestira et al., 2021	PjBL-Based Blended Learning Implementation on Energy Topic to Improve the Problem-Solving Skill	the applied blended learning-based STEM PjBL could improve the learners' problem-solving skills on energy topics.
Kilty & Burrows, 2022	Integrated STEM and Partnerships: What to Do for More Effective Teams in Informal Settings	All teams progressed through pre partnership to at least the partnership (little p) level. Two partnership dimensions achieved the highest (big P) level: one of perception of benefit and one of products and activities
Apriyani et al., 2019	Analyzing Student's Problem Solving Abilities of Direct Current Electricity in STEM-based Learning	It was found that there was an increase in students' problem-solving abilities with the application of the integration model problem and project-based learning in STEM-based learning.
Kranc, 2020	STEM Education on the Example of the "Physics for Kids" Project Implemented in the Hippo Art Non-Public Kindergarten in Wieliczka: Research Reports	During the fulfilment of the project in question, children's creative intellectual operations and actions based on making experiments are shaped. However, the adjustment and individualization of the contents and forms of working with children by the ones who carried out the "Physics for Kids" project has not always been fully implemented.
Karaahmetoğlu & Korkmaz, 2019	The effect of project-based arduino educational robot applications on students' computational thinking skills and their perception of Basic Stem skill levels	the activities based on block based robotic programming tool did not have a significant effect on both students' total scores of Stem skills and scores related to factors, but when computational thinking skills were analyzed, it was

		found that they contributed significantly more than the total score and problem solving factor based on block based programming tool
Nurramadhani, 2020	Analysis of Students' STEM Literasy Based on Gender Differences in Science Learning	STEM literacy has different score based on the gender differences. It can be concluded that boys are outperformed than girls in STEM literacy in science learning especially in basic physics laboratory activity.
Nurramadhani & Permana, 2020	Students' Generated Question Quality Throught STEM Based Project Learning in Science Activity	The quality of students generated question has slightly improved to open question quality through STEM based project learning in science activity.
Sulisworo, 2020	Boat Prototype as Teaching Material on STEM Based Education to Enhance The Hight Order Thingking Skills	STEM prototype-based science teaching materials on boats developed with the project based learning learning model could improve students' highlevel thinking skills.
Rohimah & Juandi, 2022	Hypothetical Learning Trajectory in STEM Approach with Project-Based Learning Model toImprove Students' Mathematical Proficiency	STEM approach with the PjBL model applied to a linear equation in one variable topic can improve students' mathematical proficiency.
Asih et al., 2020	Development of STEM (Science, Techonolgy, Engineering, and Mathematic) Integrated Chemical Module on Voltaic Cells	The STEM integrated chemistry module feasibility test on the topic of Voltaic cells was declared very feasible and practical.

From Table 5, it can be seen that PJBLSTEM is used as a solution to educational roblems that arise, especially in learning physics. The results of 36 research articles reviewed lead to the conclusion that STEMPJBL can be used as the newest ways of learning with uses of science, technology, engineering and math that have a positive impact in aspects of cognition, skills and attitudes towards physical learning. STEMPJBL can be integrated into learning materials and educational materials such as modules, worksheet, integration of STEMPJBL with robots, as well as the perception of physics teachers.

The authors reviewed 36 articles from reputable international journals related to the effectiveness of project-based learning Integrating STEM into physical education. This study deals with representing searches according to their common characteristics. These common characteristics include publication type, year of publication, research approach

and level of education. The authors also studied the effectiveness of STEM-PJBL used in physics education. Several previous studies analyzed the representativeness of study characteristics to explain the general description of the articles reviewed (e.g Winarno et al., 2020; MartínPáez et al., 2019; Jayarajah et al., 2014). Furthermore, Deveci & Çepni (2017) explain that presenting research based on publication type, year of publication, country, research approach, level of education, and scientific content is one of the steps. should first be explained in the literature review. Based on the results of data analysis, representative of the study characteristics showed that the articles selected for review were those that were published in the last 10 years, from 2015 to 2022. Most of these papers come from international journals that are indexed by Scopus or the Web of Science, so the authors ensure that the reviewed articles are of good quality.

