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Integration of Problem-Based Learning Model Assisted by Digital Simulation to Improve Students Analytical Skills: Literature Review

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Abstract: This study aims to determine the effectiveness of implementing a digital simulation assisted Problem-Based Learning model in improving students' analytical skills, to determine research trends regarding the integration of digital simulation assisted Problem-Based Learning in learning process, and to determine the contribution of digital simulation assisted Problem-Based Learning to improving students' analytical skills. This study uses the Systematic Literature Review (SLR) method and data collection is assisted by bibliometric analysis. Data were obtained using Google Scholar, Research Rabbit, Research Gate, and Springer. Reference articles are taken from 2020-2025. The results of the study that digital simulation is closely related to the Problem-Based Learning model. Where the integration of these two strategies can increase learner creativity in developing knowledge. Improved analytical skills occurred after the use of digital simulation in learning. this improvement occurs because the use of digital simulations can make the learning process more effective, more attractive, instructive, and visually more interactive presentations so that they can attract learners and help improve learning outcomes. Research on problem-based learning using digital simulations is still very limited. However, several schools in Indonesia have begun implementing this model and media by utilizing PhET simulations in science learning, such as physics, chemistry, and biology.

Keywords: Problem-Based Learning; Digital Simulation; Students' Analytical Skills.

Introduction

Currently, technological developments have resulted in educational developments. While education was originally implemented using conventional learning methods, in the 21st century, learning has been carried out utilizing sophisticated technology and learning media. The types of learning media used are increasingly diverse, tailored to students learning needs and the problems that frequently arise in the learning process. To improve the quality of education, collaboration between various parties, especially teachers, is necessary. Teachers can implement various learning models and integrate them with learning media. The selection of learning models and media must be aligned with the curriculum currently being implemented in the country. For example, in Indonesia, Indonesia is currently implementing the *Kurikulum*

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Merdeka with Deep Learning approach that prioritizes meaningful, mindful, and joyful learning processes. The implementation of earning models and media must be appropriate and meet the characteristics of this approach to align with the educational goals that are used as a reference in Indonesia. This Deep Learning approach enables learners to not only memorize material but also understand and internalize emotionally and cognitively during their learning process (Suwandi et al., 2024). Many learning processes require students not only to memorize concepts but also to master an understanding of the learning material by being able to analyze all learning problems in more depth and construct a coherent and in-depth learning flow. Complex material is often poorly understood by students because they focus solely on notes provided by the teacher, which must be memorized and analyzed in greater depth. It makes difficult for students to understand the connection between the concepts of the material being studied, or it can be said that abstract understanding of the material is still lacking, resulting in difficult in analyzing the material. Students also lack contextual learning experiences, even though these contextual learning experiences are very important to achieve because they indicate a meaningful an in-depth learning process. These contextual learning experiences help students connect the material to real-world situations and can build connections or associations between the knowledge they gain and its application in everyday life (Purniawati & Agustika, 2024). Contextual learning experiences, such as those used to develop students' analytical skills, are essential, especially in science. As learning facilitators, teachers must be able to present a learning process that supports the analysis of learning materials, enabling students to become more active participants and making the learning process more meaningful.

One learning media that can be used to improve analytical skills is digital simulation. In implementation, learning media requires students to experience an event being studied by simulating or demonstrating learning process directly (Handayani et al., 2017). This learning directly involves students as simulators, thus helping them understand the learning material more deeply. This simulation help students experiment by offering an interactive interface and an attractive display that supports repeated observations (Banda & Nzabahimana, 2023) This simulation facilitates challenging learning concepts, helping students develop skills in virtual laboratory experiments. Digital simulations present simulated actions of an event, as if it were actually happening (Ikfina Nurlaili et al., 2025). These simulations are highly interactive, easy-to-use animations that create a play-like learning environment. These simulations can increase student engagement, interactivity, and motivation. The use of simulations can enhance learners' affective and cognitive learning domains, specifically motivation, by attracting their attention, interest, involvement, interactivity, and desire to engage deeply in the learning process. In the cognitive domain, it can improve academic achievement and deeper thinking processes, particularly regarding meaning-making.

In addition to selecting the right learning media for classroom teaching, learners must choose the right learning model that can be integrated with used the learning media. One learning model that is suitable for use with digital simulations is the Problem-Based Learning (PBL). Problem-Based Learning involves students developing critical thinking and problem-solving skills. The learning process is designed to provide students with new knowledge and a deeper understanding of the learning material (Yakop et al., 2024). This model helps students solve problems and develop team management skills, allowing them to easily develop thinking skills, problem-solving skills, and intellectual skills based on real-life experiences or simulations in independent learning.

