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The Relationship between Concept Mastery and Scientific Literacy of High School Students' on Plant Growth and Development Concept

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Abstract: Scientific literacy and mastery of concepts are needed to prepare a generation that is ready and adaptive to face developments in science and technology in the 21st century. Therefore, there is a need to change the learning process through the application of appropriate learning models. The Project Based Learning (PjBL) model can be a solution in increasing students' scientific literacy and mastery of concepts. This research was conducted at SMAN 7 Mataram, West Nusa Tenggara (NTB) with a quasi experimental pretest-posttest design. The research subjects were 132 of the 10th grade students. The research instrument for scientific literacy and concept mastery uses essay questions. Data were analyzed descriptively and with inferential statistics, i.e correlation tests at a significance level of 1%. The results of data analysis show that the significance value is 0.00, so it can be concluded that there is a positive correlation between concept mastery and student literacy. The implication of the results of this research is that the use of the PjBL model can be used as an alternative model that can empower students' mastery of science concepts and literacy.

Keywords: Mastery of concepts; PjBL model; Scientific literacy

Introduction

Scientific literacy ability can be defined as the ability and skills to use knowledge to identify problems and explain phenomena scientifically based on scientific evidence (Syafitri & Syafriani, 2023; Willms, 2003). Scientific literacy has a character characterized by four interrelated domains, namely the domains of context, knowledge, competence and scientific attitudes. Scientific literacy abilities can be measured using a test that has been developed, namely the Test of Scientific Literacy Skills (TOSLS). The test measures skills related to the main aspects of scientific literacy, namely recognizing and analyzing the use of investigative methods that lead to scientific knowledge and the ability to organize, analyze and interpret quantitative data. The importance of literacy is stated in the EFA (Education for All) goals as stated by UNESCO. UNESCO believes that literacy of people will reduce various problems and will lead to sustainable development (Ssempala, 2017). Scientific literacy assessment is not only a measurement of the level of understanding of scientific knowledge, but also understanding of various aspects of the scientific process and abilities to apply scientific knowledge and processes in real situations faced by students, both as individuals and members of society (Rahmawati et al., 2018) and scientific information (Prayitno et al., 2015). Scientific literacy supports students' mastery of concepts (Dhanil & Mufit, 2023; Suryadi et al., 2023).

State that mastery of concepts in a field of science includes a combination of mastery of knowledge of the field of science being studied and dimensions of cognitive processes, including factual, conceptual and procedural knowledge (Anderson et al., 2001; Safarati & Zuhra, 2023). Based on this view, a person cannot be said to have mastered a concept if he or she is only able to memorize the facts and concepts that have been studied

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(Abdullah & Shariff, 2008). A person is said to have mastered a concept if he is able to combine the knowledge he has learned in a high-level thinking process (Abdurrahman et al., 2011; Anderson et al., 2013; Krathwohl, 2002).

One of the factors that determines the success of conceptual learning is the mastery of concepts by teachers or prospective teachers. Previous research revealed that there are still many problems related to the mastery of concepts by Biology teacher candidates in Indonesia (Amin et al., 2016; Aprilia, 2015; Wulandari et al., 2016). Regarding the material field of plant growth and development in biology, preliminary research also revealed the low mastery of Biology students' concepts. Through tests given to 37 students who had taken biology material, the average data on students' concept mastery was 31.35 (on a scale of 100). The test given includes three indicators of thinking, namely analyzing, evaluating and creating.

Mastery of concepts is the ability to connect newly acquired knowledge with previous knowledge as the main basis for self-improvement in using various methods to generate ideas, create valuable new ideas, explain, revise, analyze and evaluate their own ideas (Krathwohl, 2002). As for this research, what is used in assessing concept mastery is from C4-C6, namely analyzing (C4), evaluating (C5), and creating (C6) because it includes HOTS. The concept mastery test consists of 11 essay questions. The concept mastery scoring process uses a rubric on a scale of 1-5.

