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Project-Based Learning Model to Promote Preservice Science Teachers' Metacognitive Skills

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Abstract

The purpose of this study was to build a project-based learning (PjBL) model using Susan A. Ambrose et al. cycle's metacognition conceptual framework. The PjBL approach was created to improve the preservice science teacher's metacognitive skills. Methods: To modify the PjBL strategy, this study began with a basic review of PjBL and metacognitive skills backgrounds. Results: A panel of experts used the item-objective congruence index (IOC) at five distinct levels to evaluate the validity of the PjBL model. The PjBL model's appropriateness rating was calculated as 4.56, which showed that it was very suited.

Keywords: Project-based learning, Metacognitive skills, Preservice science teachers

1. Introduction

The term "metacognitive skills" refers to knowledge used in behavior management and self-regulation. The metacognitive skills component, according to Veenman (2011), consists of orientation, goal-setting, planning, monitoring, evaluation, and recapitulation. According to Vrugh and Oort (2008), metacognitive skills are 1) planning skills, which include selecting the best approach and managing the necessary resources for the learning process; 2) evaluating skills, which include understanding and performance in the learning process; and 3) evaluating skills, which include abilities to evaluate the results and performance of learning. According to Papleontiou-Louca (2003), being metacognitive generally refers to considering concepts that touch on a student's understanding of not only cognitive processes but also emotions and motivations.

Learners who have developed metacognitive skills can monitor and assess their learning activities in addition to helping them gradually adopt this technique (Cera et al., 2013). Students with metacognitive skills will be able to identify their academic strengths and shortcomings using foundational information, enabling them to enhance their capabilities for the particular job demand (Lestari et al., 2019; Permana & Chamisijatin, 2019). By depending on knowledge, abilities, and managing their engagement in the task, learners optimize their learning processes and learning results. As a result, when faced with difficulties at work, they will reassess their approach and attempt to find solutions that will further the task's objectives. Additionally, metacognitive skills result in advanced thinking abilities connected to the regulation of specific cognitive processes during the learning process (Bahri & Corebima, 2015). If students develop metacognitive skills, they become engaged in the learning process and have the potential to become outstanding people. Since we must complete more difficult tasks and assume greater responsibility for our learning, metacognitive skills are crucial in higher education and the workplace (Ambrose et al., 2010).

The development of metacognitive skills based on planning, self-monitoring, evaluation, and reflection must be supported by preservice teacher courses in universities (Saputri et al., 2020), as these skills allow preservice teachers the flexibility to plan their learning and directly influence learning behaviors, which in turn affects their students' learning outcomes (Veenman, 2008). Preservice teachers who have a strong understanding of how to learn will undoubtedly have confidence in the teaching and learning processes, which will enable them

to become lifelong learners who constantly build or enhance their learning quality. On the other hand, inexperienced preservice teachers will face significant learning obstacles because of misconceptions or gaps in their knowledge. Cognitive processes that lead to misconceptions or misunderstandings have a long-lasting effect on future teacher functions, even though they have not yet been observed in the short term (Saputri et al., 2020). As a result, having mastery of metacognitive skills and effectively expressing those abilities to students motivates them to do the same (Yasir et al., 2020) learning about metacognition in scientific students in particular (Sanium & Buaraphan, 2022). In light of this, aspiring preservice science teachers (PSTs) must practice metacognition.

In contrast, it was discovered that most studies on the metacognition of science teachers concentrated on self-regulatory strategies, metacognitive awareness levels, and metacognitive knowledge (Yerdelen-Damar et al., 2015), as well as self-regulated learning (Azizah & Nasrudin, 2021), metacognitive skills, and metacognition (Lukitasari et al., 2021; Sanium & Buaraphan, 2022). Even though these topics are presented during the learning process, they vary in terms of particular components and meanings. Additionally, a focused research search on the use of teaching models to enhance the metacognitive skills of PSTs revealed that teaching models like RQA, which consists of reading, questioning, and answering, have been used (Saputri et al., 2020; Bahri & Corebima, 2015). The QASEE learning model, a recently developed teaching strategy that consists of questioning, answering, sharing, evaluating, and extending, is another illustration of a teaching model. The student-centered QASEE and RQA learning models both emerged under the constructivist approach (Saputri et al., 2020; Saputri & Corebima, 2020).

