Project Based Learning in Online Discussion Forums and Self-Regulated Learning

*Ilham Marnola¹, I Nyoman S. Degeng², Saida Ulfa³, Henry Praherdhiono⁴
¹,²,³,⁴Universitas Negeri Malang, Jl. Semarang 5 Malang, East Java, Indonesia
*ilham.marnola.1901219@students.um.ac.id

ABSTRACT: This research aims to explain how students' problem solving abilities differ using project-based learning strategies in online discussion forums and conventional learning. It focuses on how problem-solving abilities differ between low- and high-independent learning students. The interaction of learning strategies and independent learning will also discuss the impact on problem-solving skills. In this research, a quantitative approach was used, with a quasi-experimental approach, namely a nonequivalent control group design. The population of the study was 140 students. The number of samples involved was 71 people. Data collection techniques use self-regulated learning questionnaire instruments and problem solving test instruments. The data analysis technique uses two-way 2 x 2 analysis of variance (Anova). The research results show that students who use the PjBL learning strategy in online discussion forums have different problem-solving abilities than those who use conventional learning methods. Students who use the PjBL learning method in online discussion forums are better than students who use conventional learning methods. The problem solving abilities of students with low and high self-regulated learning are different. Students with high self-regulated learning have better problem solving skills than students with low self-regulated learning. There is a relationship between self-regulated learning strategies and problem solving abilities. This shows that PjBL learning strategy variables influence problem solving skills in online discussion forums and independent learning. This research can be a valuable alternative to support student learning in higher education by utilizing technology. Educators also need to strengthen students' self-regulated learning to maximize learning outcomes.

Tujuan dari penelitian ini adalah untuk menjelaskan bagaimana perbedaan kemampuan pemecahan masalah siswa menggunakan strategi pembelajaran berbasis proyek pada forum diskusi online dengan pembelajaran konvensional. Berfokus pada bagaimana perbedaan kemampuan pemecahan masalah antara siswa belajar mandiri rendah dan siswa yang belajar secara mandiri tinggi. Selain itu juga akan dibahas interaksi strategi pembelajaran dan pembelajaran mandiri berdampak pada kemampuan pemecahan masalah. Penelitian ini, pendekatan kuantitatif digunakan, dengan pendekatan quasi

¹ orcid id: http://orcid.org/0000-0003-2700-4717
² orcid id: http://orcid.org/0000-0003-4684-552X
³ orcid id: http://orcid.org/0000-0002-2302-7172
⁴ orcid id: http://orcid.org/0000-0002-5922-7491

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I. **INTRODUCTION**

Project-based learning (PjBL) is a collaborative learning model. PjBL can help optimise learners' competencies to solve problems, collaborate, and think creatively (Feder, 2017). In this PjBL model, students come together to work in groups to solve the issues and it is very effective in fostering autonomy and student-centredness. PjBL is an approach that emphasises project-centred learning. PjBL involves students actively in projects tasked with solving real problems rather than passively acquiring information (Bertacchini et al., 2022). It is known that this strategy can improve learners' ability to solve problems. These projects are designed to be cooperative and team-based, allowing students to learn in a fun and unrestricted environment. A flexible learning structure, more exciting learning activities, and direct interaction with the environment enhance the numerous skills students should possess (D. Utari & Afendi, 2022). PjBL will be one of the main variables in this study to understand how this strategy can help learners improve their problem-solving ability in a digital learning environment.

In the realm of digital learning and project-based collaborative learning, online discussion forums have emerged as a valuable tool. These forums facilitate interaction, coordination, and strategy formulation among learners, thereby enhancing the effectiveness of project-based learning (Kılınç & Altınpulluk, 2021). They have been shown to improve PjBL and its advantages in language acquisition. A comparative study found that wikis encourage more collaborative interactions, whereas forums tend to be
more cooperative (Ioannou et al., 2015). A framework for asynchronous discussion forums has been developed to facilitate formative assessment and knowledge construction (Durairaj et al., 2023). These findings underscore the value of online discussion boards in the context of PjBL and digital learning. However, they also highlight the need for further research to fully understand the potential of these tools in enhancing learning outcomes.