So far, there has been no research that examines plant growth and development material in high school using the Project Based Learning model by looking at two aspects at once, namely science literacy and concept mastery. Therefore, it is important to conduct an in-depth study of these three aspects.

Method

This research is a quasi-experiment or quasi-experiment, i.e research that provides treatment to independent variables to determine their influence on the dependent variable, but the influencing variables cannot be strictly controlled. This research involved into two groups, i.e the experimental group and the control group (Creswell, 2012).

The design used in this research is a quasi-experimental pretest-posttest design using a 2 x 2 factorial. The treatment consists of 2 types of learning called factor A, i.e the Project Based Learning model (A1) and the Conventional model (A2). The dependent variables in this research are scientific literacy and concept mastery.

The research was carried out in the odd semester in academic year of the 2023/2024, on July-August 2023 with the research location at SMAN 7 Mataram. The subjects in this research were the 10th active grade students of IPS (Social Science students) at SMAN 7 Mataram. The number of students is 80 students divided into two classes. The selection of the two classes in determining the experimental class and control class was carried out randomly using a lot technique, so that 10th.1 (X.1) was found as the experimental class and 10th.2 (X2) as the control class. The experimental group is the group that takes part in learning using the PjBL model, while the control group is the group that takes part in learning using the conventional model, namely the model usually used by biology subject teachers in that class.

Hypothesis testing is carried out after the data is declared normal and homogeneous. The data analysis used is descriptive statistics and parametric statistics. Descriptive statistical techniques to describe scientific literacy data and students' mastery of concepts. In addition, the dependent variable score data is displayed in table and graph form. The parametric statistical analysis technique for testing the dependent variable uses a two-way correlation test at a significance level of 1%.

Results and Discussion

Research Result

Data on students' mastery of concepts presented in Table 1 shows that the average score is 57.08 with a maximum score of 83.33 and a minimum score of 16.67. Meanwhile, the average student scientific literacy score is 54.96 with a maximum score of 91.67 and a minimum score of 16.67.

Table 1. General Description of Data on Students' Mastery Of Concepts And Scientific Literacy

Variabel	Concept Mastery	Science Literacy
N	126	126
Mean	57.08	54.96
Median	58.33	58.33
Mode	58.33	50.00
St. Deviasi	1.31E	1.41E
Varians	170.07	196.87
Maxsimum	83.33	91.67
Minimum	16.67	16.67

Based on the Histogram in Figure 1, it can be seen that the data distribution is normal, with the highest values in the range of 50-60. Furthermore, the Histogram of students' scientific literacy data presented in Figure 2 shows that the average student literacy score is 50-65.

This shows that students' abilities are more at the intermediate level.