There are numerous studies on pedagogical models to enhance metacognitive skills, including PBL, E-portfolio with lesson study, RQA + TPS, PBL + NHT, TPS + RT, NHTI, RMS, SELM, inquiry-based learning, and SSCS + MS learning models. However, it is important to note that the majority of teaching models are utilized with secondary school students. However, secondary school education is very dissimilar from university education, particularly at the Faculty of Education. Preservice teachers will either finish class assignments or do in-depth, semester-long independent study. The goals of projects are to aid preservice teachers in comprehending and learning about the project process, as well as to manage the time necessary to finish the project on time. For this reason, students must be planners and specify the project's parameters, including its timeline, as well as keep tabs on how to improve their performance to meet the objectives (Ambrose et al., 2010). To change their responsibilities and empower students to study, instructors face special difficulties. In order to finish activities and accomplish their objectives throughout the semester, students must exercise self-control. As a result, project-based learning (PjBL) is a learning strategy that can be used to encourage PSTs to develop their metacognitive skills.

PjBL encourages the development of metacognitive skills (Rumahlatu & Sangur, 2017, 2019; Ilter, 2014; Musa et al., 2011; Pavkov-Hrvojevic et al., 2016). A technique that emphasizes inquiry knowledge is project-based teaching (Prachagool, 2021). In order to establish new knowledge based on prior knowledge through hands-on action experience, which can be a personal or group activity leading to product, presentation, or performance (Rumahlatu &

Sangur, 2019; Ilter, 2014; Guo et al., 2020), learners must be enthusiastic, engaged, and work collaboratively (Moursund, 2007; Meyer & Wurdinger, 2016). The five requirements of the project suggested by Thomas (2000) include an assessment that focuses on constructivist questions, independence, realism, and stressing difficulties that might expose students to the process of challenging the ideas and principles of learning materials. According to Krajcik & Shin (2014), the characteristics of project-based teaching include a central question, an emphasis on learning objectives, engagement in instructional activities, student cooperation, the use of scaffolding technology, and the production of tangible products. Instructors need to inspire students to study and provide mentorship, direction, and learning facilitators for students to learn and finish tasks on time (Rumahlatu & Sangur, 2017; Musa et al., 2011). While guiding problem-solving techniques and avoiding knowledge transfer teaching, instructors must avoid providing learners with direct answers (Wrigley, 2010; Donnell & Fitzmaurice, 2005).

Inconsistencies were discovered based on the literature review:

(1) PjBL is more commonly used in secondary education than in higher education to help students develop their metacognitive skills (Guo et al., 2020).

(2) The absence of a PjBL model to improve the metacognitive skills of PSTs.

(3) Rather than emphasizing the humanities and social sciences as subjects to be taught, PjBL reports are mostly used in STEM education and engineering instruction.

(4) The metacognitive skills motivate students to be lifelong learners, making them better teachers who comprehend the learning process and have a lasting impact on the teacher's career.

Therefore, the purpose of this study was to create a PjBL model using Susan A. Ambrose's metacognitive conceptual framework. It consists of five skills: assessing the task at hand, evaluating one's strengths and weaknesses, planning an appropriate approach, applying strategies and monitoring performance, and reflecting on and adjusting one's approach together. All skills had equipped with strategies for encouraging students to achieve their metacognitive skills.

2. Method

2.1 Research Instruments

This study is qualitative. There were two qualitative research instruments: an item-objective congruence index (IOC) and a PjBL model suitability assessment form, as shown below.

2.1.1 The IOC is a method by which content experts rate individuals according to the degree to which they measure specific objectives listed by the test developer. A content expert will assess each item by assigning it a score for each objective, ranging from 1 (obviously measuring), -1 (clearly not measuring), or 0 (the degree to which it measures the content area is unknown).

2.1.2 PjBL model suitability assessment form comprise 5-point Likert scales (Harpe, 2015).

Where a scale of 5 represented as strongly suitable, 4 represented suitably, 3 represented neutral, 2 represented as not suitable, and 1 represented as strongly not suitable.

2.2 Research Process

2.2.1 Review, analyze, and synthesize the theoretical framework of metacognitive skills.

2.2.2 Apply the theoretical framework of metacognitive skills and strategies to encourage students to achieve the metacognitive skills to generate PjBL steps, and activities according to the learning plan, and establish instructor roles and tasks.