Of the 36 articles reviewed, all used a variety of research methods such as qualitative, quantitative and mixed methods. The most widely used research approach is quantitative, while the least used research approach is qualitative one. Most research approaches use mixed methods. The data collection uses test, interview, questionnaire, observation, audio/video recording tools, etc. Research representation based on educational attainment was analyzed in this study. The results of the analysis indicate that the research implementation using STEMPJBL in physics learning is still very limited at the university level.This study also analyzes the effectiveness of STEM-PJBL in physics learning. There is a difference between this research and previous research which lies in the scope of the research. The previous literature review research only examined the effectiveness of implementing project-based learning models (PJBL) in STEM education. In this study, analyzes with a more specific scope than previous research, namely examining the effectiveness of STEM-PJBL in physics learning. This study explains the effectiveness of STEM-PJBL based on the characteristics of the author, the title of the article and the results of the article.

Based on the analysis of 36 articles, the results showed that the effectiveness of STEM-PJBL in physics education had a positive effect on physics learning. Various studies have been proved that STEM projectbased learning gives effects in several aspects. STEM-PJBL consists of a variety of hands-on activities, communication, and collaboration with peers, it helps students develop positive confidence about their ability to solve physics problems (e.g Han, 2013; Kübra & zgen, 2019; Baran et al., 2021 ;

Gestira et al., 2021).Various studies were measured students' achievement scores who participatedin the STEM PjBL (e.g Baran & Maskan, 2010; Hong et al., 2013; Samsudin et al., 2017), The STEM-PJBL approach can also be integrated into physics education materials such as modules and worksheets (e.g. Jeffry et al., 2020; Asih et al., 2020; Azis et al., 2021) and perceptionof pre-service and in-service teachers regarding theimplementation of STEM project-based learning in physics class (e. g Siew et al., 2015; Lin et al., 2021; Haryadi & Pujiastuti, 2022).

Several previous studies have also shown that PjBL-STEM can affect students' communication skills (e.g Triana et al., 2020; Baihaqi et al., 2020; Baran et al., 2021; Paruntu et al., 2018; Muharomah et al., 2019). PjBL-STEM can affect students' creative thinking skills (e.g. Widyasmah & erlina, 2020; Hanif et al., 2019; Lou et al., 2017). In PjBL-STEM learning, students can realize their ideas by building and constructing products in STEM project-based learning. Thus, students are given the opportunity to develop their ideas by using several tools and materials that can improve product quality. This can indicate that students who learn science using STEM project-based learning have good creativity (Siew et al., 2015). PjBL-STEM affects students' critical thinking skills (e.g. Mutakinati et al., 2018; Ridlo, 2019). STEM-PJBL facilitates students to understand concepts, so students will feel confident to test the products they make and present them in class (e,g Gandi et al., 2019; Ridlo, 2019). In the aspect of literacy skills, STEM-PJBL has been widely studied in relation to scientific literacy. STEM-PJBL has a good influence on scientific literacy (e, g Lestari & Rahmawati, 2020; Yuliati et al., 2020). Afriana, 2016 showed that both male and female students showed positive responses and were happy with the application of PJBL STEM in air pollution learning.

PjBL-STEM consists of five steps, namely reflection, research, discovery, application, and communication[15]. Reflection shows the context of the problem to the students and provide inspiration so that they can come soon. Research helps students gather relevant information in developing conceptual understanding. The invention aims to develop students' abilities in building habits of mind from the process of designing and designing. Application aims to test products or find solutions to solve problems. Communication aims to present a product or solution within the scope of the class. The syntax description of the STEM integrated PjBL is described in Table 6.

Table 6. Syntax of Project Based Learning Integrated STEM.

