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STEAM Integrated Project Based Learning Exploration Against Understanding the Concept of Static Fluids

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Abstract: Conceptual understanding is the capacity to grasp a variety of learning resources in which pupils are able to not only recognize and know the concepts, but also re-express them in a way that is easier to understand and apply. Students' conceptual comprehension skills in STEAM-integrated Project Based Learning on static fluid materials are the focus of this study. This study was carried out with the use of an embedded experimental model of mix methods. The participants in this study are 36 senior high school students of grade XI in Salatiga. Students' concept understanding exam scores at the pre-test and post-test were used to generate quantitative data. The test scores were examined using the statistical description test, normality test, t-test, N-Gain score, and Effect size. Qualitative data was gathered through students' interviews following the completion of the pre- and post-tests, it was analyzed using Abraham's concept understanding level category (1992). There is improvement of students' conceptual understanding, i.e. 16,66% students improved from partially understand to understand; 66,66% students improved from partially misconception to partially understand; and 16,66% students improved from misconception to partially misconception. Thus, the conceptual understanding of most of the students improved after they experience STEAM-based Project Based Learning.

Keywords: Static Fluid; STEAM-integrated Project Based Learning; Conceptual understanding

Introduction

Physics is one of the concepts in science that often creates many misconceptions among students. One material that has many misconceptions about physics is static fluid material. Students' conceptual understanding of static fluid material is still in the low category (Setyawan et al., 2017). Based on research conducted by Jannah & Ermawati (2020) there are 37.3% of students' misconceptions, 13.7% of students do not understand the concept and 2.6% of students fall into the category that cannot be categorized in Static fluid material (Jannah & Ermawati, 2020). In addition, based on research conducted by Sheila (2021), there is the highest percentage of misconceptions, namely 81% on the concept of hydrostatic pressure (Inggit et al., 2021). This research was also strengthened by research conducted by Putri and Supriana (2017) explaining that most high school students' understanding of fluid concepts was still in the low category. This is because students have difficulty understanding the concept of static fluid (Saputri & Suyudi, 2020). The misconception that usually occurs in static fluids is that students think that the pressure felt at a larger cross section is different from what is transmitted to a smaller cross section. In addition to this, students also assume that hydrostatic pressure is affected by the cross-sectional area of the vessel when the depth of the two containers is the same (Jannah & Ermawati, 2020). The correct concept states that the pressure felt at a larger cross section is the same as being transferred to a small cross section. If the misconception is maintained, of course students will have difficulty understanding the concept (Yuliati, 2017).

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Conceptual understanding is the main factor for student success during the physics learning process. Concept understanding is an individual's ability to understand a particular concept, that is when a student has the ability to translate, interpret, conclude a concept or the ability to grasp the meaning of a concept. (Mulyawati & Nana, 2020; Salim et al., 2018). Currently, Indonesian students' understanding of concepts is still relatively low because teachers are still hesitant to try new learning models, causing students to have difficulty understanding concepts (Sadiqin et al., 2017). The learning process in the 21st century requires students to have critical thinking skills and problem solving (Fatmah, 2021). Students need a good understanding of the concept because it is the basis of problem solving abilities (Yana et al., 2019). Therefore a good understanding of the concept can be built by applying the right learning model (Arni et al., 2019). There are various learning models that can be used to make it easier for students to understand the concept of static fluid. One of them is by using the Project Based Learning learning model (Artiawati et al., 2016).

Project Based Learning is often used in various learning processes, because it can train students to be more active, creative and critical. Project Based Learning is a learning model that emphasizes contextual learning and is designed to solve complex problems (Syakur et al., 2020; Priantari et al., 2020). In this model students are required to design, solve, decide, investigate, and give students the opportunity to work alone so that the teacher only becomes a facilitator (Suherman et al., 2020). Through the Project Based Learning learning model students get a positive influence in increasing understanding of concepts (Komarudin et al., 2020). Furthermore, the thinking process of students in completing projects requires a learning approach. One learning approach that is suitable for Project Based Learning is Steam (Annisa et al., 2019).