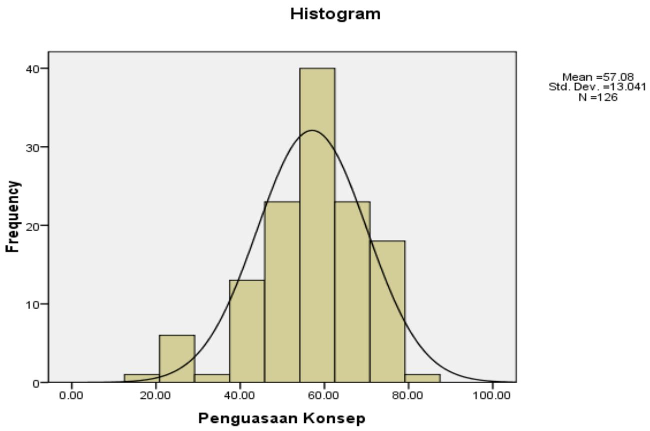

Figure 1. Histogram of student concept mastery data

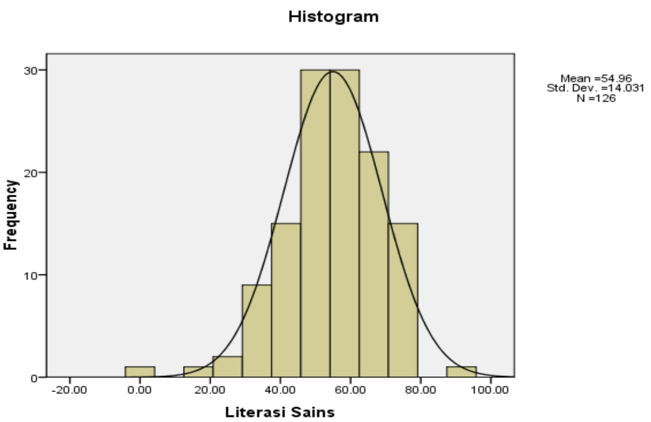

Figure 2. Histogram of student science literacy data

Table 2 is the result of the correlation test using the Pearson formula. The correlation test results show that the Sig. (2 tailed) is 0.000, which means that there is a correlation between concept mastery and students' scientific literacy. Furthermore, based on the sign of the correlation value, it is positive, indicating that the direction of the correlation between concept mastery and scientific literacy is positive. This means that when concept mastery increases, students' scientific literacy also increases.

Table 2. Relationship between Concept Mastery and Students' Scientific Literacy

		Concept Mastery	Scientific Literacy
Concept Mastery	Pearson Correlation	1	0.642
	Sig. (2-tailed)		0.000
	N	126	126
Scientific Literacy	Pearson Correlation	0.642	1
	Sig. (2-tailed)	0.000	
	N	126	126

**. Correlation is significant at the 0.01 level (2-tailed).

Discussion

The results of the correlation analysis show that the significance value is 0.000, which indicates that there is a correlation between concept mastery and students' scientific literacy. The direction of the correlation is positive, indicating that the higher a student's mastery of concepts, the higher their scientific literacy. Mastery of concepts as the main basis of knowledge for creating ideas, creating new ideas, explaining, revising, analyzing and evaluating their own ideas (Taşlıdere, 2013), turns out to be related to a person's literacy. This is because concept mastery involves educators in helping students master the concepts taught which are explicitly included in learning, so that students can be trained in literacy of their knowledge (Tsui & Treagust, 2013).

The concept translation process is very important for developing understanding of biological concepts (Schönborn & Bögeholz, 2009). A concept that makes sense must be believable and know what it means by the learner. Concept mastery is formed from the accommodation process between old and new concepts so that conceptual exchange occurs (Treagust & Tsui, 2013). Based on Bloom's taxonomy, cognitive aspects consist of: remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), creating (C6) (Anderson et al., 2001). As for this research, what is used in assessing concept mastery is from C4-C6, because it includes HOTS. The way to deepen students' mastery of science concepts in the PjBL model is to involve them in activities that provide opportunities to build new concepts with the guidance of educators (Hubber et al., 2010). On the other hand, Bell & Odom (2012) has used inquiry-based learning in teaching science and deepened teachers' knowledge of students' science concepts. Educators can deliberately try to create disequilibrium, through questions or problems posed to students, to pressure them to think deeply and express their ideas as they form conceptions (Astriani et al., 2023; Chang, 2010).

The concept of science plays a very important role today, with the very rapid rate of technological progress for society, it is related to daily life and work, including technology, equipment and products used to facilitate human life and work. Science helps humans to develop ways of thinking, be reasonable, creative, analytical, critical, develop important skills in knowledge, the ability to solve problems systematically, and to make decisions using various information in the form of verifiable evidence (Aliyah et al., 2023; Syafitri & Syafriani, 2023; Zubaidah, 2016). Therefore, good science concepts can train good literacy as well.