Stage	Description
Reflection	This stage show context of the problem to the students and intended to link what is known and what needs to be learned.
Research	Student research process. During the research phase, the teacher's role is to guide the discussion to determine whether students have developed conceptual and relevant understandings based on the project
Discovery	The discovery stage generally involves the process of bridging research and known information in project development. Some of the models from STEM PjBL divide students into small groups to present possible solutions to problems, collaborate, and build cooperation between friends in groups.
Application	At the application stage the goal is to test the product / solution in solving problems. In this stage, students test products and the results obtained are used to correct previous steps.
Communication	The final stage in each project is to create a product / solution by communicating between friends and class scope.

CONCLUSION

Based on the results and discussions conducted to analyze the effectiveness of STEM integrated Project Based Learning using the Systematic Literature Review (SLR), it can be concluded that STEM-PJBL has become one of the trends in recent years in the implementation of physics learning in schools. This can be seen from the many studies, surveys, and discussions about PjBL integrated STEM in physics learning. Most of the effectiveness of STEM-PJBL has a positive effect on learning physics. So that it can be used as input for physics teachers to apply the STEM-PJBL approach in the physics learning process at various levels of education.

REFFERENCES

Afriana, J., Permanasari, A., & Fitriani, A. (2016).*Project Based Learning Integrated to STEM to Enhance Elementary School's Students Scientific Literacy*. 7.

Anon UA, U., & Chalwatchatuphon, O. (2018). The Effects of Using Stem Project-based Learning Activities on Environmental Problem Solving Ability of Upper Secondary School Students in Bangkok Metropolis. *International Journal of Educational*

Science and Research, *8*(1), 1–8. https://doi.org/10.24247/ijesrfeb20181

Apriyani, R., Ramalis, T. R., & Suwarma, I. R. (2019). Analyzing Student's Problem Solving Abilities of Direct Current Electricity in STEM-based Learning. *Journal of Science Learning*, *2*(3), 85–91. https://doi.org/10.17509/jsl.v2i3.17559

Asih, D. N., Wijayanti, I. E., & Langitasari, I. (2020). *Development of STEM (Science, Techonolgy, Engineering, and Mathematic) Integrated Chemical Module on Voltaic Cells*S. *JTK (Jurnal Tadris Kimiya)*, *5*(1), 91–103. https://doi.org/10.15575/jtk.v5i1.8127

Azis, H. (2021). *Effectiveness of E-Module Based on Integrated Project Based Learning Model Ethno-STEM Approach on Smartphones for Student Senior High School Grade XI*. *1*, 7.

Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The Influence of Project-Based STEM (PjbL-STEM) Applications on the Development of 21st-CenturySkills. *Turkish Journal of Science Education*, 4. https://doi.org/10.36681/tused.2021.104

Bell, S. (2010). Project based learning for the 21st century: Skills for the future. Journal ofEducational Strategies, Issues and Ideas, 83(2), 39-43.

Capraro, M. M., & Capraro, R. (Eds.). (2016). *A Companionto Interdisciplinary STEM Project-basedLearning: For Educators by Educators*. Springer.

Cedillo, S. (2018). Beyond inquiry: Towards the specificity of anti-blackness studies in STEM education. Canadian Journal of Science, Mathematics and Technology Education, 18(3), 242-256.

Gestira, M., Abdurrahman, & Viyanti. (2021). PjBL-Based Blended Learning Implementation on Energy Topic to Improve the Problem-Solving Skill. *Impulse: Journal of Research and Innovation in Physics Education*, *1*(1), 32–41. https://doi.org/10.14421/impulse.2021.11-04

Hanif, S., Wijaya, A. F. C., & Winarno, N. (2019). Enhancing Students' Creativity through STEM Project-Based Learning. *Journal of Science Learning*, *2*(2), 50. https://doi.org/10.17509/jsl.v2i2.13271

Haryadi, R., & Pujiastuti, H. (2022). Enhancing Pre-service Physics Teachers' Higher-Order Thinking Skills Through STEM-PjBL Model. *International Journal of STEM Education for Sustainability*, *2*(2), 156–171. https://doi.org/10.53889/ijses.v2i2.38

Jamali, S. M., Md Zain, A. N., Ale Ebrahim, N., & Samsudin, M. A. (2020). The Effect of STEM Project Based Learning on Self-Efficacy among High-School Physics Students. *Turkish Journal of Science Education*, *17*(1), 94–108. https://doi.org/10.36681/tused.2020.15