STEAM (Science, Technology, Engineering, Arts, Mathematic) is a development of STEM that integrates five disciplines in creating problem-solving ideas. In STEAM the addition of the "Art" element is intended to increase student involvement in developing creativity, innovation, communication, adaptation, teamwork, and problem solving skills (Cholily, 2020). One of the arts that can be applied to static fluid materials is fine art. Through STEAM students are encouraged to think comprehensively to solve problems based on aspects in STEAM. These aspects aim to train critical thinking students to have techniques or designs in solving problems (Saddhono et al., 2020). In this approach the emergence of problems does not necessarily start from engineering, math, or science problems but can come from everyday life (Herro et al., 2017). STEAM can improve students' understanding of concepts in learning which includes student learning outcomes, student activities, and student responses to learning (Estriyanto, 2020). The importance of STEAM is very important to increase creativity, innovation, collaboration, and critical thinking in order to succeed in facing life's challenges that are increasingly complex and full of uncertainties and also succeed in life and career in the world of work (Redhana, 2019).

This study aims to determine students' conceptual understanding abilities on static fluid material through STEAM-based Project Based Learning (STEAM PjBL). Through this learning model and approach, students are expected to understand the concept well in static fluids.

Method

This study uses mixed methods research, with an embedded experimental design. The subjects in this study consisted of 36 high school students in Salatiga. In this study, data collection techniques used test instruments with indicators according to Anderson & Karthowohl (2010) which includes cognitive processes namely interpreting, giving examples (exemplifying), classifying (classifying), summarizing (summarizing), drawing inferences or inferring (inferring), comparing (comparing), and explaining (explaining). There are pre-tests, post-tests, interviews and documentation in data collection.

In addition, data collection techniques by conducting unstructured interviews were conducted with several students to confirm answers and explore knowledge related to students' conceptual understanding of static fluid material. The learning steps using STEAM PjBL can be seen in Table 2.

The data obtained from this study will be analyzed quantitatively and qualitatively. Quantitative data were obtained from students' conceptual understanding test scores during the pre-test and post-test, the results of the test scores were analyzed using the statistical description test, the normality test, the different test scores of pre-test and post-test, N-Gain score and effect size, While the qualitative data were obtained from the results of student interviews after completing the pre-test and post-test, the results of the interviews were analyzed by category of level of understanding of the concept according to Abraham 1992 as shown in Table 3.

Table 2. Learning Steps in Project Based Learning

Work steps	Activity	STEAM Connections
Fundamental question	Learning begins with essential questions. Students often have difficulty understanding concepts in static fluid material. The teacher gives a video related to the material that will be taught. The video contains a broken dam.	Science Technology
Design product planning	Planning contains the rules of the game, group selection, information search and project design that can support problem solving, knowing the tools and materials needed to complete the project.	Engineering Art Science Technology
Arrange production schedule	Students collaboratively arrange a schedule of activities in completing the project. Activities at this stage include making a schedule for completing the project, and determining the final time for project completion. The agreed schedule must be mutually agreed upon so that the teacher can monitor learning progress and work on projects outside the classroom.	Techonolgy
Monitor project progress	The teacher monitors student activities while completing the project. Monitoring is done by students sending videos when making projects, because project work is outside of class hours. After the project has been completed, the results are tested and recorded by students and a report is made.	Techonolgy Engineering Science Art
Outcome assessment	Assessment is carried out by each group, presenting the results of the project in front of the class. Accompanied by an explanation of why students use the design by relating the concept of static fluid and re-testing the project. The teacher assesses creativity (shape, color) and assesses how the concept is used by students.	Mathematics Science Techonolgy
Evaluation	At the end of the learning process the teacher and students reflect on the understanding of the concepts and results of the projects that have been carried out. Students are asked to express what they experienced while completing the project. After that students are given a number of questions so that the teacher really knows their understanding of the concept of static fluid.	Science Mathematics

Table 3. Categories of Concept Understanding Levels

Comprehension category	Characteristics of Student Answers
Understand the Whole (F)	Answer is correct and contains all scientific concepts
Partial Understanding (PS)	The answer is correct and contains at least one scientific concept and does not contain one concept error
Partial Misconception (MS)	The answer gives some correct information but also shows a conceptual error in explaining it
Misconceptions (M)	The answers show a fundamental misunderstanding of the concepts being studied
Don't Understand (TP)	Wrong answer, irrelevant/answer only repeats the question, and the answer is empty