Problem-Based Learning presents a problem that has already occurred and then asks students to find information through other learning resources, involving critical thinking skills and other skills, both individually and collaboratively, so that students can be actively involved in finding information related to the learning material (N. M. Putri & Hamimah, 2023). Problem-Based Learning can provide more meaningful learning for students, with many learning formats and templates used, making learning more interesting. The use of this learning model makes the learning process less boring because the presentation is made as interesting as possible, so students can focus on following the learning activities. This allows students to improve their problem-solving skills (Cahyanti et al., 2024).

Problem-Based Learning model can be integrated with digital simulations to create engaging and effective learning experiences. Problem-Based Learning emphasizes real-world problem-solving, while simulations allow students to practice and apply concepts in a controlled environment before facing real-world challenges. In the learning process, not many teachers integrate this learning model and learning media. Given the characteristic of both, these models and media complement each other in their implementation. By integrating these models and strategies, students can develop problem-solving, critical thinking, and collaborative skills by deeply understanding concepts. Problems presented in Problem-Based Learning are presented in a well-structured and complex manner, enabling students to understand all elements of the problem and how to

interact (Riwayani et al., 2019). Problem-Based Learning can facilitate the activation of knowledge formation, critical analysis of arguments, and promote a deep understanding of scientific perspectives. This aligns with learning using information technology in the form of simulations. The use of simulations in this learning strategy is used to develop several interactive components and activities. Seeing the advantages that both have, research on the use of these models and media must be reviewed again so that in the future it can overcome problems that often arise in the learning process in the classroom. The aims of this research is to determine the effectiveness of implementing a digital simulation assisted Problem-Based Learning model in improving students' analytical skills, to determine research trends regarding the integration of digital simulation assisted Problem-Based Learning in the learning process, and to determine the contribution of digital simulation assisted Problem-Based Learning to improving students' analytical skills.

Method

The method used in this research is a Systematic Literature Review (SLR). A Systematic Literature Review is a research method for conducting literature review that is carried out regularly by mapping certain phases (Yusril & Nurmiati, 2021). A Systematic Literature Review is also called a secondary study to map and identify specific research topics (Rozi, 2020). This method is carried out to collect and evaluate research related to a specific topic focused by applying an evidence-based approach to search for studies relevant to several predetermined research questions by selecting, assessing, and synthesizing findings to answer the research questions (F. R. Putri & Suharso, 2023). In this method, researchers conduct a structured review and identify journals, each process following predetermined steps to answer the research question (Afsari et al., 2021). The purpose of the SLR method is not only to collect all available evidence related to the research question but also to support the development of evidence-based guidelines for practitioners (Kitchenham et al., 2009). There are five stages in a Systematic Literature Review, namely:

1. Preparing research questions
   The research questions for this article are:
   a. How effective is the implementation of a Problem-Based Learning model assisted by digital simulations in improving students' analytical skills?
   b. What are the research trends regarding the integration of Problem-Based Learning assisted by digital simulations in learning?
   c. How significant is the contribution of Problem-Based Learning assisted by digital simulations to improving students' analytical skills?

Finding data sources from journal databases. The researcher searched for articles on Problem-Based Learning and digital simulations. The databases used were Google Scholar, Research Gate, Research Rabbit, and Springer. Then filtered based on the year of publication.

2. Completing data eligibility
   The criteria used to search for articles were: articles published between 2020 and 2025, articles on Google Scholar, Research Gate, Research Rabbit, and Springer. Before sorting, there were 100 articles, which were then curated into 10 articles.

3. Assess the quality of the study to find answers to the research questions. When assessing the quality of a study, the research questions must be guided by ensuring that the articles used as data align with the articles used for the research.

4. Extract data to analyze the findings in the articles.
   Data extraction involves reading or summarizing the entire article and most importantly examining the findings in the articles used as data.

Table 1. Table Inclusion and Exclusion

Criteria	Inclusion	Exclusion
Type of literature	Article	Bools, Proceedings
Time span	2020-2025	Before 2020
Language	Indonesia and English	Besides Indonesia and English
Accessibility	Accessible	Inaccessible
Research Focus	Problem-Based Learning, digital simulation, students' analytical abilities	In addition to Problem-Based Learning, digital simulation, students' analytical skills.

This study used the PRISMA collection. Data was searched using Publish or Perish software to obtain 200 articles related to the research keywords.

