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A Combination of Problem Based Learning and Concept Mapping Significantly Increases Science Literacy and Discussion Skills of Senior High School Student

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Abstract: The learning process consists of a sequence of instructional and learning exercises designed to ascertain the efficacy of concept mapping-aided problem-based learning model on the human reproduction system in raising science literacy as well as the efficacy of the model on the human reproduction system in raising students' discussion skills at SMAN 1 Kasihan. This research employed a quasi-experiment design. The samples of this research were selected using random cluster sampling, consisting of 1 control class used scientific learning approach and 1 experimental class used Problem Based Learning model and Concept Mapping strategy. A descriptive and inferential statistics Independent Sample T-test were employed to analyzed the data. The study's findings indicated that the experimental class's pre-test score was 46.97 and the control class's was 45.53. In addition, the experimental class scored 81.86 on the post-test, whereas the control class scored 62.28. The experimental class has a 0.7 N-Gain score in scientific literacy, whereas the control class has a 0.4 score. Based on the Independent Sample T-test findings, p=0.000 (p<0.05) is the significance threshold. It can be stated that students at SMA N 1 Kasihan's science literacy and group discussion abilities are successfully increased by Concept Mapping-aided Problem Based Learning (PBL) model on human reproduction material.

Keywords: Concept mapping strategy; Problem based learning model; Science literation; Student group discussion skills of senior high school

Introduction

Education is defined as a deliberate and organized endeavor to provide a learning environment and learning process so that students actively develop their potential to have religious spiritual power, self-control, personality, intelligence, noble character, and skills (Law No. 20 of 2003). Based on this statement, students are part of a community unit that has the right to receive education in order to broaden their horizons and increase their potential to become useful people for their lives and the environment around them. Students should be able to comprehend environmental issues and come up with solutions as a result of their education. The quality of education cannot be separated from the collaboration of educational actors, namely school principals, teachers and students. School principals and teachers work together to help students become enthusiastic about learning and achieve their goals in order to produce quality human resources based on the ability to capture material to solve a problem. Teachers need to consider more carefully how to integrate information to help students become masters of the topics they are teaching because students' conceptual depth also plays a significant role in their learning outcomes (Ramdani et al., 2020). This is obtained based on literacy skills and communication skills with others through group discussions and is the most important

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part of education for improving educational quality. Understanding scientific literacy helps us become more aware of occurrences that take place naturally or as a result of human activity that are connected to the concepts that students have studied in the classroom. It is required of students to be able to explain scientific phenomena, assess and plan scientific investigations, and analyze and interpret scientific findings (Adawiyah, 2017). Thus, it is intended that students would develop a scientific mindset due to teachers adapting educational materials to their nature, which is as a process, product, and attitude (Rahmawati et al., 2023). Additionally, it is the responsibility of the teacher to help students develop these abilities—creative, productive, critical, independent, collaborative, and communicative—in an engaging, motivating, enjoyable, and challenging way in accordance with their psychological and physical growth (Aspini, 2020).

International standard assessments on the OECD and PISA are all abilities related to science issues and how students solve a problem based on the steps to solve it. Developing students' scientific literacy is one of the objectives of education in schools, as stated in the OECD and PISA world-level education assessments, When it comes to scientific activities, students who are literate or have some knowledge of science will be expected to demonstrate proficiency in the areas of scientific data interpretation, scientific investigation design, and scientific explanation of occurrences (Oliver et al., 2020). According to the Trends in International Mathematics and Science Study (TIMSS), Indonesian students' scientific literacy scores in 1999, 2003, 2007, 2011, and 2015 were 492, 510, 471, 426, and 397, respectively. In 2015, Indonesia ranked 44th out of 47 (Mullis, 2015).

Interviews with several teachers reveal that to learn biology, students must have at least general knowledge about a material topic, which will be further developed and added to new knowledge during the learning process. However, not all students understand the nature of learning. Some understand, but not a few rely on their teacher to answer question, then the teacher again becomes the center of student knowledge. Student learning outcomes are compiled in the Final School Assessment (PAS) at the completion of the learning process. Learning achievement is the outcome of altering the learning process as measured by an exam in the educational process (Muliaman et al., 2022). The PAS score in class XI MIPA is still below average and it is necessary to review the causes and effects and improving learning patterns. In the second semester, students find it challenging to comprehend the content, particularly the part about the human reproductive system. Many theories and notions exist about the human reproductive system. Students believe that the information on the human reproductive system is tough since it requires them to understand and recall concepts. In addition, the process of the human reproductive system cannot be observed directly, making students imagine or dream of describing a process that occurs. Most students still consider it taboo to study the organs of the human reproductive system, both female and male students. Students need a place to express ideas that can spur students to learn. One of the solutions is group discussion. Activities like scientific presentations and discussions are frequently done during the learning process. As educated people who are obliged to spread their knowledge, students are required to be proficient in speaking in scientific presentation activities.

