Manogari Sianturi (The Effect of Project-Based Learning on Learning Loss in the Material of Dynamics of Rigid Body Rotation)

by Library Referensi

Phi-TERA : Journal Physics in Teaching, Education Research and Application
Vol. 1, No. 1 [Juli 2024], pp. 11-20

The Effect of Project-Based Learning on Learning Loss in the Material of Dynamics of Rigid Body Rotation

Wiwit Laraswati Lase 1*
Program Studi Pendidikan Fisika, Universitas Kristen Indonesia, Indonesia
Email: 1814150010@ms.uki.ac.id

Ngia Masta 2
Program Studi Pendidikan Fisika, Universitas Kristen Indonesia, Indonesia
Email: ngia.masta@uki.ac.id

Manogari Sianturi 3
Program Studi Pendidikan Fisika, Universitas Kristen Indonesia, Indonesia
Email: manogari.sianturi@uki.ac.id

Faradiba 4
Program Studi Pendidikan Fisika, Universitas Kristen Indonesia, Indonesia
Email: faradiba@uki.ac.id

Septina Severina Lumbantobing 5
Program Studi Pendidikan Fisika, Universitas Kristen Indonesia, Indonesia
Email: septina.lumbantobing@uki.ac.id

Abstrak. Limitations in learning resources, direct interactions, meeting times, and learning experiences during online learning amid the Covid-19 pandemic caused learning loss, including in physics subjects. This is indicated by decreased learning outcomes and competency levels. The project-based learning model (PjBL) engages students actively in learning. This study aims to determine the effect of the project-based learning model on learning loss in cognitive, affective, and psychomotor domains. The research used a pretest-posttest control group design. Research instruments included written tests, attitude questionnaires, and performance observation sheets on the dynamics of rigid body rotation. The population was class XI MIPA students at SMA N 26, with samples randomly selected: XI MIPA 2 as the control class and XI MIPA 1 as the experimental class. T-test results showed that the project-based learning model affects learning loss. The gain test indicated improvement in the control class's learning outcomes: cognitive (moderate), affective (moderate), and psychomotor (high). The PjBL model is influential and can be used to address learning loss.

Keywords: Learning loss, project-based learning (PjBL), dynamics of rotation of rigid bodies, pandemics, physics

I. Introduction

The coronavirus pandemic has forced 1.7 billion students worldwide to switch to web-based learning, leading to an increase in learning loss [1][2]. Students experienced a 50% decline in learning outcomes compared to pre-pandemic learning, as noted by teachers interviewed at SDN Senurus [3]. Developing students' affective, cognitive, and psychomotor abilities is the goal of education, but these objectives were not fully achieved during online learning [4]. Technologically, online learning provided cognitive fulfillment but lacked affective and psychomotor experiences, resulting in decreased academic performance despite increased cognitive scores [5]. Online learning negatively impacted education quality, one aspect being learning loss [6].

Students experiencing learning loss face several issues: a) Fewer opportunities to learn due to internal and external factors; b) Inadequate competence as students fail to grasp the material; c) Decreased interest in feedback and opportunities to demonstrate academic abilities [7]. According to the 2020 Education and Development Forum, "learning loss" refers to students' declining knowledge and skills. Even before the pandemic, students faced challenges mastering competencies due to monotonous teaching methods [7]. Learning losses identified during online learning include difficulties concentrating (60%), lack of student interaction (80%), and loss of educator-student interaction (86%) [1]. The emotional bond weakens when the learning pattern shifts to online, limiting student activities and experiences, as students primarily learn theory without practical application [5].

Observations at SMAN 26 Jakarta indicated students might experience learning loss in affective, cognitive, and psychomotor domains due to unengaging teaching methods and limited time allocation. These conditions hinder students' understanding of physics concepts, problem-solving abilities, and active critical thinking. Learning loss manifests as reduced academic abilities, unequal learning levels, and school dropout rates [8]. Learning outcomes and material comprehension dropped by 50% due to inadequate allocation and suboptimal learning processes [3].

The Ministry of Education, Culture, Research, and Technology defines "learning loss" as decreased learning opportunities, resulting in reduced student competency mastery and interaction between teachers and students. The lack of teacher-student interaction diminishes the importance of the learning process [6]. There are three general learning domains: affective, cognitive, and psychomotor. The cognitive domain involves intellectual thinking and behavior [5]. The affective domain involves empathetic development related to sentiments or feelings [5]. the psychomotor domain involves active movement responses [5].