2.2.3 Examine the first draft of the PjBL model.

2.2.4 The researchers asked five experts to check the correspondence between the items and components of metacognitive skills. These experts graduated in the fields of science education, educational measurement and evaluation, educational guidance, and psychology education.

2.2.5 Revise the PjBL model based on expert opinion and reach the second draft. Then, five experts examine the correspondence between metacognitive skills and PjBL design.

2.3 Data Analysis

A panel of five experts evaluated the PjBL model's validity in the field of science education, educational measurement and evaluation, educational guidance, and psychology education through the item–objective congruence index (IOC). The evaluation was assessed on four issues: correspondence of the PjBL steps and components of metacognitive skills, a correspondence of the metacognitive skills and activities according to the learning plan, a correspondence of strategies to encourage students to achieve the metacognitive skills and activities according to the learning plan, and a correspondence of strategies to encourage students to achieve the metacognitive skills and instructor roles and tasks. The IOC verified the PjBL model in two steps: (a) to assure the content validity of the model and (b) to clarify the quality of the model.

The suitability assessment of the PjBL model was evaluated by a panel of five experts in the field of science education, educational measurement and evaluation, educational guidance, and psychology education. The results were converted to a mean.

3. Results

The metacognitive cycle, which was developed using Ambrose et al. (2010)'s methodology, resulted in the creation of project-based instructional models that include the steps of defining, planning, monitoring and evaluating, and reflecting. The key to improving the metacognitive skills of PSTs is to incorporate metacognitive tactics into the teaching process (Table 1). The PSTs' metacognitive skills may be a result of the consistency of the roles and responsibilities of the instructors together with learning activities. The PjBL model achieved a 4.56 out of 5 appropriateness assessment rating. A summary of the specifics is provided in Table 2.

Table 1. Description of metacognitive skills by Ambrose et al. (2010)

Metacognitive skills	**Strategies to encourage students to achieve the metacognitive skills**	**Description**
1. Assessing the task at hand. Description: Evaluate the piece by first understanding the work's quality. What knowledge and skills are required to accomplish this task?	- Be more explicit than you may think necessary.	- Teachers communicate their needs to students to prevent misunderstandings and for learners to understand the process. Learners must record the workflow consisting of Characteristics of the workpiece and difficulty of the job performance expectations. How did you plan your work? How did you overcome obstacles/problems? What did you learn from doing this work? Coupled with the work that has been assigned.
	- Tell students what you do not want.	- Teachers understand the learner's all issues that may cause misunderstandings verbally or textually. With accurate examples and explaining what good performance looks like.
	- Check students' understanding of the task.	- Have students present work strategies. Instructors provide feedback and other strategies if what the learner is presented is not correct.
	- Provide performance criteria with the assignment.	- The teacher tells the rubric assessment criteria to show the quality level of the work to enhance the student's understanding of the work. They may say verbally or provide a checklist so learners can review the list periodically during their work. After the learners can self-examine the work, gradually stop using this technique.
2. Evaluating one's strengths and weaknesses. Description: You must assess your strengths and weaknesses before taking on any work.	- Give early, assessments.	- Instructors need to use formative assessment and feedback shortly after the start of work. To give students time to learn from the teacher's feedback.
	- Provide opportunities for self–assessment.	- Instructors may ask students to do exercises and check their answers. For learners to learn to solve problems from the given situations.
3. Planning an appropriate approach. Description: Planning how it works is valuable. Using the evaluation process and analyzing their strengths and weaknesses to make a strategy work.	- Have students implement a plan that you provide.	- Instructors assign roadmap goals for students to submit their work periodically.
	- Have students create their plan.	- Instructors let learners practice making plans when they have some work planning skills.
	- Make planning the central goal of the assignment.	- To train students to plan their work, instructors may hand over other assignments and require that only parts of the work plan be submitted and then receive feedback. Learners learn preparing from those instructions.
4. Applying strategies and monitoring performance. Description: Monitor your performance periodically by giving yourself time to pause and review your work to check for deficiencies.	- Provide simple heuristics for self-correction.	Instructors suggest ways to review their work to help students review their shortcomings early, such as teaching them how to ask questions to check their work.
	- Have students guide self–assessments.	Students' self-assessment Then, bring the points from the assessment to discuss with the teacher and classmates.
	- Require students to reflect on and annotate their work.	Learners reflect on and record their workflows. To allow oneself to learn the working and thought processes at that time.
	- Use peer review/reader response.	- Students take turns evaluating performance and providing feedback to practice self-assessment and others. The teacher must make clear and appropriate rubric assessment criteria.