Online discussion forums are essential to digital education in order to facilitate interaction and exchange of ideas and enhance conceptual comprehension (Covelli, 2017). These forums can foster a sense of community in learning, particularly in distance learning programmes, and encourage collaborative knowledge construction (Mohamad & Shaharuddin, 2014). However, their effectiveness depends on the application of constructivist techniques, the roles of instructors and students, and the design of the discussion board. Technology, such as online forums, can enhance learning, teaching, student interaction, and learning outcomes.

In the digital learning era, self-regulated Learning (SRL) is a crucial skill that students must develop to take charge of their learning process (Brydges et al., 2015). This shift towards self-regulation is particularly significant given the increasing use of digital technology and the need for lifelong learning. Digital learning environments, through their tools and instructional architectures, can effectively support SRL by promoting understanding, planning, and monitoring of learning tasks. SRL is essential for online learners to set objectives, track their progress, and evaluate their education.

Academic accomplishment has been demonstrated to be significantly impacted by SRL, which comprises abilities including motivation, autonomy, and focus. SRL can influence creative problem-solving, with self-efficacy, interest and strategic planning playing key roles (Callan et al., 2021). Mental effort is critical to fostering SRL, particularly in problem-solving tasks (van Gog et al., 2020). Therefore, SRL can be applied when learning time is also spent honing problem-solving techniques.

Students must be able to solve problems as one of the 21st-century learning abilities, especially while handling disruptive changes such as rapid technological advancements, climate change, and socio-political shifts. Students must possess the ability to think creatively and unconventionally and solve challenging challenges. For students to overcome obstacles in various circumstances, problem-solving skills are necessary (Choudhar et al., 2022). Developing these skills from an early age is essential to prepare individuals for the future (Lambert, 2019). Studies constantly emphasise the value of creative problem-solving and creative thinking in a range of different contexts. Martz et al., (2017) state that these competencies are essential for personal development and workplace success. Further highlighting the value of creative approaches in the teaching and learning process, Larraz-Rábanos, (2021) suggested that these approaches can enhance problem-solving abilities. Finally, Yadav & Cooper, (2017) explored the potential of computing to foster creativity, which can be applied to address complex social problems.

An essential emphasis of this study will be SRL’s function in the context of digital learning. How learners organise themselves, engage in the learning process, and develop critical skills will be crucial. It has been demonstrated that incorporating PjBL and SRL into mixed-learning settings enhances students' learning methodologies and collaboration abilities (Paraskeva et al., 2017). Tsai, (2014) also found that combining PjBL and SRL can significantly improve students' engagement and thinking about the

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subject. This is further supported by the potential of online collaborative environments to support SRL, particularly in social competence, emotional and motivational aspects, and cognitive and metacognitive skills. Using online discussion forums and chat rooms as project communication tools has enhanced collaboration and increased accountability in group projects.

Furthermore, interactive and self-managed problem-solving experiences, especially in collaborative situations, can foster the development of creative thinking and problem-solving skills (Drigas & Karyotaki, 2016). Other research has explored the potential of integrating SRL and PjBL in educational settings. From these data findings there is an opportunity to integrate SRL with PjBL and online discussion forums to enhance learning by improving problem solving skills.

II. METHOD

This quantitative study aims to ascertain the connection between problem solving and PjBL using SRL and a quasi-experiment design approach. This design was chosen as it allows for comparing the treatment and control groups, providing a more robust understanding of the impact of PjBL and SRL on problem-solving abilities. The pretest-posttest nonequivalent control group design is the sort of experiment employed (Inderanata & Sukardi, 2023).

The population of this study was 140 students of Madrasah Ibtidaiyah Teacher Education Study Programme of UIN Maulana Malik Ibrahim Malang Semester 6 academic year 2021/2022. 71 samples were split into two classes: a treatment- or experimental-receiving class and a control-group class. Purposive sampling was employed. This method is used when sample members are chosen according to their study goals (Creswell, 2019).

This research procedure uses a one-group design with Prates-Pascates. According to Setyosari, (2020) before the subject is subjected to treatment, we as researchers carry out observations in the form of pre-test. Treatment is carried out, and after that observation or post-test is held. A questionnaire instrument was employed in this study's data collection to ascertain the association between PjBL and SRL. An instrument with closed questions in the form of up to 25 5-point Likert scales is the type that is utilised. In the meantime, a problem-solving test instrument was employed to determine the association between PjBL and students' problem-solving skills. The test consisted of 12 essay questions with a rubric as an assessment guide.