One strategy to address learning loss in cognitive, affective, and psychomotor domains is the application of the Project-Based Learning (PjBL) model. In PjBL, students work in small groups on projects, experiments, and new ideas, promoting engagement and creativity in problem-solving [9]. Studies show that the average mathematical creative thinking ability of students using the PjBL model is higher (83.52) compared to conventional teaching methods (52.77) [10]. Thus, the PjBL model is an appealing strategy to mitigate learning loss. This study investigates "The Effect of Project-Based Learning (PjBL) on Learning Loss in the Dynamics and Equilibrium of Rigid Bodies at SMA Negeri 26 Jakarta."

II. Method

A pretest-posttest control group design and quasi-experimental design were employed in this study. The experimental group received Project-Based Learning (PjBL) treatment, while the control group did not receive any intervention. The independent variable was the Project-Based Learning (PjBL) model, and the dependent variable was learning loss in affective, cognitive, and psychomotor domains. The study was conducted at SMA Negeri 26 Jakarta.

The study assessed learning loss in the cognitive domain using specific tests before and after intervention. The psychomotor domain was evaluated through movement, manipulation, and communication during learning, and the affective domain was measured using motivation, care, responsibility, and confidence questionnaires. The questionnaires used were closed-ended with 25 Likert-scale items. Competence skills during practical learning were linked to the psychomotor domain, with performance observation sheets comprising 10 Guttman-scale questions.

Instruments were validated by specialists who provided feedback for improvements. Normality tests, using pretest and posttest data, ensured the sample's normal distribution. The Kolmogorov-Smirnov test conducted with SPSS for Windows 26 was used for normality testing. Hypothesis testing in cognitive, affective, and psychomotor domains was conducted using t-tests if data were normally distributed. Hypotheses were accepted if the significance value was ≤ 0.05 and rejected if > 0.05.

III. Result and Discussion

A. Control Class Learning Process

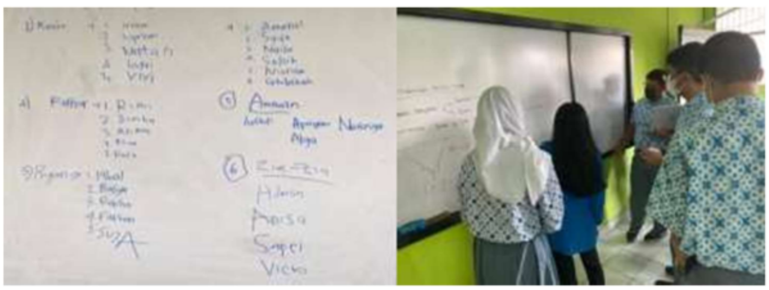
Class XI MIPA 2, with 35 students, served as the control class using lecture and Q&A methods. The teacher explained rigid body equilibrium material, and students asked questions, which were sometimes redirected to peers. The teacher summarized the lesson at the end of the class (Picture 1). Challenges included insufficient time allocation and lack of student engagement, as lectures allowed distractions.

Picture 1 Learning Process in Control Class

B. Experimental Class Learning Process

1. Problem Presentation, Planning, and Scheduling

Class XI MIPA 1, with 34 students, employed the Project-Based Learning (PjBL) model. The teacher presented real-life problems related to rigid body equilibrium (Picture 2), motivating students to identify issues and form discussion groups for project work and scheduling (Picture 3) In the Problem Presentation, Planning, and Scheduling phases of PjBL, students understand and define the problem, set goals, brainstorm and select solutions, plan their project in detail, assign roles, develop a timeline, set deadlines, create a project calendar, and allocate resources. These activities provide a solid foundation for the successful execution of their projects.



Picture 2 Problem Presented in Experiment Class

Teachers present a real-world problem or challenge that the project will address. This problem should be engaging and relevant to the students' lives or future careers. Students work to understand the problem, often discussing it in groups to explore its various aspects and implications. Students clearly define the problem, ensuring they understand the scope, constraints, and objectives. They may ask questions to clarify details and ensure they have a comprehensive understanding of the problem they are about to tackle. Students conduct preliminary research to gather background information on the problem. This helps them to understand its context and identify potential solutions or approaches. They review existing literature, case studies, or similar projects to gain insights and inspiration.