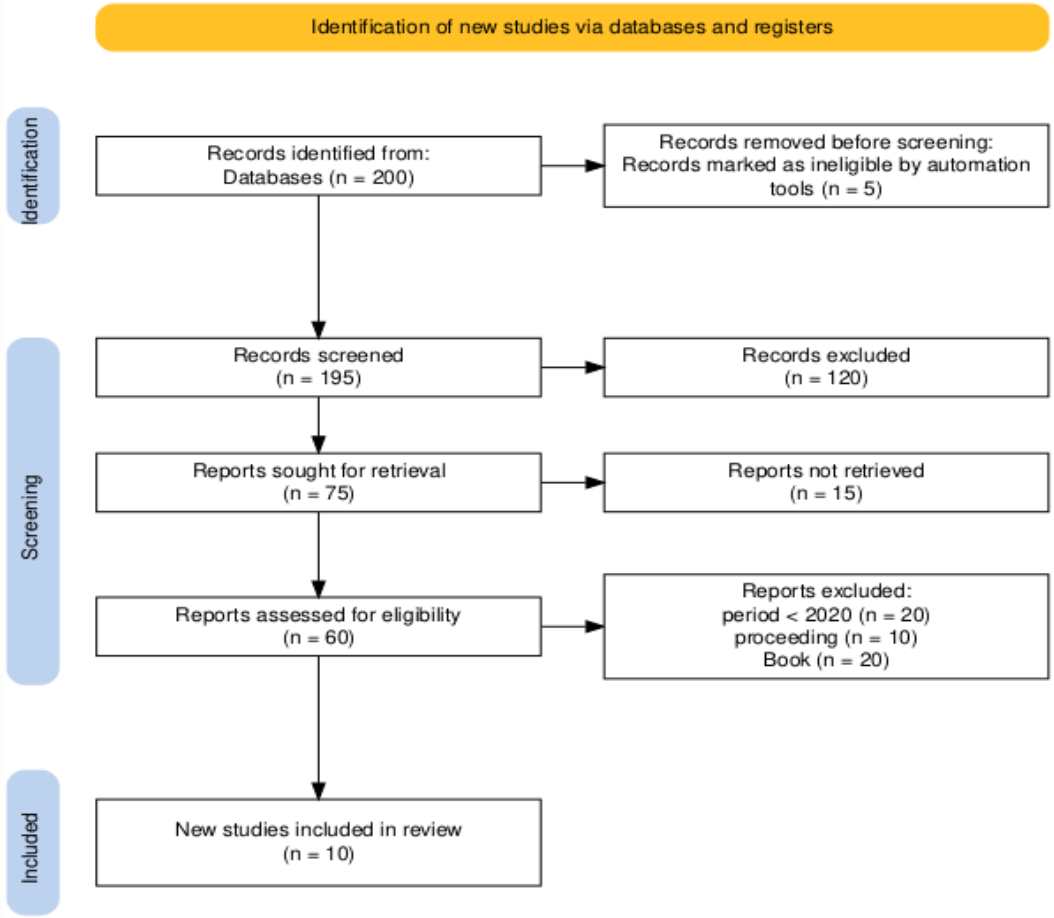

Figure 1. Bibliometric Result

Of the 200 articles, five articles were curated using the PRISMA method, with details of which did not meet the standard criteria. Furthermore, 195 articles met the standar criteria. Then, of the 195 articles, 120 articles did not match the keywords in the study, and only 75 articles did. Of the 75 articles, 15 articles were filtered again, which could not be opened, and only 60 articles could be opened. These 60 articles were filtered again by matching them to the year of the article to be used. In this study, the criteria used for the year of the article were articles published between 2020 and 2025. Twenty articles published before 2020 were not used. Furthermore, 10 articles in the form of proceedings and 20 in the form of books. The final result was that 10 articles met the standard criteria for the articles used in this study.

Result and Discussion

Based on the analysis of the selected articles, it was shown that integrating Problem-Based Learning models with digital simulations to improve students' analytical skills has proven effective. Here are the further results:

Table 2. Article Review

Title	Findings
Yakop S.S., Yusuf, Muhammad., & Buhungo T.J. (2024). Analisis Kepraktisan Penggunaan Model Problem Based Learning Berbasis Phet Simulation Untuk Meningkatkan Pengetahuan Konseptual Fisika Pada Materi Elastisitas & Hukum Hooke. Jurnal Jendela Pendidikan. *4*(3).	The use of a Problem-Based Learning model based on Physics simulation is considered practical for improving conceptual knowledge of Physics. This is evident from the results of the study, which showed that the learning implementation reached 91.85% with very good criteria. The results of the learner questionnaire also showed that the model met the good criteria, and seen from the results of the overall learner response, the average was 92.01%, thus meeting good criteria. All of these results indicate that this model is practical and suitable for application in learning.