Following data collection, the IBM SPSS software, a widely used tool for statistical analysis, will be used to process the data. The present investigation will subject the data to many testing phases, including the conventional precursor tests (normality and homogeneity tests) and the hypothesis test employing Analysis of Variance (Anova) with two routes of two by two (Budiyono, 2015). If the normality and homogeneity test requirements are met, then the data can be tested for variance to test for differences in two related data samples. The research hypotheses are There is a difference in the problem solving ability of students who learn with the PjBL learning strategy on the Online Discussion Forum with conventional learning, There is a difference in problem solving ability in students who have low SRL with high SRL and There is an interaction between learning strategies and SRL on problem solving ability. The hypothesis is accepted if the two-way Anova test results have a significance value of less than a (sig
<0.05). Meanwhile, the hypothesis is rejected if the calculated significance value is more than a (sig > 0.05).

III. RESULT AND DISCUSSION

Analysis Prerequisite Test

Before testing the hypothesis, two necessary tests were conducted: the Levene test for homogeneity between groups and the Liliefors test for normality.

Normality Test

The Kolmogorof-Smirnov (KS) test, a normalcy test, was used for this investigation. Table 1 below shows the results of the normalcy test. This test determines whether or not the study’s samples are drawn from a regularly distributed population.

<table>
<thead>
<tr>
<th>Table 1. Tests of normality</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Shapiro-Wilk</td>
</tr>
<tr>
<td>Statistic</td>
</tr>
<tr>
<td>problem solving</td>
</tr>
<tr>
<td>a. Lilliefors Significance Correction</td>
</tr>
</tbody>
</table>

In this research, we conducted a series of statistical tests to analyze the data. The first step was to check the normality of the data, which is evident from data table 1. above that the significance value is 0.076>0.05, indicating that the data is usually distributed. The next step was to perform a homogeneity test, which is discussed in the following section.

Homogeneity Test

This investigation used the Levene Test to perform the variance homogeneity test. The homogeneity test aims to ascertain whether the variances in each class are homogeneous in the experimental and control groups. Table 2 is shown below. The Test Table of Levene.

<table>
<thead>
<tr>
<th>Table 2. Tabel Levene’s test</th>
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<tbody>
<tr>
<td></td>
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<td></td>
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<tr>
<td>Levene Statistic</td>
</tr>
<tr>
<td>Problem solving</td>
</tr>
<tr>
<td>Based on Mean</td>
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<tr>
<td>Based on Median</td>
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<tr>
<td>Based on Median and with adjusted df</td>
</tr>
<tr>
<td>Based on trimmed mean</td>
</tr>
</tbody>
</table>

From table 2. above shows the value (Significance) Sig. 0.592 where > 0.05 so the variants are homogeneous.

Hypothesis Test

Two-way Analysis of Variance (Two Way Anova) will be used to evaluate the hypothesis. With the right level of measurement, the variables in this analysis are used to examine the impact of one independent variable on another. SRL, a control variable with two categories high and low is analysed using two-way analysis of variance to examine the relationship between two independent variables, namely PjBL strategy and conventional strategy. Differences in problem solving skills between the PjBL strategy and the traditional technique should be found using the two-way analysis of variance.

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The hypothesis can be accepted or rejected by utilising the SPSS for Windows computers to evaluate the significant value in the test of the between-subject effect table based on the variance analysis.

### Table 3. Tests of between-subjects effects

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected model</td>
<td>1157.324</td>
<td>3</td>
<td>385.775</td>
<td>12.333</td>
<td>.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>74516.327</td>
<td>1</td>
<td>74516.327</td>
<td>2382.155</td>
<td>.000</td>
</tr>
<tr>
<td>Strategy</td>
<td>443.144</td>
<td>1</td>
<td>443.144</td>
<td>14.167</td>
<td>.000</td>
</tr>
<tr>
<td>SRL</td>
<td>487.107</td>
<td>1</td>
<td>487.107</td>
<td>15.572</td>
<td>.000</td>
</tr>
<tr>
<td>Strategy *SRL</td>
<td>156.491</td>
<td>1</td>
<td>156.491</td>
<td>5.003</td>
<td>.029</td>
</tr>
<tr>
<td>Error</td>
<td>2095.830</td>
<td>67</td>
<td>31.281</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>78670.000</td>
<td>71</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected total</td>
<td>3253.155</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .356 (Adjusted R Squared = .327)