Jason D, M., & Timothy, H. M. (2021). The Effect of Authenticity on Project-Based Learning: A Quasi-Experimental Study of STEM Integration in Agriculture. *Journal of Agricultural Education*, *62*(1). https://doi.org/10.5032/jae.2021.01144

Jr, J. J. R., & Sulaiman, F. (2020a). The Development of Integrated STEM-PBL Physics Module for Learning Classical Mechanics in Secondary Education. *Solid State Technology*, *63*(6), 25.

Jr, J. J. R., & Sulaiman, F. (2020b). The Effectiveness of Integrated STEM-PBL Physics Module on Students' Beliefs about Physics and Learning Physics. *Solid State Technology*, *63*(6), 17.

Karaahmetoğlu, K., & Korkmaz, Ö. (2019). The effect of project-based arduino educational robot applications on students' computational thinking skills and their perception of Basic Stem skill levels. *Participatory Educational Research*, *6*(2), 1–

14. https://doi.org/10.17275/per.19.8.6.2

Kartini, F. S., Widodo, A., Winarno, N., & Astuti, L. (2021). Promoting Student's Problem-Solving Skills through STEM Project-Based Learning in Earth Layer and Disasters Topic. *Journal of Science Learning*, *4*(3), 257–266. https://doi.org/10.17509/jsl.v4i3.27555

Kilty, T. J., & Burrows, A. C. (2022). Integrated STEM and Partnerships: What to Do for More Effective Teams in Informal Settings. *Education Sciences*, *12*(1), 58. https://doi.org/10.3390/educsci12010058

Kranc, M. A. (2020). Edukacja STEM na przykładzie warsztatów programu "Fizyka dla Smyka" realizowanych w Niepublicznym Przedszkolu Artystyczno-Językowym Hippo Art w Wieliczce. Raport z badań. *Edukacja Elementarna w Teorii i Praktyce*, *14*(4(54)), 95–107. https://doi.org/10.35765/eetp.2019.1454.07

Lin, K.-Y., Hsiao, H.-S., Chang, Y.-S., Chien, Y.-H., & Wu, Y.-T. (2018). The Effectiveness of Using 3D Printing Technology in STEM Project-Based Learning Activities. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(12). https://doi.org/10.29333/ejmste/97189

Lin, K.-Y., Wu, Y.-T., Hsu, Y.-T., & Williams, P. J. (2021). Effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers' engineering design thinking. *International Journal of STEM Education*, *8*(1), 1. https://doi.org/10.1186/s40594-020-00258-9

Lou, S.-J., Chou, Y.-C., Shih, R.-C., & Chung, C.-C. (2017). A Study of Creativity in CaC2 Steamship-derived STEM Project-based Learning. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(6). https://doi.org/10.12973/eurasia.2017.01231a

Lou, S. J., Tsai, H. Y., & Tseng, K. H. (2011). STEM Online Project-Based Collaborative Learning for Female High School Students.Kaohsiung Normal University Journal, 30, 41–61.

Nurramadhani, A. (2020). *Analysis of Students' STEM Literasy Based on Gender Differences in Science Learning*. *JHSS (JOURNAL OF HUMANITIES AND SOCIAL STUDIES)*, *4*(1), 21–25. https://doi.org/10.33751/jhss.v4i1.1903

Purwaningsih, E., Sari, S. P., Sari, A. M., & Suryadi, A. (2020). The Effect of STEM-PjBL and Discovery Learning on Improving Students' Problem-Solving Skills of Impulse and Momentum Topic. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 465–476. https://doi.org/10.15294/jpii.v9i4.26432

Rohimah, S. M., & Juandi, D. (2022). *Hypothetical Learning Trajectory in STEM Approach with Project-Based Learning Model to Improve Students' Mathematical Proficiency*. *12*(1), 7.