Title	Findings
Nirya & Putera. (2025). Development of Macro Media Flash 8-Based Media to Improve Student Learning Outcomes with the Problem-Based Learning Model in Pancasila Education. Journal of Practice Learning and Educational Development. *5*(2).	The results of the study indicate that with a score of 90%, the interactive multimedia used I learning can be said to be very valid, with a validity test reaching 96% with the same category as the media validity test. The effectiveness test showed a percentage result of 92.2%, which is said to be very effective. This can be concluded that the use of media produced using Macromedia Flash 8 in class IV Pancasila Education has proven valid, practical, and effective.
Safitri Y.E & Asih S.S. (2023). Pengembangan Media Komik Strip Digital Berbasis Problem Based Learning untuk Meningkatkan Kemampuan Berpikir Kritis IPA. Joyful Learning Journal. *12*(2).	Based on the validation results from media experts, material experts, and language experts, this media generally meets the criteria of being very suitable for use as a learning medium. Learners can also actively participate in the use of this media. Digital comic strip media based on Problem-Based Learning is successful, very suitable, and effective for improving students' critical thinking skills in science content. The increase in the average critical thinking skills of learner is due to the learning environment created by this learning which is fun and requires students to be actively involved in every learning process.
Musa'ad & Suparman. (2023). Pengembangan E-modul Berbasis Problem Based Learning untuk Memacu Kemampuan Berpikir Kritis Abad-21. AKSIOMA: Jurnal Program Studi Pendidikan Matematika. *12*(3).	There are significant differences in the use of PBL based e-modules to improve critical thinking skills, and they are quite effective. These differences and improvements are due to the teaching materials designed with Problem-Based Learning e-modules enabling students to solve real-world problems. The use of this Problem-based Learning model creates a learning process that is connected to the real world, and students gain a wealth of knowledge in solving the given problems. Learners are also able to think critically based on their experiences, thus increasing their abilities.
Safiena & Goh Y.M. (2024). Authentic Learning Questionnaire for Digital Simulation Games in Higher Education: A Construction Safety Case Study. *29*(1)	Digital Simulation Games (DSG) are effectively used in learning. this evident in the percentage of learners who use simulation games in learning who have new experiences. As many as 70% of learners reported having gaming experiences in learning. Game-related features have been incorporated into factors related to authentic learning, further strengthening the coherence and relevance of the ADSG questionnaire in assessing authentic learning in higher education DSG. DSG presents learners with real-world scenarios that require collaboration to overcome complex challenges, enabling them to develop teamwork, adaptability, and effective communication skills crucial for their future careers.
Sumiasyih. (2022). Pengembangan LKPD Berbasis PBL Berbantuan PhET Simulation untuk Meningkatkan Hasil Belajar IPA Pada Materi Getaran dan Gelombang di MTS Negeri 1 Bantul. Jurnal Pendidikan Madrasah. *7*(2).	The development of PBL based LKPD assisted by PhET Simulation on vibration and wave material is very effective in improving the learning outcomes of class VIII students of MTsN 1 Bantul. The improvement of cognitive learning outcomes on vibration material with the calculation of the gain-score of 0.35 meetings to 0.56. At the second meeting, the wave material with a moderate category with an interpretation of n-gain effectiveness with a percentage of 56-75% is quite effective. The improvement of learning in the affective aspect, the first meeting average 75.0 and at the second meeting rose to 86.3. When viewed from the results of observations of learner activities, the average value at the first meeting was 88.22 and at the second meeting was 88.33 with the criteria for very good learner activity. The continuity of the learning process at the first and second meetings resulted in a percentage of 100% with very good criteria. The results of learner responses in this learning have a high value of 8.94.
Banda, H.J., & Nzabahimana, J. (2023). The Impact of Physics Education Technology (PhET) Interactive Simulation-Based Learning on Motivation and Academic Achievement Among Malawian Physics Students. *32*(1).	The analysis of the impact of Simulation Based Learning using PhET on students' motivation and academic achievement in oscillations and waves shows that PhET simulation-based learning can improve academic achievement and motivation among students. Data analysis conducted in this study shows that students in the experimental group have a significant increase compared to students in the control group in academic achievement. PhET simulation-based learning improves students' understanding of content knowledge which has an impact on students' academic achievement.
Simanjuntak, M.P., Hutahaean, J., Lestari, R.I., & Barus, P. (2019). Penerapan Model Problem Based Learning Berbantuan Simulasi Komputer Terhadap Karakter Siswa. Jurnal Pendidikan Fisika. *8*(1).	There was a higher increase in the character of the experimental group-1 learners compared to the experimental group-2 and the control group. The experimental group-1 obtained an average score of 77, the experimental group-2 obtained an average of 75 while the control group obtained an average of 66. This means that PBL assisted by computer simulation is more effective in improving the character of learners compared to PBL without the help of computer simulation and conventional learning. the highest increase in n-gain character was seen in the curiosity indicator, which was 34%.