These issues make it important to implement a biology learning method that may sharpen students' critical thinking abilities to raise their science literacy and their discussion abilities to enhance their group discussion abilities. One alternative to building a more varied learning atmosphere by raising issues or problems that are happening around us is the Problem-Based Learning (PBL) model and the Concept Mapping (CM) strategy. It is vital to use learning models that are embedded in students in order to engage them both intellectually and emotionally and draw their attention to the need of learning from their own awareness. By doing this, the use of appropriate learning models can maximize students' conceptual mastery abilities (Fajrina et al., 2018). The PBL model is a useful framework for higher-order thought processes that concentrate on issues including the stages of problem orientation, organization, inquiry, development and presentation, analysis, and evaluation (Utami et al., 2023). PBL also provides opportunities for students to be fully involved and assume greater responsibility for learning because students express all their ideas, thoughts, and efforts to solve a problem (Brilingaite et al., 2018). It is in line with the opinion of Hagi et al. (2021) that the PBL models can improve students' capacity for creative thinking. Students will have the freedom to search for, create on their own, comprehend, and apply ideas to solve problems—whether they are academic or practical (Herdiawan et al., 2019). Consequently, employing the PBL learning approach requires being adept at conducting research, used to applying creativity in thought processes, and developing problem-solving skills (Saputri et al., 2017). Problem solving is an alternate method that involves mapping a network of issues and utilizing a mind map to investigate the sources of problems (Ismayani, 2020).

Mind maps are a means of organizing facts visually, and occasionally pictorially, with text. Concept mapping may be used to highlight the links between concepts as well as the categories of concepts. Mind maps could significantly boost the creation of ideas. The concept of

mind maps is a method for organizing data in the form of images, concepts that are interconnected and can increase an idea significantly (Jensen et al., 2018). Mind mapping can increase student creativity, improve student learning outcomes, and serve as a tool for monitoring student outcomes of learning (Nurulwati et al., 2023). Creating mind maps increases their curiosity, as seen through how each mind map picture sequence presents a different notion (Nuramalina et al., 2022). Students' ability to think holistically is required while using mind mapping, which enhances their system thinking abilities (Alhusein et al., 2023).

Using the PBL and CM paradigm, students will find no difficulty to examine and link ideas based on the challenges they find because the reproductive system content has been chosen. Based on the aforementioned problems and descriptions, the researcher applied the CM-aided PBL model to enhance high school student's science literacy and group discussion skills.

Method

This study employed a quasi-experiment with control group design. Maciejewski (2020) states that In quasi-experimental research, a group of participants receives treatment in order to contrast the efficacy of the supplied interventions. There are two groups in a design experiment: the experimental group (X) and the control group (Y).

Table 1. Research Design

Variable	Pretest	Treatment	Posttest
Ke_1 (pbl+cm)	O_1	X_1	O_2
Kk_1 (scientific)	O_2	X_2	O_3

Description:
Ke_1 = Experiment Class
KK = Control Class
O_1 = Pretest Experiment Class
O_2 = Posttest Experiment Class
O_3 = Posttest Control Class
X_1 = CM-aided PBL model
X_2 = PBL models with Scientific Approach

The participants in this study are second graders at Bantul City's SMA N 1 Kasihan, knowing the lesson for 2022/2023. A sample is a subset of individuals, things, or things drawn for measurement from a larger population. Thus, to obtain precise findings, sampling is done (Bhardwaj, 2019). The samples used were students of XI Science. XI-Science 1 is control class with scientific approach for 36 students, XI-Science 4 is experimental class which is used a treatment CM-aided PBL model for 36 students. Cluster random sampling was the method used for the sample process.

The research employed numerous instruments, including lesson plans, student worksheets for CM-aided PBL models, scientific method worksheets for students, and observation papers for group discussion techniques. Meanwhile, the instrument used a test instrument consist of 20 multiple choices and and 5 essay questions to measure the ability of science literacy, while non test instrument is observation sheet to rate student group discussion skills. In additioin, RPP, LKPD and instrument test have tested the contents and construct validity. Several forms of evidence can be used to demonstrate the validity of the instrument. This evidence consists of constructs, also referred to as construct validity, criteria, also referred to as criterion validity, and content, also known as content validity (Yusup, 2018).