(Abraham (1992)

Result and Discussion

Based on the results of the descriptive analysis, the average pre-test and post-test scores of students' understanding of the static fluid material respectively were 23.44 and 68.43. These results indicate that students' understanding of concepts increases after STEAM integrated Project Based Learning is applied in the learning process. This is also supported by the Wilcoxon Signed Rank Test with Asymp.Sig. (2-tailed) 0.000 which indicates that STEAM integrated Project Based Learning has an effect on increasing students' understanding of concepts. In addition, the increase in students' scientific literacy can also be seen from the N-gain and effect size obtained respectively, namely 0.58 in the medium category and 0.90 in the strong category.

The increased understanding of each student's concept of static fluid material can be seen in Figure 1.

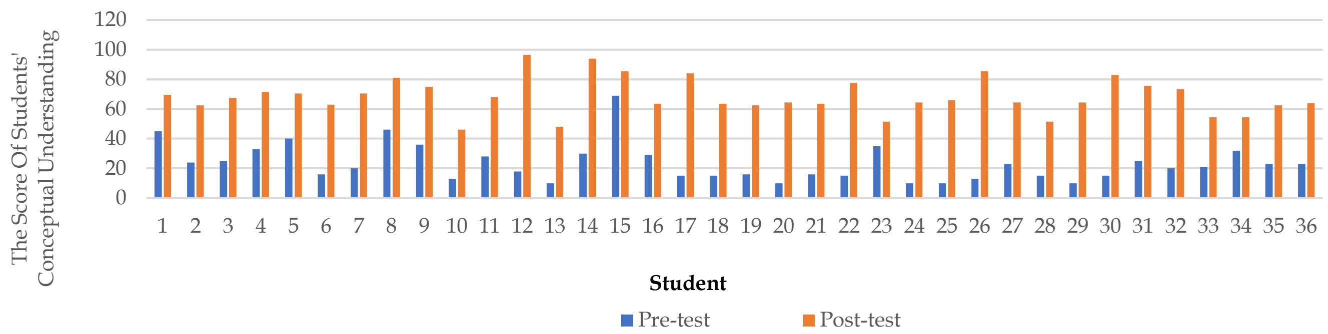


Figure 1. Understanding of the Pre-test and Post-test Concepts for Each Student

Based on observations during learning, students can respond to the activities provided by the teacher well and enthusiastically. In addition, in making projects, students come up with creative ideas. Learning that produces products and involves students in solving problems makes it easier for students to understand concepts. Based on the results of student interviews, they argue that learning by producing projects makes students easy to understand and can develop creativity. Not only that, students can explain the application of concepts in everyday life, not only in theory. This is consistent with the results of research (Anis et al., 2021) that the integration of STEAM and PjBL together can become a learning innovation that can generate ideas, creative and critical solutions, making it easier to solve a problem (Fitriyah & Ramadani, 2021). In addition, the PjBL STEAM learning model has a very good influence on student interaction on high school students' creative thinking skills in terms of understanding physics concepts (Rohman & Husna, 2021). Students feel happy and motivated to learn using the STEAM PjBL model, and feel that learning using the STEAM PjBL model helps students understand physics learning material (Lestari, 2021). This learning process also involves the teacher, where the teacher's role is as a facilitator who directs students to think further in solving problems, so that students are provoked to find their own answers (Dewi et al., 2021). Thus, learning using the PjBL STEAM approach increases students' understanding of concepts.

The categorization of students' conceptual understanding of static fluid material in this study used Abraham's assessment (Dhiasari, 2006) namely understanding (P), partial understanding (PS), partial misconception (MS), misconception (M), and not understanding (TP). The percentage of students' scientific literacy for each category in the pretest and posttest is shown in Figure 2.