Picture 3 Planning and Scheduling

Students establish specific, measurable goals and objectives for their project. These goals guide their efforts and provide a clear direction for their work. Objectives may include what they aim to learn, create, or achieve by the end of the project. Then, Students brainstorm potential solutions or approaches to address the problem. This creative process involves generating a wide range of ideas without immediate judgment. They discuss and evaluate the feasibility, pros, and cons of different ideas. From the brainstormed ideas, students select the most promising solution or approach to pursue. This decision is often based on criteria such as feasibility, resources, time constraints, and potential impact. They may use decision-making tools or methods, such as voting or ranking, to arrive at a consensus. After that, students create a detailed plan for their project, outlining the steps they need to take to implement their chosen solution. The plan includes specific tasks, required resources, potential challenges, and strategies for overcoming those challenges. In group projects, students assign roles and responsibilities based on individual strengths, interests, and skills. They ensure that each team member knows their duties and how they contribute to the overall project.

In scheduling phase, students develop a timeline or schedule for their project, breaking down the plan into manageable phases or milestones. They allocate time for each task or activity, ensuring that they can complete the project within the given timeframe. Specific deadlines are set for each phase or milestone, providing clear targets for progress. Deadlines help students stay on track and ensure steady progress towards project completion. Students remain flexible and open to adjusting their plans and schedules as needed. They may encounter unforeseen challenges or opportunities that require changes to their original plan. Regular check-ins and progress reviews help them stay adaptable and responsive. Students identify the resources they need, such as materials, tools, information, and support from teachers or external experts. They ensure that they have access to these resources or plan how to obtain them.

2. Project Creation and Presentation

Students prepared materials for their projects and presented them to the class (Picture 4). Other groups asked questions relating to the project and the equilibrium material, fostering active engagement and creativity (Picture 5). The Project Creation and Presentation phases of PjBL involve planning, designing, developing, and documenting projects, followed by preparing, delivering, demonstrating, engaging, reflecting, and assessing presentations. These activities help students apply their knowledge, develop practical skills, and communicate their learning effectively.

Picture 4 Project Preparation

Students begin by planning their projects, defining their goals, and determining the steps needed to achieve them. They gather necessary materials and resources, which may involve research, sourcing supplies, and organizing their workspace. Then, students design their projects, often creating sketches, blueprints, or prototypes. They develop their projects by constructing, experimenting, and iterating on their designs. In group projects, students collaborate, dividing tasks based on their strengths and interests. They communicate regularly to coordinate their efforts, solve problems, and ensure that all aspects of the project are progressing smoothly. Students apply their academic knowledge and practical skills to create their projects. This can include writing, calculating, building, programming, or other discipline-specific tasks. They integrate concepts from different subjects, demonstrating interdisciplinary learning. As challenges arise, students engage in problem-solving, troubleshooting issues, and making adjustments to improve their projects. They think critically about their approach, evaluating the effectiveness of their methods and making necessary refinements.

Picture 5 Project Presentation

Students present their projects to an audience, which could include classmates, teachers, parents, or community members. They explain the purpose of their project, the process they followed, the challenges they faced, and the solutions they implemented. Depending on the nature of the project, students may provide a live demonstration, showing how their project works or explaining its key features. They use visual aids, prototypes, or digital presentations to enhance their explanations. During the presentation, students engage with their audience, inviting questions, feedback, and discussion. They respond to questions thoughtfully, demonstrating their understanding and mastery of the subject matter. After the presentation, students reflect on their performance, considering what went well and what could be improved. They may receive feedback from peers and teachers, which they can use to enhance future projects. Teachers assess students based on predefined criteria, which may include the quality of the project, the effectiveness of the presentation, the depth of understanding, and the level of creativity and innovation.

C. Analysis Prerequisite Test

Normal distribution (Table 1) was achieved if significance values were > 0.05. Data in cognitive, affective, and psychomotor domains met this criterion, allowing hypothesis testing to determine PjBL's impact on learning loss.

Table 1. Normal distribution in Cognitive Aspect

		Significance Value		
No	Label	Cognitive	Affective	Psychomotor
1	Pretest Score in Control Class	0,500	0,084	-
2	Posttest Score in Control Class	0,217	0,107	-
3	Pretest Score in Experiment Class	0,076	0,104	0,087
4	Posttest score in Experiment Class	0,103	0,734	0,283

D. Cognitive, Affective, and Psychomotor Domains Pretest and Posttest Results

Data indicated higher scores in the experimental class compared to the control class, suggesting PjBL positively influenced cognitive (Table 2), affective (Table 3) , and psychomotor domains (Table 4).