The prerequisite test analysis and the hypothesis test comprise the data analysis in this study. The Kolmogrov Smirnov normality test and Levene's homogeneity test are two of the research's necessary tests. Independent sample t-test is used to assess hypotheses based on post-test data. Using SPSS 20, prerequisite analysis and hypothesis testing were performed.

Result and Discussion

Information gathered from science literacy and student group discussion abilities study. Data on science literacy are derived from the posttest results. Table 2 displays the average science literacy data.

Table 2. Science Literacy Data

Learning model	Data	Amount of data	Average
Pbl+cm	Pretest	36	46.97
	Posttest	36	81.86
Scientific approach	Pretest	36	45.53
	Posttest	36	62.28

Pretest and posttest results are used in the prerequisite analysis test to ascertain the distribution of the data. The normality of the Kolmogorov Smirnov test is the first necessary analytical test. Table 3 displays the results of the science literacy normality test.

Table 3. Science Literacy Ability of Normality Test Result

Learning model	Data	Sig	Conclusion
Pbl+cm	Pretest	0.061	Normal
	Posttest	0.075	Normal
Scientific approach	Pretest	0.067	Normal
	Posttest	0.127	Normal

Based on Table 3, as the normality test result is greater than 0.05, the entire set of data is considered to

be normally distributed. Levene's homogeneity test serves as the second prerequisite analysis. Table 4 displays the homogeneity test's outcome.

Table 4. Science Literacy of Homogenity Test Result

Information	Sig.	Conclusion
Science literation ability	0.346	Homogeneous

According to Table 4, the entire set of data is homogenous, with a significant value of 0.346 ($p<0.05$) for science literacy. From Table 5, group discussion skills variable shows that class with CM aided-PBL model have a higher value than class with scientific approach. Science literacy should be taught in science classes so that students can identify misinformation (Sharon et al., 2020).

Table 5. Group Discussion Skills

Information	Amount of data	Average
Pbl+cm	36	67
Scientific approach	36	59

Students' group discussion abilities are rated using an observation sheet as part of the prerequisite analytical test. The normality of the Kolmogorov Smirnov test is the first necessary analytical test. Table 6 displays the results of the group discussion abilities normality test.

Table 6. Group Discussion Skills of Normality Result Test

Learning Model	Sig.	Conclusion
Pbl+cm	0.111	Normal
Scientific approach	0.123	Normal

Table 6 indicates that the whole data has a significance value greater than 0.05, indicating that the data is normally distributed.

Table 7. Group Discussion Skills of Homogenity Test Result

Information	Sig.	Conclusion
Group discussion skills	0.109	Homogeneous

Based on Table 7, it indicates that group discussion abilities have a significance value of 0.109 ($p<0.05$), implying that all data is homogenous. Testing for prerequisite analysis has been done, and an independent sample t-test is used to evaluate the hypothesis using posttest data. Table 8 displays the hypothesis testing result.

The outcome of the t-test of student science literacy is shown in Table 8 with a value of sig = 0.000. As a result, the value of sig 0.000 ($p<0.05$) indicates that Ha is accepted and H0 is rejected; in other words, the CM-assisted PBL model significantly influences the disparity in science literacy between the experimental and control classes.

Table 8. Result of the Science Literacy Independent Samples T-Test

Science literacy	T-test for equality of means		
	t	df	Sig. (2-tailed)
Equal variances assumed	-6.638	70	0.000
Equal variances not assumed	-6.638	69.303	0.000

To enhance students' comfort level and foster their critical thinking abilities, a variety of learning models have been established. One such model included in the 2013 curriculum is Problem Based Learning (PBL) (Susilawati et al., 2022). Students become familiar with the problem-based learning approach via the use of the PBL model, enabling them to connect it to tangible topics related to the human reproductive system. Moreover, combined with the CM strategy, students can remember scientific concepts in the material on the human reproductive system. The research study's findings showed that the students' mind mapping skills fell into the "good" category. When it comes to keyword density and content depth, students are adept at creating mind maps. Students frequently overlook the categories of pictures, colors, and branches while creating mind maps (Nugraha et al., 2020). Additionally, using PBL might boost student enthusiasm to study (Fatimahwati et al., 2021).