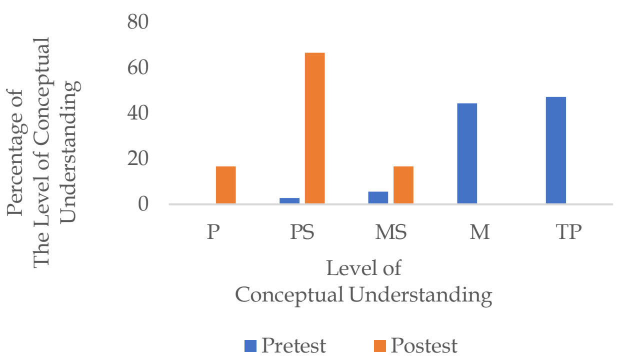


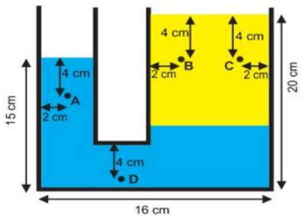
Figure 2. Percentage of Scientific Literacy of Students for Each Category

During the pre-test, it was seen that the students' answers were in 4 categories, namely PS (2.77%), MS (5.56%), M (44.4%), and TP (47.27%). Based on these data, most students are in the category of not understanding (TP), where most students solve problems in general without connecting them with scientific concepts. (Corrigan et al., 2007). Whereas for students who are in the Misconceptions category (M), most of them answer questions based on their daily experiences, but have not been able to package them in a scientific concept. This causes some students to experience misconceptions when solving a given problem (Mufarridah, 2015). This is consistent with the research conducted, after being taught using STEAM integrated PjBL from the post-test results, students' understanding of concepts changed into 3 categories namely P (16.67%), PS (66.66%), although there were still some students who remained in the MS category (16.67%). This shows that most students have been able to use the correct concepts in solving problems and are able to develop and relate their understanding to other science concepts, although there are still a small number of students who experience misconceptions. These results are in line with several previous studies which stated that most of students' conceptual understanding was in the understanding (P) and partial understanding (PS) categories after being taught using STEAM integrated PJBL (Rohman & Husna, 2021). Students in the understanding (P) and partial understanding (P) categories are actively involved in learning because learning is carried out in groups, where each is asked to solve problems through making projects. In addition, through STEAM-integrated PJBL students can easily apply the material obtained into everyday life. The student learning process becomes more interesting, where students are also required to be able to think critically and be able to work in teams or groups to shape students' creativity and learning experiences with real projects (Na'imah et al., 2015). Increased understanding of students' concepts can be trained through the learning syntax of STEAM-integrated PJBL, especially in the "product design and planning" and "product assessment" steps. This is because in the product design and planning step, students must be able to find a suitable solution to a given problem with their conceptual abilities. Meanwhile, there is a product assessment step that aims to test products/solutions in solving problems. In some cases, students test the products they make from predetermined conditions, the results obtained are used to improve on the previous steps. In another model, at this stage students learn a broader context outside of STEAM or make connections between STEAM disciplines (Jauhariyyah et al., 2017).

An example of students' conceptual understanding of static fluid material in the post-test can be seen in Table 4. In Table 4 there are examples of student questions and answers in each category.

Table 4. Examples of Student Questions and Answers for Each Category

Question:



A U-shaped tank as shown in FIG. 2 is filled with different liquids. Water is blue (ρ = 1000 kg/m3) and oil is yellow (ρ = 500 kg/m3). If the pressure at point A is PA, the order of hydrostatic pressure at points A, B, C, and D from smallest to largest is...

a. $P_A = P_B = P_C < P_D$
b. $P_B = P_C < P_A < P_D$
c. $P_D < P_A < P_C = P_B$
d. $P_A = P_B = P_C = P_D$

Understand

"Because PB and PC have the same density because they are in the same or parallel liquid and pressure. Pc is smaller than PA because the density of PC (oil) is smaller than the density of PA (water). PA is smaller than PD because it is under/bottom of the water will be greater than the top pressure"

Partly understand

"Because the location of points B and C are closest to the surface so that the hydrostatic pressure is the smallest when compared to point A which is in the middle and point O which is the farthest and F from the surface"

Partial misconception

"The reason I answer this is because the pressure PB=PC has the same pressure while PA and PB are less"

Based on Table 4, students in the understanding category choose option B and think that the density of PB and PC is the same because both points PB and PC are located in the same or parallel liquid and pressure (depth); (pressure at) PC is smaller than PA because the density of PC (oil) is less than the density of PA (water); (the pressure at) PA is less than (at) PD (because PD) lies below or the bottom (so PD) will have greater pressure than the pressure (at points above) above it. Based on the results of interviews, they argue that when connected vessels of different shapes are given the same amount of hydrostatic pressure, the pressure in each vessel is the same, because hydrostatic pressure is not affected by the shape of the container or vessel. This is in accordance with research put forward by Sofiuddin et al. (2018), that the shape and volume of the vessel does not affect the amount of hydrostatic pressure. In addition, Estianinur (2021) also states that depth and density affect the amount of hydrostatic pressure, but the shape of the container does not affect (Estianinur et al., 2021).