A more appropriate theoretical scale that can be used to assess scientific literacy in schools is to use scale 5 (Mahanal et al., 2019; Mahardika et al., 2016). This scale can be used as a theoretical framework for research. The scale is as follows: first, Scientific illiteracy: students are unable to respond to basic questions about science. Students do not have the concept, context to identify questions as a scientific process. Second, Nominal scientific literacy: students can recognize concepts related to science, but the level of understanding shows errors or misunderstandings. Third, Functional scientific literacy: students have the ability to explain concepts well and correctly, but have limited understanding. Fourth, Conceptual science literacy: students can develop some understandisng of conceptual schemes related to understanding science. Procedural abilities which can include the process of scientific investigation and technological design are also within the level of scientific literacy. Fifth, Multidimensional scientific literacy: this literacy is a combined understanding of science that goes beyond the concepts of scientific disciplines and scientific investigation procedures. It covers the philosophical, historical and social dimensions of science and technology (Eurika, 2021; Paramitha et al., 2023).

Project based learning (PjBL) is a learning model that organizes classes in a project (Nilyani et al., 2023; Rezeki et al., 2015). Student independence in learning to complete the tasks they face is the goal of PjBL. In PjBL, students' independence in learning is trained by the teacher so that they get used to learning when using PjBL. Middle school students still need to be guided in completing project assignments, therefore the teacher's role as a facilitator is really needed in the learning process using PjBL. Teacher guidance functions to direct students so that the learning process can run according to the learning flow.

In the PjBL Step there is an in-depth investigation of a real world topic, this is valuable for students' attention and effort (Kuo et al., 2019). Furthermore, Al-Hassawi et al. (2020) stated that: project based learning focuses on creating a product or an artifact by using problem-based and inquiry-based learning depending on the depth of the driving question. There is a connection between project based learning (PjBL) and inquiry based learning (IBL) in PjBL. PjBL focuses on real-world solving, and inquiry learning focuses on problem-solving skills, while PjBL focuses on creating projects or products in building concepts. PjBL is student-centered learning, the teacher is a facilitator, and students work in groups (Lou et al., 2017; Saputri et al., 2023).

The PjBL learning stages have trained students in scientific literacy. The PjBL stages were developed by two experts, The George Lucas Education Foundation and Dopplet. PjBL syntax (Harto et al., 2019; Rezeki et al., 2015):

Phase 1: Determining basic questions (start with essential question)

Learning begins with essential questions, namely questions that can assign students to carry out an activity. Questions are prepared by taking topics that correspond to real world realities and starting with an in-depth investigation. The questions that are prepared should not be easy to answer and can lead students to create projects. Such questions are generally open (divergent), provocative, challenging, require high order thinking skills, and are related to students' lives. Teachers try to make the topics raised relevant to students.

Phase 2: Develop project planning (design project)

Planning is done collaboratively between teachers and students. In this way, students are expected to feel "ownership" of the project. Planning contains the rules of the game, selecting activities that can support answering important questions, by integrating various possible materials, and knowing the tools and materials that can be accessed to help complete the project.

Phase 3: Develop a schedule (create schedule)

Teachers and students collaboratively prepare a schedule of activities to complete the project. Activities at this stage include: making a schedule for completing the project, (2) determining the final time for completing the project, (3) bringing students to plan new ways, (4) guiding students when they make ways that are not related to the project, and (5) ask students to make an explanation (reason) about how to choose the time. The agreed schedule must be mutually agreed upon so that teachers can monitor learning progress and work on projects outside of class.

Phase 4: Monitoring students and project progress (monitoring the students and progress of project)

The teacher is responsible for monitoring student activities while completing the project. Monitoring is carried out by facilitating students in each process. In other words, the teacher plays the role of mentor for student activities. In order to simplify the monitoring process, a rubric was created that can record all important activities.

Phase 5: Assess the outcome

Assessments are carried out to assist teachers in measuring the achievement of competency standards, play a role in evaluating each student's progress, provide feedback on the level of understanding that students have achieved, and assist teachers in developing subsequent learning strategies.

Phase 6: Experience Evaluation (evaluation the experience)

At the end of the learning process, teachers and students reflect on the activities and results of projects that have been carried out. The reflection process is carried out both individually and in groups. At this stage students are asked to express their feelings and experiences while completing the project. Teachers and students develop discussions in order to improve performance during the learning process, so that in the end a new finding (new inquiry) is found to answer the problems raised in the first stage of learning. This series of learning activities has trained students to deepen their mastery of science concepts. Thus, the higher their mastery of concepts, the more automatically their scientific literacy will also increase.