5. Reflecting on and adjusting one's approach. Description: Ready to adjust a new work strategy if there is a defect in the work.	- Provide activities that require students to reflect on their performances.	- Teachers must assign learners to reflect on their thoughts to practice metacognitive skills. Assess your level of success through given questions, such as how your students' skills have changed after a project.
	- Prompt students to analyze the effectiveness of their study skills.	- After the presentation, have students assess their learning competencies in connection with their learning methods and work methods.
	- Present multiple strategies.	- The teacher provides examples of how to interpret problems and solve various issues. Then train students to present solutions to problems in different ways.
	- Create assignments that focus on strategizing rather than implementation.	- Learners practice analyzing each work strategy to see where there are strengths and weaknesses. Practice predicting each strategy that will produce what kind of results.

Table 2. Designing the PjBL model to enhance the metacognitive skills of PSTs

Project-based learning steps	**Metacognitive skills (Ambrose et al., 2010)**	**Strategies to encourage students to achieve the metacognitive skills (Ambrose et al., 2010)**	**Activities according to the learning management plan**	**Instructor roles and tasks**
1. Defining	1. Assessing the task at hand	- Be more explicit than you may think necessary. - Tell students what you do not want. - Check students' understanding of the task. - Provide performance criteria with the assignment.	1. Set Up problems to cause debate, brainstorming, and comments. 2. Learners choose the problem they want to solve themselves. 3. Members of the group together analyze the cause of the problem that they want to solve. 4. Together, summarize the scope of the project. 5. Students studied the evaluation criteria for project design.	Role: coach Tasks: 1. Keep the goal clear. 2. Check the understanding of the learner. 3. Describe the performance evaluation criteria. 4. Encourage learners.
2. Planning	2. Evaluating one's strengths and weaknesses	- Give early, performance-based assessments. - Provide opportunities for self-assessment. - Have students implement a plan that you provide.	1. Plan the project, starting from determining the responsibilities of the members within the group. 2. Members exchange findings derived from further queries to analyze the ability of team members to solve selected problems. 3. Each group presents a cause and a solution. 4. The instructor provides feedback instructions. Use a formative assessment.	Roles: coach, facilitator, co-learner Tasks: 1. Ask questions to make exchanges. 2. Provide feedback periodically. 3. Schedule project progress reporting.

	3. Planning an appropriate approach	- Have students create their plan. - Make planning the central goal of the assignment.	5. Learners report the progress of the project once a week, covering the following topics. - Problem synthesis. - Project plan. - Workpiece progression. - Experiments. - Revision of workpieces. - Project summary.	
3. Monitoring & Evaluating	4. Applying strategies and monitoring performance	- Provide simple heuristics for self-correction. - Have students guide self–assessments. - Require students to reflect on and annotate their work. - Use peer review/reader response.	1. Get involved in projects. 2. Take note of the project. 3. Evaluate your work and your friends evaluate your friends.	Roles: coach, facilitator, co-learner Tasks: 1. Use feedback questions/ suggestions to correct defects promptly. 2. Suggest a questioning method to determine the consistency of purpose with the work done. 3. Assign students to self-assessment. Friends evaluate friends and take notes.
4. Reflecting	5. Reflecting on and adjusting one's approach	- Provide activities that require students to reflect on their performances. - Prompt students to analyze the effectiveness of their study skills. - Present multiple strategies. - Create assignments that focus on strategizing rather than implementation.	1. Review practices with after action review process. 2. Learners assess the level of success of the work. 3. Learners analyze the effectiveness of their learning skills. 4. Provocative presentation. 5. Critique the piece together.	Role: coach, facilitator, mentor Tasks: 1. Create an atmosphere of reflection on the level of success of the project. 2. Create an atmosphere of creative criticism to see a wide range of aspects in thinking about solving problems.