Table 2. Pretest and Posttest in Cognitive Domain

No	Label	N	Minimum	Maximum	Mean
1	Pretest Score in Control Class	35	0	70	37,43
2	Posttest Score in Control Class	35	20	90	58,86
3	Pretest Score in Experiment Class	34	0	90	52,65
4	Posttest score in Experiment Class	34	60	100	85,00

Project-based learning (PjBL) influences the cognitive aspect of the learning process in several ways. PjBL encourages students to engage in real-world problems that require critical thinking and complex problem-solving. This active involvement helps students develop their analytical abilities, enabling them to approach problems systematically and creatively. PjBL promotes deep learning. By working on projects that require in-depth research and sustained effort, students move beyond surface-level memorization to achieve a deeper understanding of the subject matter. This deep learning is facilitated through exploration, questioning, and application of knowledge in various contexts. PjBL Encourages Self-Directed Learning. PjBL often involves self-directed learning where students take initiative, make decisions, and seek resources independently. This autonomy fosters cognitive growth as students learn to manage their learning process, set goals, and evaluate their progress.

Towards to cognitive domain, PjBL fostering knowledge integration. Projects typically require the integration of knowledge from various disciplines. This interdisciplinary approach helps students make connections between different areas of study, enhancing their cognitive flexibility and ability to apply knowledge in diverse situations. PjBL improves retention. By engaging in hands-on, meaningful projects helps students retain information longer and transfer their learning to new and different contexts. The active involvement and relevance of the projects make the learned concepts more memorable and applicable. PjBL develops research skills. Students participating in PjBL engage in extensive research to gather information, analyze data, and draw conclusions. This process sharpens their research skills, critical evaluation, and information synthesis, all of which are crucial cognitive functions. PjBL enhances metacognitive skill. PjBL encourages students to reflect on their learning experiences, understand their cognitive processes, and develop strategies for improvement. This reflection enhances metacognitive skills, enabling students to become more effective learners.

Table 3. Pretest and Postest in Affective Domain

No	Label	N	Minimum	Maximum	Mean
1	Pretest Score in Control Class	35	25	57	37,80
2	Posttest Score in Control Class	35	39	53	47,03
3	Pretest Score in Experiment Class	34	31	70	51,41

4	Posttest score in Experiment Class	34	34	125	78,84

Project-based learning (PjBL) positively influences the affective domain in several key ways. PjBL enhances motivation and engagement: PjBL involves real-world, meaningful tasks that are often more engaging and motivating for students than traditional learning methods. The relevance and application of projects to students' lives and interests increase their intrinsic motivation to learn. PjBL builds Confidence and Self-Efficacy. Through the process of planning, executing, and presenting projects, students build confidence in their abilities. Successfully completing projects enhances their self-efficacy, or belief in their capacity to achieve goals and tackle challenges. PjBL encourages responsibility and independence. PjBL requires students to take ownership of their learning, fostering a sense of responsibility and independence. They learn to manage their time, set goals, and make decisions, which cultivates a sense of accountability for their work. 4) PjBL promotes collaboration and social skills: Many PjBL activities involve group work, where students collaborate with peers. This collaborative environment helps students develop essential social skills, such as communication, teamwork, and conflict resolution. It also fosters a sense of community and belonging.

PjBL develops empathy and perspective-taking by working on projects, especially those addressing social issues or community needs, encourages students to consider different perspectives and develop empathy. They learn to appreciate diverse viewpoints and understand the impact of their work on others. PjBL fosters a positive attitude towards learning. The hands-on, student-centered nature of PjBL makes learning more enjoyable and relevant, fostering a positive attitude towards education. Students are more likely to develop a love for learning when they see the value and application of their efforts. PjBL enhances emotional regulation, by managing the challenges and frustrations that come with complex projects helps students develop better emotional regulation skills. They learn to cope with setbacks, handle stress, and remain resilient in the face of difficulties. PjBL cultivates a growth mindset. PjBL encourages a growth mindset by framing challenges as opportunities for learning and growth. Students learn to view effort and persistence as pathways to improvement, fostering resilience and a positive approach to overcoming obstacles.