Table 3 above shows the Two Way Anova test calculation output of PjBL data with student SRL and problem solving ability. The calculated F value on the effect of strategy on problem-solving is 14.167 with a probability value of 0.000, indicating that the significance value is less than 0.05, indicating that the hypothesis is accepted. Additionally, a likelihood value of 0.000 and an F value of 15.572 were obtained for the impact of SRL on problem-solving. It is also claimed that there is a difference in problem solving capacity between children with low and high levels of self-regulated learning, indicating that the significance value is less than 0.05, indicating that the hypothesis is accepted. The calculated F value of 5.003 with a probability value of 0.000 suggests that the significance value is smaller than 0.05, indicating that the hypothesis is accepted and that there is an interaction between learning strategies and SRL on problem solving ability. This results from testing the effect of strategy and SRL on problem solving.

The following plot diagram is valuable for determining if variables impact interaction. However, it's important to note that this diagram is not intended as a source of reference but rather as a visual aid to provide an overview. The chart shows a misalignment of lines, indicating a potential interaction effect when more lines are drawn and they cross. This understanding can help interpret the results of the Anova test.
The Effect of Project Based Learning on Problem Solving Skills

The first hypothesis was tested, and the findings showed a sig value of 0.000 <0.05, indicating that the hypothesis is accepted. Thus, students who learn using the Project Based Learning (PjBL) approach, which involves [specific details of the PjBL approach], on the online discussion forum have different problem-solving abilities than those who learn conventionally. Students who use the PjBL learning approach on the online discussion forum outperform those who use traditional learning tactics.

The findings of studies examining how collaborative learning affects problem-solving by Balta & Awedh (2017) are resoundingly clear: collaborative learning significantly improves problem-solving skills compared to individual learning. Collaborative learning emerges as the superior method when students are tasked with problem-solving. While traditional classroom instruction imparts information, cooperative group learning is more effective for developing problem-solving abilities (Mandušić & Blašković, 2015). In problem-solving, students who engage in collaborative learning consistently outperform those using traditional learning methods. The use of PjBL steps in the experimental class is directly linked to enhancing students' problem-solving abilities, a finding that aligns with previous research conducted by Hindriyanto et al., (2019) which underscores the constructive learning syntax of PjBL that fosters independent learning.

Numerous research studies have examined the impact of online learning on problem-solving skills. Research has indicated that students' problem-solving skills can be markedley enhanced by online learning (Santosa et al., 2020). Problem-solving learning outcomes will be better with collaborative learning supported by mobile computers than with individual learning.

The following research results relevant to this are the research of Utari, (2019) explaining that situational learning strategies affect problem solving skills. Applying a sophisticated new solution to a problem by working cooperatively is known as problem-solving. Judging from the implementation, online-based project collaborative learning is included in situative learning because projects carried out collaboratively through online devices are an excellent way to carry out activities that take place in cyberspace without time limits. Students can maximally utilise their time and resources.
The ability to solve problems will be further developed if the teacher uses the PjBL model. The opinion of English & Kitsantas, (2013), which claims that PjBL is an activity that requires a lot of inquiry, supports this claim. Through the investigation process, many questions will be created from within students, then they try to find solutions to these problems.

By adopting PjBL, you can increase students' desire to learn and equip them with the skills they need to thrive in the 21st century. Research by Dole et al., (2017) shows that students educated with project-based learning models have better problem-solving skills than those educated with conventional methods. This underscores the value of PjBL in fostering 21st-century skills, attitudes, and behaviours, inspiring you to continue implementing this innovative approach in your teaching.

Research shows that PjBL, when implemented with collaborative strategies and problem-solving processes, can improve academic achievement, motivation, and the development of critical thinking and problem-solving skills. Using online discussion forums in a PjBL setting can facilitate deeper cognitive processing of information, leading to better understanding and problem-solving ability. In addition, research has explored the quality of collaboration in PjBL based on group awareness, which can be applied to online discussion forums to enhance collaborative problem-solving experiences (Chiang & Lee, 2016). A case study utilising cooperative online instructional discussion activities to solve problems scientifically investigated the learning process (Asfihana et al., 2022). This suggests that PjBL when implemented with online discussion forums, can be a practical approach to encourage problem-solving skills and promote deeper learning.