Title	Findings
Ilham, M., Husniati, A., & Muzaini, M. (2024). Implikasi Model Problem Based Learning Berbantuan Media PhET Simulations Terhadap Aktivitas dan Hasil Belajar Matematika Siswa. Jurnal Riset HOTS Pendidikan Matematika. *4*(4).	The PBL model assisted by PhET Simulations media has a significant influence on mathematics learning activities. This can be seen from the results of the hypothesis test on learning outcomes obtained that the sig. value is 0.000 < 0.05 with df – 70 and a T value of 18.390 > 1.667. The integration of PhET Simulations with PBL enriches the learning experience by providing in-depth visualization and interaction, which facilitates conceptual understanding, increases learner engagement, and encourages active participation in discussions and collaboration.
Molamahu. D., Buhungo, T.J., Payu, C.S., & Arbie, A. (2025). Pegaruh Model Pembelajaran Problem Based Learning (PBL) Berbantuan PhET Simulation Terhadap Hasil Belajar Siswa Pada Materi Gerak Parabola. *8*(1).	The average post-test score in experimental class was 84.3 while in replication classes 1 and 2 it was 82.9 so it can be said that the use of the PBL model assisted by PhET Simulation has an effect on student learning outcomes. In addition, the single student normalized gain analysis shows that the increase in student learning outcomes is in the medium to high category in the experimental class, replication 1, and replication 2. The results of the cognitive aspect n-gain analysis also show an increase in student learning outcomes in the medium to high category.

The results of several studies indicate an increased potential for the use of simulations in learning that uses Problem-Based Learning. The use of digital media in this learning can automatically detect and respond to learners' difficulties and overcome their confusion in understanding the subject matter. Several studies also state that the integration of Problem-Based Learning with digital simulations also indicates an increase in learning outcomes in Science learning because the learning process presented with the integration of Problem-Based Learning with digital simulations enriches the learning experiences by providing in-depth visualizations and interactions that facilitate conceptual understanding, increase learner engagement, and encourage active participation in discussions and collaboration. The use of digital simulations in learning results in savings in learner labor costs and allows students to practice and improve their abilities based on feedback from the digital system without having to rely on learner guidance and learning time also becomes relatively more flexible (Tang et al., 2025).

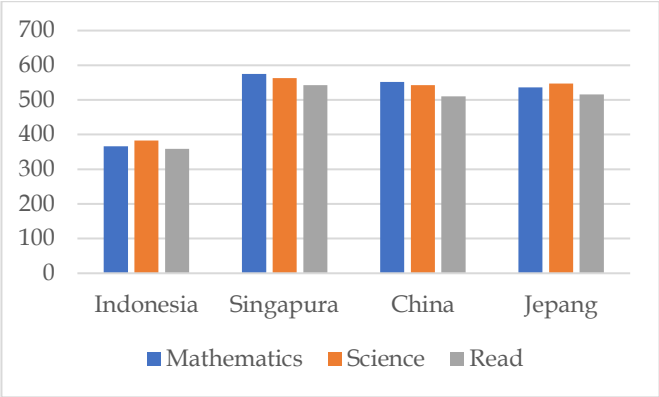

Figure 2. PISA Indeks

According to the PISA index, which highlights the development of science, literacy, and mathematics skills conducted by the OECD and TIMSS, Indonesia's score is still relatively low compared to the OECD average. In 2022, Indonesia ranked 69th out of 80 countries registered in the PISA 2022 assessment, with a total score of 1108 and a science score of 383. This indicated that the learning process carried out in the schools has not optimally achieved learning objectives. Students still struggle to understand Science, Literacy, and Mathematics. Therefore, the Problem-Based Learning model can be an alternative to address this problem because its learning steps are in accordance with a Science approach. The Problem-Based Learning model provides contextual and real-world problems to be solved through a series of scientific processes, thereby helping students improve their Higher-Order Thinking Skills (HOTs) (Alfiah & Dwikoranto, 2022). Digital learning media is suited to learner characteristics, such as: being able to activate learners during learning activities, making the learning process more interesting and enjoyable, and making it easier for learners to access new knowledge. The use of learning media assistance such as simulation games can also help clarify the concepts of the learning material being studied, make it easier for teachers to deliver learning materials, thereby increasing time efficiency, and provide opportunities for learners to actively participate, thus creating a more meaningful and enjoyable learning process.