Conclusion

There is a positive relationship between concept mastery and students' scientific literacy. The higher the mastery of concepts, the higher the students' scientific literacy. The implication of this research is that the PjBL model can be used as an alternative to improve students' mastery of concepts and scientific literacy.

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Preparation of proposals, plans for using costs, A. F., B. M. H., and T. L. H.; Data collection and classroom teaching, H. H.; Data analysis, conceptual, preparation of research articles and reports, A. F., B. M. H., and T. L. H.; correction of data results and financial reports, B. M. H., and T. L. H.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

References

Abdullah, S., & Shariff, A. (2008). The effects of inquiry-based computer simulation with cooperative learning on scientific thinking and conceptual understanding of gas laws. *Eurasia Journal of Mathematics, Science and Technology Education*, *4*(4), 387–398. https://doi.org/10.12973/ejmste/75365

Abdurrahman, Liliasari, Rusli, A., & Waldrip, B. (2011). Implementasi pembelajaran berbasis multi representasi untuk peningkatan penguasaan konsep fisika kuantum. *Cakrawala Pendidikan*, *1*, 30–45. http://dx.doi.org/10.21831/cp.v1i1.4189

Al-Hassawi, F. A., Al-Zaghul, F. Y., & Al-Jassim, I. A. R. (2020). The Effect of A Project-Based Program to Develop The of Critical and Creative Thinking Skills. *International Journal of Social Sciences*, *6*(1), 306–323. https://doi.org/10.20319/pijss.2020.61.306323

Aliyah, H., Hartono, D., & Mubarok, H. (2023). Explore Students ' Metacognitive Thinking Process in Solving Compound Polarity Problems Based on The Level of Academic Ability. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9332–9340. https://doi.org/10.29303/jppipa.v9i11.4293

Amin, M. A., Corebima, A. D., Zubaidah, S., & Mahanal, S. (2017). Identifikasi kemampuan bertanya dan berpendapat calon guru biologi pada mata kuliah fisiologi hewan. *Bioedukasi, 15*(1), 20-27. https://doi.org/10.19184/bioedu.v15i1.4704

Anderson, L. W., Krathwohl, P. W., Airasian, D. R., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *Taxonomy for_ Assessing a Revision of Bloom's Taxonomy Of Educational Objectives*. Retrieved from https://www.uky.edu/~rsand1/china2018/texts/Anderson-Krathwohl - A taxonomy for learning teaching and assessing.pdf

Anderson, T. R., Schönborn, K. J., du Plessis, L., Gupthar, A. S., & Hull, T. L. (2013). Identifying and Developing Students' Ability to Reason with Concepts and Representations in Biology. *Thinking Skills and Creativity*, https://doi.org/10.1007/978-94-007-4192-8_2

Aprilia, N. (2015). Pengaruh Aktivitas dan Gaya Belajar Mahasiswa terhadap Pemahaman Konsep Pada Mata Kuliah Perkembangan Peserta Didik. In Symposium on Biology Education. In *Symposium on Biology Education* (pp. 61-68).

Astriani, D., Martini, Rosdiana, L., Fauziah, A. N. M., & Purnomo, A. R. (2023). STEAM-Project Based Learning (PjBL): Efforts to Train Critical Thinking Skills for Prospective Science Teacher. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 7909–7915. https://doi.org/10.29303/jppipa.v9i10.3823

Bell, C. V., & Odom, A. L. (2012). Reflections on Discourse Practices During Professional Development on the Learning Cycle. *Journal of Science Teacher Education*, *23*(6), 601–620. https://doi.org/10.1007/s10972-012-9307-y

Chang, C.-Y. (2010). Does Problem Solving Prior Knowledge Reasoning Skills in Earth Science? An Exploratory Study. *Research in Science Education*, *40*(2), 103–116. https://doi.org/10.1007/s11165-008-9102-0

Creswell, J. W. (2012). *Educational Research: Planning, Conducting, and Evaluating Quantitative and*

Qualitative Research (4th Editio). Pearson Education, Inc.