4. Discussion

This study's goal was to create a PjBL model based on the metacognitive cycle proposed by Ambrose et al. (2010), which comprises a five-skill cycle and a metacognitive skills approach. This resulted in the PjBL model, which has the following four steps:

4.1 Defining

In this stage, students practice evaluating the work's difficulty and easiness and determining what abilities and knowledge are required to execute the assignment. Study the characteristics of quality work. Learners are guided through the teaching process by the teacher as they work together to comprehend the problem, and they are then given rubric criteria to use to gauge the degree of expectation for their work. Once a problem has been identified and understood

by the learner, the problem should be defined, along with its origin. Next, the project's requirements should be studied, along with the project's level of difficulty. Explain the project's parameters and the group's plans. The teacher serves as a coach throughout this phase. For students to examine the project's goals, questions are asked. Provide feedback if the learner doesn't understand the objectives or the standard of good performance and ask the learner to keep a project journal to document the project's completion, including how to determine the quality of one's work. Analyze the evaluation criteria and explain how good the work is. What qualities? Why, and what lessons did you take away from this project? Which task on this project was the hardest and the simplest? What strategy is in place to deal with the project's challenges? How did you overcome the challenges you faced while working on the project? What knowledge do you need? What knowledge may be learned more slowly? And how can I increase my knowledge to learn more?

4.2 Planning

This stage allows students to practice identifying their strong points and areas for improvement as well as planning and strategizing their assignments. The definition of good performance levels and the project evaluation criteria from step 1 must be understood by the students before they can assess their strengths and weaknesses for use in task planning. This is achieved by letting students define their actions, such as reporting on project progress or submitting periodic work plans, so that teachers can always provide feedback and stop students from getting bogged down in projects. The following subjects may be included in project progress reports that are provided once every week: 1) Problem synthesis, 2) Project plan, 3) Workpiece advancement, 4) Experimentation, 5) Workpiece editing, and 6) Project conclusion. In addition to serving as a coach and giving feedback, the instructor must also actively collaborate with students to acquire innovative approaches to a pressing problem. Because of this, it could be necessary to learn new information or techniques since the instructor's prior experience might no longer be relevant. Additionally, the teacher must function as a facilitator to create a conducive learning environment, for example, by offering learning resources or expert speakers who are relevant to the learner's assignment. The situation must also be stated for development and reflection (Guo et al., 2020).

4.3 Monitoring and Evaluating

To assess their flaws through reflection and learning the procedure for completing their projects, learners must conduct follow-up work in this stage. In particular, asking the right questions can enable students to review their work. Instructors must have the questions to produce a review of how the learner work. Because taking notes on projects can help learners learn, students should always record their projects in a notebook. The instructor must define contributions explicitly to avoid misunderstandings about the level of work's quality before learners judge their performance and that of others. The students later spoke with their peers about the examination findings. Better learning occurs when students are equipped with self-assessment skills before, during, and after activities (Yusnaeni & Corebima, 2017). Self-aware learners who have self-assessment skills will employ tactics that promote learning and develop metacognitive skills (Schraw & Dennison, 1994).

4.4 Reflecting

Reflecting calls for learners to be flexible enough to always change their project strategy if it is discovered to be inadequate. According to research, most students are content with their current learning methods and don't transition to new ones even when they perform better. Unless they are aware that the advantages outweigh the costs, especially the costs of work and time, learners frequently do not use newly taught tactics (Ambrose et al., 2010). Learners must evaluate their level of achievement using the questions provided by the teacher, such as how learner projects have changed, and how learners review their work to be trained on the significance of improving work practices. In addition to the methods mentioned above, learners must evaluate their learning performance after each progress report. This assessment must link the work completed at that stage and have learners evaluate their work strategies for how they have strengths and weaknesses (Mohamed et al., 2017; Tang et al., 2020). The final stage will involve a presentation, so there must be a chance to show the work that is provocative and open to criticism of the piece collectively. If the project has stakeholders, it is desirable to invite them to the presentation and have them take part in the project evaluation. For the student to view a variety of perspectives on addressing the problem—because certain difficulties can be solved in multiple ways—the instructor creates an atmosphere of reflection on the work's success.

The model reflects redesigning, revising, and evaluating the loop to complete the four-step learning process (Grossman et al., 2019), with the instructor serving as the assistant by modeling intelligence strategies for learners. This process is repeated with PjBL in four steps. These four steps of the PjBL model presented in this work can be applied in future research by those interested in creating a PjBL model to support PSTs' metacognitive skills.

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References

Ambrose, S. A., Bridges, M. M., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. San Francisco, CA: Jossey-Bass.