The effects of PjBL on online discussion forums for problem solving have been examined in several research. Ioannou found that PjBL when coupled with cognitive aids, can enhance higher mental processes in online discussions. Ioannou et al., (2015) compared the use of wikis and forums for collaborative problem-based activities, with wikis being more cooperative and forums more cooperative cooperative. These studies collectively show that PjBL can improve problem solving in online discussion forums, especially when combined with cognitive aids. Another research study on online project-based learning was revealed by Mardiana & Amalia, (2022). Students who participate in online project-based learning with group discussions are fond of it, and acceptance rates are very high. The implementation of PjBL has the potential to enhance student achievement.

Online discussion forums are a platform that encourages students to ask questions, exchange ideas, and think critically. They provide a space for students to transcend the boundaries of conventional thinking and gain diverse perspectives. These forums enhance learning and higher-order thinking and improve information processing (Chen et al., 2022). The 'teacher presence' in these forums significantly influences the outcome of online interactions (Batardière, 2015). Moreover, integrating technology into online learning is a powerful tool that can facilitate the development of such skills (Nussbaum et al., 2021). In asynchronous online discussions, heuristics, project-based prompts, and problem-based prompts can all encourage innovation (Corfman & Beck, 2019).

Interactivity can be implemented in online discussion forums. Teaching strategies, such as those involving student-teacher contact, impact students' motivation to participate. In face-to-face class discussion forums, the interaction could be maximised. Time constraints can be a barrier to achieving learning objectives (Fehrman & Watson, 2021).

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It is crucial that students are highly motivated to participate in online discussions right away for those conversations to be fruitful (Patel, 2021). Moreover, the optimisation of this discussion forum is needed to implement collaborative project-based learning that requires interactivity.

Based on the description of some of the research findings above, online PjBL is efficacious in improving student problem-solving. This effectiveness can be seen from the learning process that is carried out online, where students can learn anywhere and anytime without being limited to the time and place of learning. An additional advantage is that students or group members who have taken on specific duties for the work can immediately address any challenges they face online with instructors and other students in their study group.

**The Effect of Self Regulated Learning on Problem Solving Ability**

After testing, the second hypothesis was found to have a sig value of 0.000 <0.05, indicating that it is accepted. Thus, it is claimed that pupils with low self-regulated learning and those with high self-regulated learning differ in their capacity to solve problems. Pupils with high levels of SRL are more advanced than those with low levels.

Several research have been undertaken to support the findings of this analysis. Some studies show that SRL can improve problem-solving (Wulandari & Alyani, 2022). When compared to conventional teaching approaches, the study revealed that SRL significantly increased students' academic achievement. Furthermore, studies have demonstrated that the growth of competency-based teaching methods and the advancement of students' metacognition, motivation, and strategic behaviours are linked to SRL (Brenner, 2022). Self-regulated learning can support academic accomplishment, in this case the ability to solve problems utilising critical thinking skills. To enhance their critical thinking skills, students must be cognizant of these attributes to customise their study strategies and self-control methods (Atmojo et al., 2023). Additionally, research has been done on the connection between problem-solving skills and SRL. The results indicate the mediation function that self-directed learning may play in this relationship (Hwang & Oh, 2021). The research generally points to the beneficial effects of SRL on problem-solving skills.

The impact of SRL on problem-solving ability is a complex and multifaceted issue. However, mainly when supported by metacognitive questioning, can improve problem-solving performance and reduce anxiety in math problem-solving tasks. Further supports this by suggesting that encouragement for self-regulated learning can effectively develop cognitive structures during problem solving. These findings collectively indicate that although self-regulated learning may not be the sole determinant of problem solving ability, it can play an important role, mainly if supported by metacognitive questions and prompts.

Supriatna et al., (2019) found that SRL and higher learning approaches positively impacted students' capacity to solve mathematical problems. Shin & Song, (2022) found positive effects of support and SRL strategies on problem-solving performance. These results imply that various factors, including the nature of the problem and the particular learning approach or strategy employed, may impact the relationship between self-regulated learning and problem solving.

According to Pedrotti & Nistor, (2019), in SRL, students try to steer their education by establishing objectives, making plans for achieving them, assessing the learning
process, using problem-solving techniques, and tracking their advancement. The development of abilities and reasoning through self-directed learning leads to the emergence of the ability to plan activities and learning processes. This ability to organise can influence students' problem-solving ability.