The use of simulation games allows learners to conduct virtual experiments, observe physical phenomena, and apply learned concepts interactively (Marliani et al., 2024). Simulation games emphasize the relationship between real-life phenomena and the underlying science, supported by an interactive and constructivist approach that provides feedback and provides an effective workplace (Isbah & Adi, 2024). The use of simulation games in the learning process makes learning more engaging because it can provide learners with learning and playing experiences. These games can also make learners feel interested in participating in the learning process and make them enthusiastic about following each stage of the learning process, thereby improving student learning outcomes. The use of

simulation games often generates questions that can train students' higher-order thinking skills because they are guided to test ideas in learning activities. Furthermore, simulation games can reduce misunderstandings about learning materials because the characteristics of simulations can present abstract phenomena in a realistic way. The scientific approach in the problem-based learning model assisted by simulation games can improve problem-solving skills (Satipa et al., 2024). The problem-based learning model assisted by simulation games can develop problem-solving skills, where students must be able to analyze problems and find solutions to them.

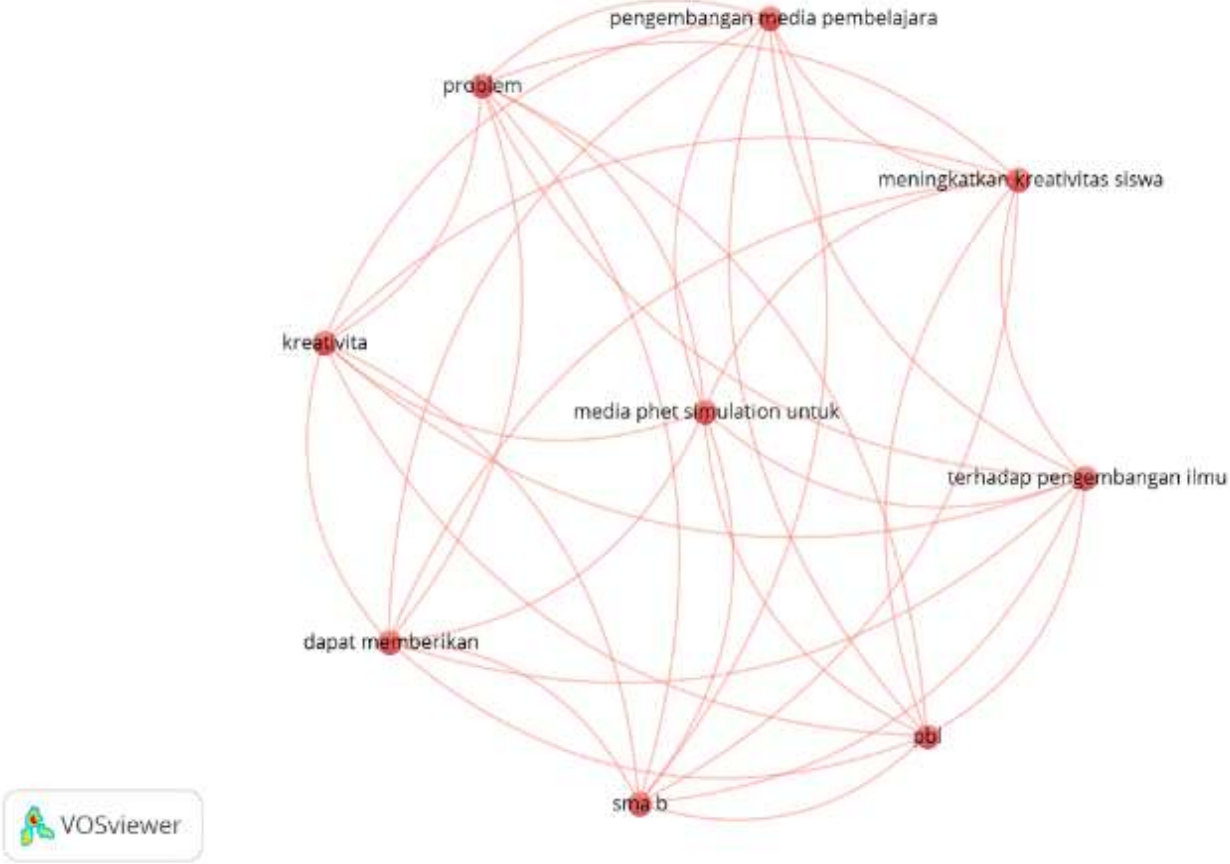

Figure 3. Vosviewer Data

Bibliometric results show that developments such as PhET simulation indicate that simulation games are closely related to problem-based learning models. The integration of these two strategies can enhance learner creativity in developing knowledge. Research trends on the integration of Problem-Based Learning assisted by digital simulations in the learning process show significant development. Many researchers have begun to examine this topic related to the fields of Science, Technology, Nursing, Health, Engineering, and Mathematics. Researchers have begun developing these digital simulations in various forms, such as PhET, virtual labs, and Simulink. Recent trends even show the development of these digital simulation into various PBL-based learning models packaged with a blended learning or STEM based learning approach. The development of digital simulations integrated with problem-based learning has proven feasible, practical, and effective in improving learner skills. Furthermore, digital simulations also encourage active learning, helping students solve problems and enriching the educational experience by providing visual aids, practical demonstrations, and engaging graphical representations (Buhera et al., 2024). Using these learning media allows learners to visualize complex ideas, facilitating easier understanding and potentially improving academic performance and learning enthusiasm. They also help teachers facilitate learning and contribute to the learning process. Learning using digital simulations also enhances higher-order thinking skills, aided by a scaffolding approach that can enhance learning activities.