Saefullah, A., Suherman, A., Utami, R. T., Antarnusa, G., Rostikawati, D. A., & Zidny, R. (2021). Implementation of PjBL-STEM to Improve Students' Creative Thinking Skills On Static Fluid Topic. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *6*(2), 149. https://doi.org/10.26737/jipf.v6i2.1805

Saleh, S., Muhammad, A., & Syed Abdullah, S. M. (2020).*STEM Project-Based Approach In Enhancing Conceptual Understanding and Inventive Thingking Skills Among Secondary School Studenst*. *Journal of Nusantara Studies (JONUS)*, *5*(1), 234–254. https://doi.org/10.24200/jonus.vol5iss1pp234-254

Samsudin, M. A., Md Zain, A. N., School of Educational Studies, Universiti Sains Malaysia, 11800 USM Pulau Pinang, Malaysia, Jamali, S. M., School of Educational Studies, Universiti Sains Malaysia, 11800 USM Pulau Pinang,

Malaysia, Ebrahim, N. A., & Centre for Research Services, Institute of Research & Monitoring (IPPP), University of Malaya, Kuala Lumpur, Malaysia. (2018). Physics Achievement in Stem Project Based Learning (PjBL): A Gender Study. *Asia Pacific Journal of Educators and Education*, *32*, 21–28. https://doi.org/10.21315/apjee2017.32.2

Siew, N. M., Amir, N., & Chong, C. L. (2015). The perceptions of pre-service and in-service teachers regarding a project-based STEM approach to teaching science. *SpringerPlus*, *4*(1), 8. https://doi.org/10.1186/2193-1801-4-8

Sulisworo, D. (2020).Boat Prototype as Teaching Material on STEM Based Education to Enhance The Hight Order Thingking Skills. 15.

Syukri, M., Yanti, D. A., Mahzum, E., & Hamid, A. (2021). Development of a PjBL Model Learning Program Plan based on a STEM Approach to Improve Students' Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *7*(2), 269–274. https://doi.org/10.29303/jppipa.v7i2.680

Tseng, K. H., Chang, C. C., Lou, S. J., & Chen, W. P. (2013). Attitudestowards science, technology, engineering and mathematics (STEM)in a project-based learning (PjBL) environment. International Journalof Technology and Design Education, 23(1), 87-102.

Thongsri, P., & Susilowati, E. (2021). *Analysis Dimensions of Creativity in STEM Integrated Project-Based Learning*. *Jurnal Kependidikan: Penelitian Inovasi Pembelajaran*, *5*(2). https://doi.org/10.21831/jk.v5i2.35306

Tyas, L., Harjana, H., & Wahyuningsih, D. (2021). Need Analysis for the Development of STEM-PjBL Physics Teaching Materials to Improve Students' Problem Solving Ability in the 21st Century. *International Journal of English Literature and Social Sciences*, *6*(1), 402–406. https://doi.org/10.22161/ijels.61.51

Vela, K. N., Pedersen, R. M., & Baucum, M. N. (2020). Improving perceptions of STEM careers through informal learning environments. *Journal of Research in Innovative Teaching & Learning*, *13*(1), 103–113. https://doi.org/10.1108/JRIT-12-2019-0078

Winarno, N., Rusdiana, D., Samsudin, A., Susilowati, E., Jahan Ahmad, N., & Ratih Mega Ayu Afifah. (2020). The Steps of the Engineering Design Process (EDP) in Science Education: A Meta-Analysis. *Journal for the Education of Gifted Young Scientists*. https://doi.org/10.17478/jegys.766201

Yulkifli, Y., Yohandri, Y., & Azis, H. (2022). Development of physics e-module based on integrated project-based learning model with Ethno-STEM approach on smartphones for senior high school students. *Momentum: Physics Education Journal*, 93–103. https://doi.org/10.21067/mpej.v6i1.6316

Zulirfan, Z., & Yennita, Y. (2022). Feasibility test of STEM at home prototype kit as science project-based learning media for Junior High School students. *Jurnal Penelitian Pendidikan IPA*, *8*(1), 57–66. https://doi.org/10.29303/jppipa.v8i1.1122