Hačatrjana & Linde, (2023) said there is a connection between pupils' problem-solving capacity and their SRL level. Setting goals, planning strategically, managing your time, seeking help when needed, and conducting self-evaluations are just a few of the procedures involved in learning at various levels (Zimmerman et al., 2017), which are crucial elements of the capacity to solve problems. Students must possess the ability to utilise these techniques and self-regulate their learning to take on problem-solving activities (van Gog et al., 2020).

Two of the six transversal abilities that the Competence Approach to Curriculum project, launched in Latvia in 2016, are problem-solving and SRL. Less time will be spent thinking as students become accustomed to planning their learning during problem solving and regularly use self-monitoring, self-reflection, and metacognition. This is because metacognitive processes will grow and eventually become an automatic part of problem-solving (Contente & Galvão, 2022).

Furthermore, Winarti, (2022) stated that SRL is crucial in solving problems in learning activities. So problem-solving-based learning that involves self-regulated learning has an impact on students' metacognition skills. Students' metacognitive skills are found in each indicator of self-regulated learning. Clarke & Roche, (2018) revealed that a person will think about solving problems when involved with mathematical problems. The motivation to solve the problem will drive the idea of devising, planning, and completing strategies. The ability to cultivate it is known as self-regulation. According to Seufert, (2018), this is a component of metacognitive knowledge. On the other hand, issue-solving is the process of applying reason or self-motivation to solve problems and arrive at the correct answer. Metacognitive regulation is the mental processes that control problem-solving techniques (Vula et al., 2017).

**Interaction of Learning Strategies and Self Regulated Learning on Problem Solving Ability**

Following testing, the third hypothesis was accepted with a sig value of 0.000 <0.05, suggesting that SRL and learning strategies interact to influence problem-solving skills. This illustrates how SRL and PjBL learning technique variables on online discussion forums interact to affect problem solving abilities.

Research was looked up, and information regarding the relationship between SRL and PjBL and problem solving skills was discovered. One study by Asri et al., (2017) found that SRL and PjBL techniques interact with learning outcomes for mathematics. In a different research, Stefanou et al., (2013) investigated how healthy students are self-regulated when participating in online project- and problem-based learning environments. According to this study, learning outcomes were higher for students who employed SRL techniques. Zarouk et al., (2020) created a reversed PjBL environment for their third study to improve students' capacity for self-regulated learning.

SRL and PjBL can be combined in the classroom using various instructional techniques. Research suggests the following approaches: *firstly*, promoting Student Responsibility. In PjBL, students should take responsibility for the learning process by defining learning outcomes, monitoring, reflecting, and maintaining their enthusiasm during the task;
second, Providing Guidelines for Developing SRL in PjBL. Educators can design specific learning environment features and teaching practices to support SRL in PjBL, ultimately increasing students' motivation and ability to learn (English & Kitsantas, 2013); third, Enhancing Self-Regulation and Creativity through PjBL. PjBL can enhance students' self-regulation and creativity, leading to the development of independent learners who can define learning outcomes, design, perform, manage and assess their learning activities (Mashfufah et al., 2024); and fourth, Offer Indicators of Progress, Thoughts and Feelings: Providing learners with indicators of their progress, thoughts, and feelings during PjBL activities can help them become self-regulated by allowing them to reflect on their learning process. By combining these approaches, educators can effectively integrate PjBL and SRL in the classroom, thus promoting student engagement, motivation and problem-solving skills.

According to research, numerous advantages can be realised when PjBL and SRL are combined in the classroom. These include the following: PjBL has been demonstrated to enhance students' self-regulation and creativity in the first place. Secondly, it has been shown to dramatically improve students' learning outcomes, such as academic accomplishment and motivation; third, it Increased Student Responsibility: Integrating SRL in PjBL promotes student responsibility for the learning process. Students must set learning outcomes, control their progress, reflect on their learning, and maintain enthusiasm throughout the assignment, leading to greater ownership and autonomy in their knowledge. Fourth, Cultivation of Higher Level Skills: PPA, when combined with SRL, develops higher-order abilities like problem-solving, creativity, and integrated application skills (Zhang & Ma, 2023). Thus, including SRL and PjBL in the classroom improves students' academic performance and motivation while also promoting the development of essential skills like problem-solving.

Other search results include studies examining how PjBL and SRL affect students' problem-solving abilities. The relationship between PjBL and SRL in online discussion forums and problem solving has been the subject of numerous study publications. One study found that PjBL with the LMS Moodle can improve students' ability to learn independently and solve mathematical problems (Kusuma et al., 2021).