Applying CM-aided PBL model can increase the ability of science literacy. PBL also aims to improve students' academic freedom and social skills. Students can develop independent learning and social skills by collaborating to locate appropriate knowledge, tactics, and learning resources for solving problems (Saputra, 2020). The PBL paradigm allows students to be active and independent in stringing information. Furthermore, PBL helps develop problem-solving abilities since it assigns issues that require students to assess and solve the difficulties at hand (Permata et al., 2022).

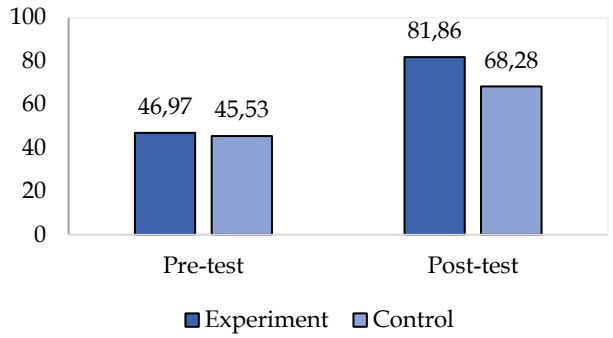

Figure 1. Comparisons of pretest and posttest science literacy abilities

In this research, learning model used CM-aided PBL can prove that the model is effective with the strategy, compared to scientific approach, this learning model shows the difference of posttest value. The average of CM-aided PBL model prove a higher value than scientific approach. Figure 1 shows the average of posttest experiment is 81.86 and posttest control is 62.28. The assessment of scientific literacy in 15-year-olds, as measured by PISA scores, offers educators, researchers, and policy makers a worldwide perspective and point of reference. The development of students' attitudes, sense of responsibility for environmental awareness, and level of interest, motivation, and engagement in science are all aided by school science (Oliver et al., 2020). An innovative learning model is focused on students to understand creativity in solving problems, innovative learning models are needed by teachers to increase students' scientific literacy (Townley, 2018).

Table 9. Result of Group Discussion Skills Independent Samples T-Test

Science literacy	T-test for equality of means		
	t	Df	Sig. (2-tailed)
Equal variances assumed	-5.739	70	0.000
Equal variances not assumed	-5.739	66.538	0.000

Table 9 shows that the group discussion skills t-test result has a value of sig = 0.000. In other words, this indicates that there is a substantial effect of the CM-aided PBL model to enhance group discussion abilities between the experimental class and control class. The value of sig 0.000 ($p<0.05$) indicates that H0 is rejected and Ha is accepted. PBL involves students engaging in scientific activities through group projects (Rerung et al., 2017).

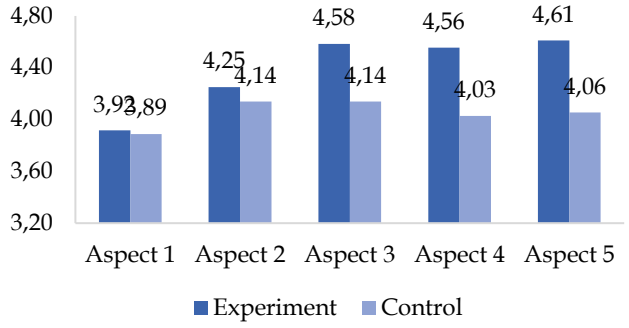

Figure 2. Comparisons of experiment and control score for each aspect

Figure 3 group discussion skills demonstrate the distinction between the scientific method and the CM-assisted PBL model. CM-aided PBL model can help the student to develop group discussion skills. Figure 2 shows that the highest score is aspect number 5, the characteristic from PBL is based from a problem, from the problem student can explore, analyze which each other. Students actively will discuss the problem. A fit models can help the other things more effective and efficient. We observe that students are actively involved in discussions with their groups, and create quality work products (Anderson et al., 2020). Student performance is enhanced when the problem-based learning approach is used in conjunction with mind mapping. This outcome is seen in the way that students participate in groups (Yusniza et al., 2023). According to Nuha's research study's findings, the Mind Mapping method is influenced by students' creative application of learning outcomes; students' creative mind mapping product creation falls under the creative category. Participants' comprehensive learning outcomes and high-quality education come in second and third, respectively (Nuha et al., 2020).