Azizah, U., & Nasrudin, H. (2021). Metacognitive skills and self-regulated learning in pre-service teachers: Role of metacognitive-based teaching materials. *Journal of Turkish Science Education, 18*(3), 461-476. https://doi.org/10.36681/tused.2021.84

Bahri, A., & Corebima, A. D. (2015). The contribution of learning motivation and metacognitive skill on cognitive learning outcome of students within different learning strategies. *Journal of Baltic Science Education, 14*(4), 487-500. https://doi.org/10.33225/jbse/15.14.487

Cera, R., Mancini, M., & Antonietti, A. (2013). Relationships between metacognition, self-efficacy, and self-regulation in learning. *Journal of Educational, Cultural and*

Psychological Studies, 7, 115-141. https://doi.org/10.7358/ecps-2013-007-cera

Donnelly, R., & Fitzmaurice, M. (2005). Collaborative Project-based Learning and Problem-based Learning in Higher Education: a consideration of tutor and student role in learner-focused strategies. In G. O'neill, S. Moor, & B. McMullin (Eds.), *Emerging issues in the practice of University Teaching and Learning* (pp. 87-98). All Ireland Society for Higher Education. https://doi.org/10.4018/978-1-59140-555-9.ch211

Grossman, P., Pupik Dean, G., Kavanagh, S., Kavanagh, S. S., & Herrmann, Z. (2019). Preparing teachers for project-based teaching. *Phi Delta Kappan, 100*(7), 43-48. https://doi.org/10.1177/0031721719841338

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research, 102*, 1-13. https://doi.org/10.1016/j.ijer.2020.101586

Harpe, S. E. (2015). How to analyze Likert and other rating scale data. *Currents in Pharmacy Teaching and Learning, 7*, 836-850. https://doi.org/10.1016/j.cptl.2015.08.001

Ilter, I. (2014). A Study on the efficacy of project-based learning approach n social studies education: Conceptual achievement and academic motivation. *Journal Educational Research and Reviews, 9*(15), 487-497. https://doi.org/10.5897/ERR2014.1777

Krajcik, J. S., & Shin, N. (2014). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 275-297, 2nd ed.). University of North Carolina, Chapel Hill. https://doi.org/10.1017/CBO9781139519526.018

Lestari, P., Ristanto, R. H., & Miarsyah, M. (2019). Metacognitive and conceptual understanding of pteridophytes: development and validity testing of an integrated assessment tool. *Indonesian Journal of Biology Education, 2*(1), 15-24. https://doi.org/10.31002/ijobe.v2i1.1225

Lukitasari, M., Hasan, R., Sukri, A., & Handhika, J. (2021). Developing student's metacognitive ability in science through project-based learning with e-portfolio. *International Journal of Evaluation and Research in Education, 10*(3), 948-955. http://doi.org/10.11591/ijere.v10i3.21370

Meyer, K., & Wurdinger, S. (2016). Students' perceptions of life skill development in project-based learning schools. *Journal of Education Issues, 2*(1), 91-114. https://doi.org/10.5296/jei.v2i1.8933

Mohamed, Z., Valcke, M., & De Wever, B. (2017). Are they ready to teach? Student teachers' readiness for the job with reference to teacher competence frameworks. *Journal of Education for Teaching, 43*(2), 151-170. https://doi.org/10.1080/02607476.2 016.1257509

Moursund, D. (2007). *Problem-based Learning and Project-based Learning*. Retrieved from http://darwing.uoregon.edu/~moursund/Math/pbl.html

Musa, F., Mufti, N., Latiff, R. A., & Amin, M. M. (2011). Project-based Learning: promoting

meaningful language learning for workplace skills. *Procedia Social and Behavioral Science, 18*, 187-195. https://doi.org/10.1016/j.sbspro.2011.05.027

Papleontiou-Louca, E. (2003). The concept and instruction of metacognition. *Teacher Development, 7*(1), 9-30. https://doi.org/10.1080/13664530300200184

Pavkov-Hrvojevic, M., Obadovic, D. Ž., Cvjeticanin, S., & Bogdanovic, I. (2016). Fostering pimary school students' metacognition using project-based learning. *The Eurasia Proceeding of Educational and Social Sciences, 4*, 123-126. Retrieved from http://www.epess.net/en/download/article-file/332252

Permana, F., & Chamisijatin, L. (2019). Project-based learning through edmodo: Improving critical thinking and histology concepts. *Jurnal Biologi dan Pendidikan Biologi, 12*(1). https://doi.org/10.21009/biosferjpb.v12n1.58-69