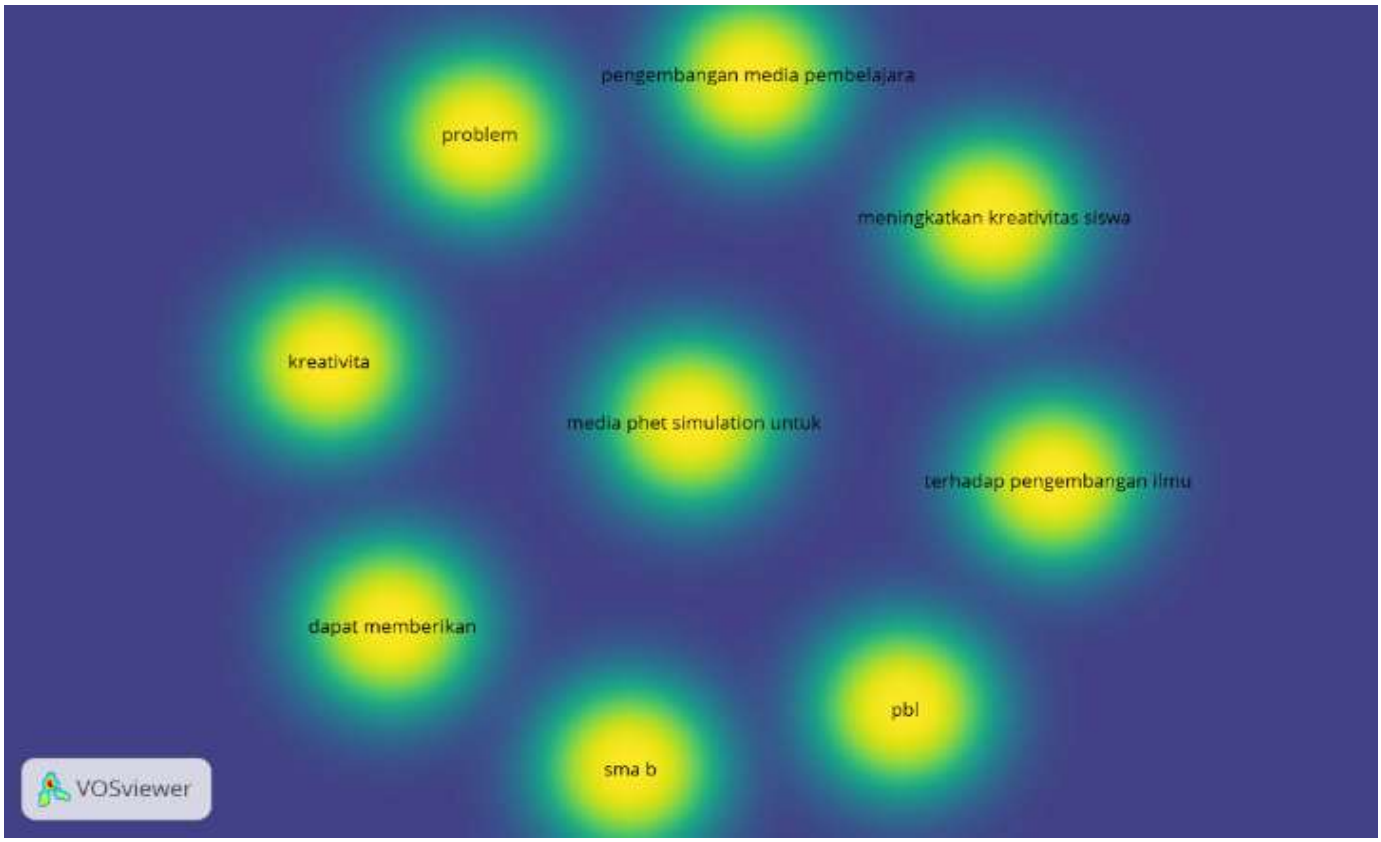

Figure 4. Vosviewer Analysis

Research related to digital simulation and Problem-Based Learning is quite extensive, but most of them are still isolated and rarely integrated. However, considering the characteristics of these two learning strategies, they can complement each other, given that they can create a more in-depth learning experience that aligns with the characteristics of 21st –century learners. Therefore, research related to the integration of these two learning strategies is needed. Improved analytical skills occur after the use of digital simulations in learning. this improvement occurs because the use of digital simulations can make the learning process more effective, more attractive, instructive, and visually more interactive, thus engaging learners and helping improve learning outcomes (Parthiban J & Dr. Leo Stanly S, 2024). The use of Problem-Based Learning models can increase learning motivation, making learners more active I exploring problems, discussing them, and seeking relevant solutions. Collaborative activities in group enable learners to solve learning problems authentically, with each group member contributing according to their understanding. With this collaboration, learners can develop critical and analytical thinking skills and can improve communication skills in solving problems more collectively (Santoso, 2025).

The use of digital simulations in the learning process equips learners with essential skills, knowledge, and experience needed for the world of work, thereby enhancing their employment opportunities (Yildirim et al., 2025). The use of digital simulations in learning, particularly in science, allows learners to observe and understand learning materials in detail and enhance their understanding of the learning materials (Li et al., 2025). In addition to mastering professional knowledge, learners can also engage in innovative development and application based on digital simulation technology that contributes to learning. the use of digital simulations can also enable learners to explore how spatial information is framed, abstracted, or manipulated to guide perception and action (Morawski & Budke, 2025). Digital simulations can create high technological competencies derived from professional learning competencies such as: the use of new resources and technologies in learning, research, and management; integration of technology in various learning situations; management of flexibility and technology-rich learning environments; and technology-supported innovation (Trujillo-Juárez et al., 2025). For this