Dhanil, M., & Mufit, F. (2023). Preliminary Analysis of Scientific Literacy in Fluids at SHS 6 Padang. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9257–9262. https://doi.org/10.29303/jppipa.v9i11.4320

Eurika, N. (2021). Teacher and Student's Expectation towards Biochemistry STEM Based Module in Promoting Critical Thinking and Creativity. *Jurnal Penelitian Pendidikan IPA,* *9*(11), 9120–9127. https://doi.org/10.29303/jppipa.v9i11.5382

Harto, N., Sarwo, S., & Sudarmin, S. (2019). Effectiveness of the Project Based Learning Model Integrated Ethno Technology to Actualize Superior Teacher Candidates. In *1st International Conference on Education and Social Science Research (ICESRE 2018)* (pp. 58-62). Atlantis Press. https://doi.org/10.2991/icesre-18.2019.12

Hubber, P., Tytler, R., & Haslam, F. (2010). Teaching and learning about force with a representational focus: Pedagogy and teacher change. *Research in Science Education*, *40*(1), 5–28. https://doi.org/10.1007/s11165-009-9154-9

Krathwohl, D. R. (2002). A Revision of Bloom's Taxonomy. *Theory into Practice*, *41*(4), 212–219. https://doi.org/10.1207/s15430421tip4104

Kuo, H. C., Tseng, Y. C., & Yang, Y. T. C. (2019). Promoting college student's learning motivation and creativity through a STEM interdisciplinary PBL human-computer interaction system design and development course. *Thinking Skills and Creativity*, *31*(September 2018), 1–10. https://doi.org/10.1016/j.tsc.2018.09.001

Lou, S. J., Chou, Y. C., Shih, R. C., & Chung, C. C. (2017). A study of creativity in CaC 2 steamship-derived STEM project-based learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(6), 2387–2404. https://doi.org/10.12973/EURASIA.2017.01231A

Mahanal, S., Tendrita, M., Ramadhan, F., Ismirawati, N., & Zubaidah, S. (2019). The Analysis of Students' Critical Thinking Skills on Biology Subject. *Anatolian Journal of Education*, *2*(2). https://doi.org/10.29333/aje.2017.223a

Mahardika, E. A. S., Suwono, H., & Indriwati, S. E. (2016). Eksplorasi Kemampuan Awal Literasi Biologi Siswa Kelas X. In *Seminar Nasional Pendidikan Dan Saintek 2016*. Retrieved from https://publikasiilmiah.ums.ac.id/xmlui/handle/11617/8005

Nilyani, K., Asrizal, A., & Usmeldi, U. (2023). Effect of STEM Integrated Science Learning on Scientific Literacy and Critical Thinking Skills of Students: A Meta-Analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 65–72. https://doi.org/10.29303/jppipa.v9i6.2614

Paramitha, D., Prasetyo, Z. K., Jumadi, J., & Siregar, A. N. (2023). The Influence of Use of Problem-Based Learning E-Book Materials of Optical Equipment on Improving Students ' Critical Thinking Ability. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9149–9155. https://doi.org/10.29303/jppipa.v9i11.5165

Prayitno, B. A., Corebima, D., Susilo, H., Zubaidah, S., & Ramli, M. (2015). Issn 1648-3898 Issn 2538-7138 Closing the Science Process Skills Gap Between Students With High and Low Level. *Journal of Baltic Science Education*, *16*, 266–277. Retrieved from https://www.ceeol.com/search/article-detail?id=974053

Rahmawati, Handayanto, S. K., & Dasna, I. W. (2018). Pengaruh Learning Cycle 5E terhadap Keterampilan Proses Sains Peserta Didik Kelas VIII. *Jurnal Pendidikan*, *3*(3), 286–290. Retrieved from http://journal.um.ac.id/index.php/jptpp/