Furthermore, students in the partially understood category chose option B and argued that because the location of the PB and PC points is closest to the surface, the hydrostatic pressure is the smallest when compared to the PA point which is located in the middle and the PD point which is located farthest from the surface. Based on the results of the interviews, students believed that the pressure on the piston was transmitted in all directions equally and did not explain the concept as a whole. Whereas in the concept of Pascal's Law, it is stated that the pressure exerted on one part of a liquid in a closed room will be continued by the liquid in all directions equally. This is in accordance with research put forward by (Wanda et al., 2019) that the magnitude of the force that occurs in the vessel associated with different cross-sectional areas is the same (Puspita et al., 2019). This is also in accordance with research put that when a hydraulic pump is given a compressive force on a piston which has a small surface area, it will generate pressure in a closed space, where the pressure exerted will be transmitted equally in all directions. so that the piston which has a large area can be lifted easily.

Then, students in the misconception category chose option C and argued that PB and PC had the same pressure, but PA and PD had less (less) pressure. The correct concept states that the greater the depth, the greater the hydrostatic pressure felt by the object. According to the student, PB and PC have the same pressure; this statement corresponds to the correct concept. However, the pressure on PA and PD is less than on PB and PC; this statement does not correspond to the correct concept. So students answered correctly for PB and PC but answered incorrectly for PA and PD. This means that students experience partial misconceptions. Based on the interview results, students still think that the deeper an object sinks, the greater the hydrostatic pressure and the density of the substance has no effect. Whereas in the concept of hydrostatic pressure, the deeper an object sinks in a liquid, the greater the pressure it will receive, depending on the depth of the liquid, the density of the liquid, and the acceleration due to gravity. This is in accordance with research put forward by Anis, et al (2021) that students' difficulties in determining hydrostatic pressure are not only influenced by the volume and shape of the vessel, but students also have difficulty determining hydrostatic pressure in vessels that have different density of substances. . The same thing was stated by Rosalina, et al (2021) who stated that the hydrostatic pressure in water is the same even though the depth points are different; In addition, the hydrostatic pressure of water is the same as that of oil when it is at the same depth (Hamundu et al., 2021). Thus, the results of the interviews strengthen the analysis using crosstabulation.

Next, students in the misconception category chose option D and argued that there was a balance between the mass of water and its area. From the students' answers, it can be seen that the density of the substance in the vessel and the cross-sectional area of the vessel. Even though the correct concept states that an object sinks in a different type of liquid, the resulting hydrostatic pressure is of a different magnitude, but if an object sinks in the same type of liquid with a different shape of the vessel, the resulting hydrostatic pressure is equal to the depth. object, the acceleration due to gravity and the density of the liquid. This means that students experience misconceptions.

Students in the do not understand category chose option C and argued that pressure was seen from the shape of the vessel. From the student's answer, it can be seen that the student determines the pressure based on the shape of the vessel. Even though the correct concept states that the amount of hydrostatic pressure depends on depth. This means that students do not understand the concept of hydrostatic pressure.

Conclusion

From this study it appears that there was an increase in students' understanding of concepts after being taught the STEAM integrated Project Based Learning learning model, namely 16.66% of students increased from partial understanding to understanding; 66.66% of students increased from partial misconception to partial understanding; and from 16.66% students increased from misconception to partial misconception. Therefore, it can be concluded that the understanding of the concept of most students increased after getting learning using the STEAM-integrated Project Based Learning learning model. because teachers cannot see directly and fully control student activities in completing the products produced, because face-to-face meetings are limited. Alternative solutions to these weaknesses can be considered for further research.

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Author Contribution
The process of writing this paper was carried out with the cooperation of all team members.

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Conflicts of Interest
The authors declare no conflict of interest.

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