Figure 3. Presentation in group discussion

Differences in science literacy and group discussion skills located in learning models. The models show that PBL more effective with CM than scientific approach. Figure 4 illustrates how the use of a CM-aided PBL model may assist students in developing concepts, gaining additional information, and deriving solutions from their literacy. By teaching students this aspect of science literacy, they should be able to recognize that scientific misinformation can come from little evidence or from faulty reasoning based on large volumes of data. This implies that the ability of content knowledge provides opportunities to acquire scientific literacy, through PBL science literacy is taught in class to identify misinformation, and it is implied that knowledge in the form of content can provide science literacy through the PBL model. PBL with CM substantially effects or is successful in improving science literacy and group discussion abilities, as indicated by the significance value calculation results, which reveal a value of 0.000.

Assessment of group discussion skills is an attitude assessment. Students follow a series of learning processes and the teacher assesses the attitude of each student based on the criteria that become the reference.

At the time of the research, the teacher asked the observer to help the process of taking values for each group discussion activity. On average, students took part in group discussions well, structure, students were active in group discussions, but some students also seemed unfocused during discussions. The results of this study are consistent with the findings of Anderson et al. (2020) which indicates that, we observe that students are actively involved in discussions with their groups, and create quality work products.

Figure 4. CM-aided PBL in experimental class

Students who have broad insight into the subject matter will try to study the problems given by the teacher, look for reference sources and try to share tasks with each other. This can facilitate the work of each student so that they can achieve the goal of finding a solution. McCrum believes that the habit of thinking to find problem-solving needs to be practiced continuously, which means that the habit of thinking to solve problems must be accustomed to and practiced continuously (McCrum, 2017).

Students who actively discuss will give their opinion related to the problem. Students will look for references if their opinions are considered lacking. However, students who are not active in discussions, lack knowledge about the problem will tend to follow the flow, agreeing with the answers of students who have more knowledge of the problems given. Problem solving depends on how students trying to think through the problem step by step. PBL is one of the learning strategies that may be utilized to cultivate 21st Century abilities, particularly those related to critical thinking. There is a learning syntax in PBL that may be utilized to encourage students' critical thinking in particular. Asyhari et al. (2021) argues that PBL gives students the chance to become more independent thinkers and problem solvers. Students can tackle challenges that the teacher poses by being able to examine this particular problem. The process by which an individual may become more independent in his thought process is known as problem-solving capacity.

Interaction between PBL and CM to increase science literacy and group discussion skills improve students' knowledge ability and discussion skills. Both model and strategy involve students actively seek out information, manage information, analyze data, and articulate thoughts or concepts to solve issues. Furthermore, because the CM-aided PBL approach necessitates that students share their perspectives with one another during discussions, using it in groups can help students improve their group discussion abilities. The PBL model combined with mind mapping, according to Khairunnisa et al. (2022), impact on students' creative thinking because the PBL model pushes students to tackle everyday issues,. This research found that PBL classrooms were more interesting than conventional classes. It encourages students to consider the current systems in a topic of discussion and is closely related to the particular issue being discussed (Meilinda et al., 2018).

The hypothesis test has a significance value of 0.000. It is assumed that there is an interaction between CM-aided PBL to raise science literacy and CM-aided PBL to improve group discussion abilities. Research by Putri et al. (2023) the PBL paradigm is used in learning by presenting students with real-world issues and then allowing them to actively participate in developing answers in discussion groups. Another researcher found that using idea mapping as part of a learning technique provides benefits such as making it easier for students to grasp and develop, as well as connecting different sections of a topic. According to Asril (2018), the mind mapping approach can help students study more effectively. The research findings of Ristiliana et al. (2022) indicate that mind mapping can enhance student learning process. This method is anticipated to help student's better grasp the topic being studied (Bilik et al., 2020). This condition corresponds to study findings from Adodo (2013), which suggest that mind mapping might help students perform better.

Conclusion

Based on the study's findings, the conclusion is that PBL with mind mapping is beneficial in boosting science literacy and group discussion skills concurrently. PBL using mind mapping is moderately helpful in improving science literacy and group discussion skills. This study also shows that there is a significant positive relationship between scientific literacy and group discussion skills.

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Author Contributions

Conceptualization, K. R. P. L. M. M.; methodology, K. R. P.; validation, L. M. M.; formal analysis, L. M. M.; investigation, S., and E. M.; resources, K. R. P. and A. T. P.; data curation, L. M. M.: writing—original draft preparation, K. R. P and L. M. M.; writing—review and editing. All authors have reviewed and approved to the published version of the manuscript.

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Conflicts of Interest

The authors have declared no conflicts of interest in this study.

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