Rezeki, R., Nurhayati, N., & Mulyani, S. (2015). Penerapan Metode Pembelajaran Project Based Learning (Pjbl) Disertai Dengan Peta Konsep Untuk Meningkatkan Prestasi Dan Aktivitas Belajar Siswa Pada Materi Redoks Kelas X-3 Sma Negeri Kebakkramat Tahun Pelajaran 2013 / 2014. *Jurnal Pendidikan Kimia Universitas Sebelas Maret*, *4*(1), 74–81. Retrieved from https://jurnal.fkip.uns.ac.id/index.php/kimia/article/view/5129

Safarati, N., & Zuhra, F. (2023). The Use of Problem-Solving Based Physics Comic Media on Global Warming Material in Increasing Learning Motivation and Students ' Understanding Concept. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9193–9199. https://doi.org/10.29303/jppipa.v9i11.4828

Saputri, R., Wilujeng, I., Jumadi, J., Nurohman, S., & Purnama, A. Y. (2023). Development of PBL Modul-El to Improve Problem Solving Students of Physics Education Program. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8376–8382. https://doi.org/10.29303/jppipa.v9i10.4092

Schönborn, K. J., & Bögeholz, S. (2009). Knowledge transfer in biology and translation across external representations: Experts' views and challenges for learning. *International Journal of Science and Mathematics Education*, *7*(5), 931–955. https://doi.org/10.1007/s10763-009-9153-3

Ssempala, F. (2017). Science Teachers' Understanding and Practice of Inquiry-Based Instruction in Uganda. *ProQuest Dissertations and Theses*, *June*, 334. Retrieved from https://search.proquest.com/dissertations-theses/science-teachers-understanding-practice-inquiry/docview/1926761847/se-

2?accountid=41849

Suryadi, A., Alatas, F., & Hanifa, N. A. (2023). Supporting Students' Problem Solving Skills Using Science, Technology, Religion, Art, and Mathematics (STREAM) Approach on Sound Wave Concept. *Jurnal Penelitian Pendidikan IPA, 9*(11), 9106–9112. https://doi.org/10.29303/jppipa.v9i11.5385

Syafitri, Y., & Syafriani. (2023). Need Analysis for Development of Physics E-Module Integrated with Critical Reading to Enhance Critical Thinking and Scientific Literacy in Senior High School. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8065–8069. https://doi.org/10.29303/jppipa.v9i10.4976

Taşlıdere, E. (2013). Effect of Conceptual Change Oriented Instruction on Students' Conceptual Understanding and Decreasing Their Misconceptions in DC Electric Circuits. *Creative Education*, *04*(04), 273–282. https://doi.org/10.4236/ce.2013.44041

Treagust, D. F., & Tsui, C.-Y. (2013). Models and Modeling in Science Education : Multiple Representations in Biological Education. In *Paper Knowledge Toward a Media History of Documents*. Springer International Publishing. https://doi.org/10.1007/978-94-007-4192-8

Tsui, C.-Y., & Treagust, D. F. (2013). Multiple Representations in Biological Education. *Multiple Representations in Biological Education, Series: Models and Modeling in Science Education*, *7*, 19–38. https://doi.org/10.1007/978-94-007-4192-8

Willms, J. D. (2003). *Student engagement at school: A sense of belonging and participation.* OECD https://doi.org/10.1787/19963777

Wulandari, S., Suarsini, E., & Ibrohim, I. (2016). Pemanfaatan Sumber Belajar Handout Bioteknologi Lingkungan Untuk Meningkatkan Pemahamankonsep Mahasiswa S1 Universitas Negeri Malang. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *1*(5), 881–884. https://doi.org/10.17977/jp.v1i5.6297

Zubaidah, S. (2016). Keterampilan Abad Ke-21: Keterampilan Yang Diajarkan Melalui Pembelajaran. In *Seminar Nasional Pendidikan Dengan Tema "Isu-Isu Strategis Pembelajaran MIPA Abad 21*. Retrieved from https://rb.gy/ctz851