Perry, N. E., Hutchinson, L., & Thauberger, C. (2007). Mentoring student teachers to design and implement literacy tasks that support self-regulated learning and writing. *Reading and Writing Quarterly, 23*, 27-50. https://doi.org/10.1080/10573560600837636

Prachagool, V. (2021). Scientific attitude of young children through literature and project-based learning organization. *Journal of Education Issues, 7*(2), 217-226. https://doi.org/10.5296/jei.v7i2.19054

Rumahlatu, D., & Sangur, K. (2017). Implementation of project-based learning strategies to improve metacognitive skills and understanding of biodiversity concepts in state High School 2 Kairatu, West District of Seram. *Proceeding of the 2nd International Seminar on Education* (pp. 43-48). Retrieved from https://ojs.unpatti.ac.id/index.php/ises/article/view/127/79

Rumahlatu, D., & Sangur, K. (2019). The influence of project-based learning strategies on the metacognitive skills, concept understanding and retention of senior high school students. *Journal of Education and Learning, 13*(1), 104-110. https://doi.org/10.11591/edulearn.v13i1.11189

Sanium, S., & Buaraphan, K. (2022). Developing a Coding Scheme for Exploring Preservice Science Teachers' Metacognition in a Method Course. *Sustainability, 14*, 5644-5660. https://doi.org/10.3390/su14095644

Saputri, W., Corebima, A. D., Susilo, H., & Suwono, H. (2020). QASEE: A potential learning model to improve the critical thinking skills of pre-service teachers with different academic abilities. *European Journal of Educational Research, 9*(2), 853-864. https://doi.org/10.12973/eu-jer.9.2.853

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Education Psychology, 19*, 460-474. https://doi.org/10.1006/ceps.1994.1033

Struyven, K., & De Meyst, M. (2010). Competence-based teacher education: Illusion or reality? An assessment of the implementation status in Flanders from teachers' and students' points of view. *Teaching and Teacher Education, 26*(8), 1495-1510. https://doi.org/10.1016/j.tate.2010.05.006

Tang, S. Y., Wong, A. K., Li, D. D., & Cheng, M. M. (2020). Millennial generation preservice teachers' intrinsic motivation to become a teacher, professional learning, and professional competence. *Teaching and Teacher Education, 96*, 103180-103192. https://doi.org/10.1016/j.tate.2020.103180

Thomas, J. W. (2000). *A review of research on project-based learning, California: The Autodesk Foundation*. Retrieved from https://www.asec.purdue.edu/lct/HBCU/documents/AReviewofResearchofProject-BasedLearning.pdf

Veenman, M. V. J. (2008). Giftedness: Predicting the speed of expertise acquisition by intellectual ability and metacognitive skillfulness of novices. In M. F. Shaughnessy, M. V. J. Veenman, & C. Kleyn-Kennedy (Eds.), *Meta-cognition: A recent review of research, theory, and perspectives* (pp. 207-220). Hauppage: Nova Science Publishers.

Veenman, M. V. J. (2011). Learning to self-monitor and self-regulate. In R. Mayer, & P. Alexander (Eds.), *Handbook of research on learning and instruction* (pp. 197-218). New York: Routledge.

Vrugt, A., & Oort, F. J. (2008). Metacognition, achievement goals, study strategies and academic achievement: Pathways to achievement. *Metacognition and Learning, 3*(2), 123-146. https://doi.org/10.1007/s11409-008-9022-4

Wrigley, H. S. (2010) *Knowledge in Action: The Promise of Project-Based Learning*. Retrieved from http://www.ncsall.net

Yasir, M., Fikriyah, A., Qomaria, N., & Al Haq, A. T. (2020). Metacognitive skill on students of science education study program: Evaluation from answering biological questions. *Jurnal Pendidikan Biologi Indonesia, 6*(1), 157-164. https://doi.org/10.22219/jpbi.v6i1.10081

Yerdelen-Damar, S., Özdemir, O. F., & Ünal, C. (2015). Pre-service Physics Teachers' Metacognitive Knowledge about Their Instructional Practices. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(5), 1009-1026. https://doi.org/10.12973/eurasia.2015.1370a

Yusnaeni, A., & Corebima, A. D. (2017). Empowering students' metacognitive skills on sscs learning model integrated with metacognitive strategy. *The international Journal of Social Sciences and Humanities Invention, 4*(5), 3476-3481. https://doi.org/10.18535/ijsshi/v4i5.03

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