reason, if digital simulation is applied with problem-based learning model, it will create a continuity of the learning system that is aligned with the learning objectives in the curriculum being implemented. However, even though the integration of digital technology in the learning process is increasing, challenges remain when this media is applied in the learning process, such as: gaps in teachers' understanding regarding the use of digital

technology, facilities and infrastructure that do not support the application of digital technology, internet access that is still very limited, making researchers have to reconsider research related to the integration of this media.

Conclusion

Problem-Based Learning model integrated with digital technology, such as digital simulations, has a significant impact on the learning process. Integrating the two technologies enhances learners' creativity in enhancing their knowledge. The use of simulations in the learning process makes learning more engaging by providing learners with a playful learning experience. Using this learning medium allows learners to visualize complex ideas, facilitating easier understanding and potentially improving academic performance and learning enthusiasm. It also helps teachers facilitate and contribute to the learning process. The integration of Problem-Based Learning with digital simulations enriches the learning experience y providing in-depth visualizations and interactions that facilitate conceptual understanding, increase learner engagement, and encourage active participation in discussions and collaboration. Therefore, the integration of the two is worth considering for learners to achieve learning objectives aligned with the deep learning approach and the *Kurikulum Merdeka*. Several schools in Indonesia have begun implementing this model and media by utilizing PhET simulations in science learning, such as physics, chemistry, and biology.

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Author Contributions
J.N.P.R: formulates research ideas, prepare designs, collects data, and writes the main manuscript. M.F: revision of manuscript content. C.K: revision of manuscript content. M.D.K: give research assignments.

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Conflicts of Interest
This research is a manifestation of the completeness of a master's student in Instructional Technology to be able to implement the knowledge they have acquired during their lectures with the hope that after graduating, they can have a social impact on the wider community.

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