SRL had an impact on learning outcomes, according to a different study that looked at how online PjBL settings with varying degrees of self-regulation affected collaborative behaviour (Lin & Tsai, 2016). Hujjatusnaini et al., (2022) discovered that integrating PjBL and 21st-century skills can enhance aspiring biology educators' higher-order thinking abilities. These studies demonstrate, in general, that SRL and PjBL can improve problem-solving skills.

There are several effective ways to promote problem-solving in online PjBL, one is to teach students time management skills essential for developing and presenting a successful project. Another strategy is to expose students to real-world problems and challenges, which can help them develop critical thinking skills and creativity. Instructors can also model problem-solving strategies and encourage students to articulate unclear principles and concepts. Furthermore, teachers can foster the development of students' metacognitive abilities by using case studies to pose challenging questions and provide thought-provoking answers. Lastly, to encourage problem-solving skills and SRL, PjBL can be combined with SRL practices including goal-setting and self-monitoring (Karan & Brown, 2022). Teaching time management skills, exposing students to real-world situations, modelling problem-solving.

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techniques, employing case studies, and including SRL are excellent ways to encourage problem-solving in PjBL. A publication discusses particular elements of the learning environment and instructional strategies that promote student ownership of the learning process in problem- and PjBL.

Online discussion boards can help students communicate and work together on projects while supporting their problem-solving abilities in PjBL. Students can ask questions, exchange ideas, and get comments from professors and other students in discussion forums. Different learning styles can be accommodated in project-based learning by using discussion forums as a collaborative space for project development and content creation. Furthermore, discussion boards help students develop their critical thinking abilities, communicate more effectively, build a feeling of community, and solve problems together. To effectively include online discussion forums in PjBL, educators should consider the forum's intended use, offer clear instructions and advice, and ensure the forum is utilised sparingly to accomplish the desired results (Floriasti, 2023).

Online discussion forums allow people to use an asynchronous textual communication medium to share their personal experiences and interact supportively with others going through similar struggles (Ghio et al., 2022). In the context of online learning, online discussion forums serve as learning spaces where students can primarily expand their knowledge inside their own physical and mental workspaces. They can also connect with other learners in the community and share their information there.

After Covid-19, online discussion boards whose origins are in social constructivist learning theory are more important as a teaching tool for blended and online learning, which is gradually reintegrating into regular classroom environments (Lockee, 2021). A well-designed online discussion forum can provide several learning benefits, including enhanced behavioural engagement, sharpened critical thinking, enhanced social presence, and improved academic performance (Yang et al., 2022). Also, online discussion forums have two distinct benefits over in-person discussions: (1) they are more convenient because there are no time or space restrictions, and (2) discussion topics allow for repetition (Koszalka et al., 2021). Discussion boards on the internet can be set up as cooperative learning spaces where students can build, validate, or alter their knowledge through interactions with one another (Hammond, 2017).

Online discussion forums can assess student learning in project-based learning by tracking students' participation levels and reviewing their contributions. When using PjBL, peer-reviewed online forums can also be utilised to assess students' learning. Teachers can also utilise the forum to pose questions that call on students to apply their understanding of concepts to actual situations. Finally, educators can use the forum to evaluate students' learning by reviewing their contributions, assessing their knowledge of the subject matter, and providing feedback.

IV. CONCLUSION

The results of data testing show that the use of the PjBL learning strategy on the Online Discussion Forum is significantly superior to conventional learning in students' problem solving ability, students who have high SRL significantly have a higher average value of problem solving ability and together the variables of PjBL learning strategy on the Online Discussion Forum and SRL affect problem solving ability. However, PjBL on the Online Discussion Forum has several challenges such as the need for greater student
involvement in Online Discussion Forum learning due to limited devices, networks and so on and requires a long learning time compared to synchronous direct online learning or face-to-face learning. For the best learning outcomes, SRL and integrating technology into projects like project learning on discussion forums are crucial, especially in light of the demands of modern education in the twenty-first century. Online discussion forums are an essential component of digital education, providing a platform for learners to interact, share ideas and deepen their understanding of various concepts. These forums can foster a sense of community in learning, particularly in distance learning programmes, and encourage collaborative knowledge construction. Further studies on the impact of implementing the PjBL model on additional 21st-century abilities and the application of AI technology development in online discussion forum-assisted learning are suggested.

V. REFERENCES


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