Table 4. Pretest and Posttest on Psychomotor Domain

No	Label	N	Minimum	Maximum	Mean
1	Pretest Score in Control Class	35	-	-	-
2	Posttest Score in Control Class	35	-	-	-
3	Pretest Score in Experiment Class	34	13	16	14,26
4	Posttest score in Experiment Class	34	11	50	41,29

PjBL involves practical activities that require students to physically manipulate materials, tools, and equipment. These hands-on experiences help students develop fine and gross motor skills through tasks such as building models, conducting experiments, and creating physical products. The implementation of the guided PjBL model encourages students to actively collaborate with their groups while working on projects. Working on projects in groups often involves collaborative tasks where students must coordinate their actions with others. This fosters teamwork and communication skills, as students need to physically collaborate, share tools, and collectively work on the project.During learning activities, students are more confident in demonstrating the projects they have created. Learning also becomes more democratic as teachers better understand the different abilities, intelligences, and backgrounds of the students. Considering the above, it can be concluded that the guided PjBL model is effective in empowering students' science process skills.

E. PjBL Model's Impact on Learning Outcomes

Using parametric tests with SPSS for Windows 26, results showed PjBL significantly affected learning loss in cognitive, affective, and psychomotor domains (Table 5).

Table 5 T-test Results

No	Domain	Significant	Label
1	Cognitive	0,00<0,05	PjBL affected cognitive domain
2	Afective	0,00<0,05	PjBL affected affective domain
3	Psychomotor	0,00<0,05	PjBL affected psychomotor domain

PjBL enhances students' cognitive skills by promoting critical thinking, problem-solving, and deep understanding of subject matter. Students engage in complex tasks that require them to apply their knowledge, analyze information, and synthesize ideas. This active learning process leads to improved retention of information and the ability to transfer knowledge to new contexts. PjBL positively impacts students' affective development by increasing their motivation, engagement, and confidence. Through hands-on projects, students become more invested in their learning, develop a sense of ownership, and gain satisfaction from completing meaningful tasks. The collaborative nature of PjBL also fosters social skills, empathy, and a positive attitude towards learning. PjBL supports the development of psychomotor skills by involving students in practical, hands-on activities that require physical manipulation and coordination. Students build models, conduct experiments, and engage in activities that enhance their fine and gross motor skills. The real-world applications of these projects help students see the relevance of their physical skills and encourage continuous improvement.

N-Gain analysis confirmed PjBL improved learning outcomes, demonstrating its effectiveness in addressing learning loss in physics at SMA Negeri 26 Jakarta (Table 6). Future research could explore project implementation with precise time management to enhance creativity through miniaturized projects.

Table 6 N Gain results

		N-Gain value		
No	**Class**	**Cognitive**	**Afective**	**Psychomotor**
1	Control	0,2 (low)	0,09 (low)	-
2	Experiment	0,5 (mid)	0,6 (mid)	0,75 (high)

The PjBL model enhances learning outcomes by fostering critical thinking, deep understanding, and interdisciplinary learning in the cognitive domain; increasing motivation, confidence, and collaboration in the affective domain; and developing practical skills, coordination, and active engagement in the psychomotor domain. Overall, PjBL creates a holistic learning environment that prepares students for real-world challenges.

IV. Conclusion

The study confirmed that the PjBL model significantly impacts learning outcomes, reducing learning loss in cognitive, affective, and psychomotor domains. The findings highlight the PjBL model's effectiveness in mitigating learning loss in physics education at SMA Negeri 26 Jakarta. Future research should focus on project timing and miniaturization to further enhance student creativity.

References

[1] W. G. Wiwin Andriani, M. Subandowo, Hari Karyono, “Learning Loss dalam Pembelajaran Daring di Masa Pandemi Corona,” *Learn. Loss dalam Pembelajaran Daring di Masa Pandemi Corona*, vol. 1, no. 2, p. 501, 2021.

[2] R. Donnelly and H. A. Patrinos, “Learning loss during Covid-19: An early systematic review,” *Prospects*, vol. 51, no. 4, pp. 601–609, 2022, doi: 10.1007/s11125-021-09582-6.

[3] M. A. Maulyda, M. Erfan, and V. R. Hidayati, “Analisis Situasi Pembelajaran Selama Pandemi Covid-19 Di Sdn Senurus: Kemungkinan Terjadinya Learning Loss,” *J. Elem. Educ.*, vol. 04, no. 03, p. 3, 2021.

[4] J. J. Cerelia *et al.*, “Learning Loss Akibat Pembelajaran Jarak Jauh Selama Pandemi Covid-19 di Indonesia,” *Semin. Nas. Stat.*, pp. 1–14, 2021, [Online]. Available: http://semnas.statistics.unpad.ac.id/wp-content/uploads/erf_uploads/2021/11/Learning-Loss-Akibat-Pembelajaran-Jarak-Jauh-Selama-Pandemi-Covid-19-di-Indonesia.pdf.

[5] D. R. Assiddiqi and Soeryanto, “Peluang Menurunnya Capaian Hasil Belajar (Learning Loss) dan aAlternatif Solusinya: Kajian Kasus Pembelajaran Online di Era Pandemi covid-19 Jurusan Teknik Mesin UNESA,” *J. Pendidik. Tek. Mesin*, vol. 10, no. 3, pp. 47–45, 2021.

[6] F. H. Setyawan, “Small Group Learning : Solusi Belajar pada Masa Pandemi,” *J. Pendidik. Mod.*, vol. 07, no. 01, pp. 20–25, 2021.

[7] S. Amsikan, S. Nahak, and F. Mone, “Analisis Kemampuan Siswa Sebagai Alternative Solusi Mengatasi Learning Loss Siswa Smpn Nunufafi,” *J. Pendidik. dan Pengabdi. Masy.*, vol. 4, no. 4, 2021,

doi: 10.29303/jppm.v4i4.3043.
[8] Y. Huang *et al*., "Curricularface: Adaptive curriculum learning loss for deep face recognition," *Proc. IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit.*, pp. 5900–5909, 2020, doi: 10.1109/CVPR42600.2020.00594.
[9] J. Karnando, I. K. Rezki, and E. Tasrif, "Efektivitas E-Modul Berbasis Project Based Learning Selama Pembelajaran Jarak Jauh," *Jav. J. Vokasi Inform.*, pp. 1–4, 2021, doi: 10.24036/javit.v1i1.17.
[10] Dhia Octariani and Isnaini Halimah Rambe, "Model Pembelajaran Berbasis Project Based Learning Untuk Meningkatkan Kemampuan Berpikir Kreatif Matematika Siswa Sma," *Genta Mulia*, vol. XI, no. 1, pp. 126–130, 2020, [Online]. Available: https://www.academia.edu/download/75983962/348.pdf.

Manogari Sianturi (The Effect of Project-Based Learning on Learning Loss in the Material of Dynamics of Rigid Body Rotation)

ORIGINALITY REPORT

10%	8%	4%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.researchgate.net Internet Source	2%
2	repository.uki.ac.id Internet Source	1%
3	www.atlantis-press.com Internet Source	1%
4	jerwoodvisualarts.org Internet Source	1%
5	ejournal.undiksha.ac.id Internet Source	<1%
6	Matthew Barr. "Approaches to Work-Based Learning in Higher Education - Improving Graduate Employability", Routledge, 2024 Publication	<1%
7	Submitted to University of Namibia Student Paper	<1%
8	www.iojes.net Internet Source	

<1%

9	Submitted to University of West Alabama Student Paper	<1%
10	www.newsanyway.com Internet Source	<1%
11	jurnal.fkip.unila.ac.id Internet Source	<1%
12	www.collegedekho.com Internet Source	<1%
13	jppipa.unram.ac.id Internet Source	<1%
14	Adetia Yeyen Purnamasari, Nuryani Rustaman, Widi Purwianingsih, Weni Lestari. "Implementation of project based learning containing esd to improve students' creative thinking skills", JPPI (Jurnal Penelitian Pendidikan Indonesia), 2024 Publication	<1%
15	garuda.kemdikbud.go.id Internet Source	<1%
16	jurnalftk.uinsby.ac.id Internet Source	<1%
17	repository.up.ac.za Internet Source	<1%

18	www.scholarlinkinstitute.org Internet Source	<1 %
19	Ozkul, Altay. "Critical Thinking, Reflection, and Perception in a Climate Change Project for English Translation Students: An Exploratory Study", Iowa State University, 2024 Publication	<1 %
20	Zaenab Amatillah Rodhiyya, Caraka Putra Bhakti. "Developing Handbook of Job-Embedded Professional Development to Improve Social Presence for Teacher in Post Covid-19 Era", G-Couns: Jurnal Bimbingan dan Konseling, 2024 Publication	<1 %
21	ijere.iaescore.com Internet Source	<1 %
22	Petr Vágner, Michal Pavelka, Oğul Esen. "Multiscale thermodynamics of charged mixtures", Continuum Mechanics and Thermodynamics, 2020 Publication	<1 %
23	journal.staihubbulwathan.id Internet Source	<1 %

Exclude quotes	On	Exclude matches	Off

Exclude bibliography On