

Conference Paper

Laboratory Work Package with Authentic Assessment to Develop Collaborative Performance Skills of Physics Education Students

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Abstract

Electromotive force is one of the abstract subjects that require laboratory work for better understanding of its concepts. This research aims to develop a package of electromotive force laboratory work using authentic assessment. The other benefit expected is that students experience collaborative performance skills. The method is research and development in order to get expert recommendation on the feasibility of a laboratory work package for induced electromotive force and the use of its results. Hence, the expected outcome of this research is a package of laboratory work on induced electromotive force. Results of data analyses show that experts recommend the use of induced electromotive force laboratory work package as a medium in the learning process as it comes with meaningful experiences. These results show that students performing the laboratory work package on induced electromotive force understand the concept better and they also learn collaborative performance skills.

Keywords: induced electromotive force, collaborative performance skills

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1. Introduction

Scientific activities in the laboratory allow students to manipulate instruments, develop scientific attitude, and improve collaborative performance skills. Students get hands-on experience in solving problems based on observed phenomena or investigations made. Moreover, students can also find prove for and test theories. Over the past five years in Universitas PGRI, physics education students' chance to carry out experiments in the laboratory is only limited to laboratory works of the following subjects: Introduction to Physics 1 (one credit in semester one), Introduction to Physics 2 (one credit in semester two), Fundamentals of Electronics 1 (two credits in semester three), Fundamentals of Electronics 2 (two credits in semester four), and Experimental Physics (in semester five). The average number of credits taken by students for each semester is 20 to 22.

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Students' ability to apply conceptual knowledge, understanding it, and analyzing it, should be facilitated with laboratory work. Moreover, performance to improve psychomotoric ability of students as future physics teachers can also be trained in the laboratory (Dunnett et al., 2018. Khoiri et al., 2017. Samsudin et al., 2012). The other aspect that also affects learning process and results in physics is the teachers themselves. That is the methods teachers use to teach and how they understand physical concepts. These will affect students' academic ability as well as their thinking pattern in dealing with problems (Kurnia F., et al., 2014).

A learning process oriented toward laboratory work can encourage higher level thinking. Higher level thinking skills does affect students' ability in understanding physical concepts, in terms of the theory and experiment (Wilcox et al, 2017, and Ramos, J.L., et al., 2013. Susilawati et al., 2016). Those skills include mastery of the mathematics, the theories, the principles and laws in physics, and also the relationships of those facets using proper symbols (Abdullah et al., 2013, Huda et al., 2016).

The goal is to find a strategy that will help physics education students to become educators having the ability perform and collaborate in a team with one single mission to create skillful human resources for the future. Independence and creativity must also be instilled in order for them to inspire their students to also be independent and creative. Regulation the Ministry of Education and Culture or Permendikbud (2013) mentions that high school students should be taught to be skillful, able to live independently, able to meet their own needs, and to prevail in the world. Students must understand the concept of electromotive force and its application. And this understanding must be accompanied by an ability to design laboratory work package on induced electromotive force along with a guideline to apply that very concept. This means that students must master both the theoretical and experimental concepts of electromotive force to teach to their future students.

The concept of induced electromotive force serves as the foundation for the development in electronics, engineering, and mechanics. This concept is recommended for development as to allow creativity in applied physics. One of the main indicators of good teachers who can compete in the global world is their ability to develop experimental instruments along with the whole experimental set up. This research aims to develop a package of Induced Electromotive Force laboratory work using authentic assessment to improve collaborative performance skills among students of physics education.

Students aspiring to be physics teachers are now required to keep up with the ever changing science, technology, and work that are even more complex by mastering the necessary skills and intelligence. Therefore, physics education students must train their

skills, and able to face the real world by understanding the real content and context of physics teaching (Akbar, 2013).

Design of this laboratory work package is expected to help physics education students to have the proper collaborative performance skills to encourage them to come up with inspiring products of great value. Those facts underlie the need for a laboratory work package of induced electromotive force that boosts students' collaborative performance skills.

2. Method

This research employs the research and development method. According to Gall & Borg (2003), *Research and Development* is a development model industry-based with the result used to design new procedures and products. This research consists of planning, execution, evaluation, and revision (Sugiyono, 2014). Design for research and development of laboratory work package of induced electromotive force consists of seven (7) stages. First is the need and potential identification, which tries to analyze the abstract and not easy to understanding concept of electricity.

Second, design of induced electromotive force instrument, which involves a mini research to design a prototype that will inspire students by providing them with hands-on experience. Third, laboratory work guideline outlining, which involves outlining the systematics of experiment, the theoretical foundation, the instruments and materials required, the work flow, and the observation sheet. Fourth is construction of induced electromotive instrument. This prototype consists of DC ampere meter, DC voltmeter, coil, power supply, Wheatstone bridge, resistance box, rheostat, and connecting wires.

Fifth is authentic evaluation questionnaire outlining, which will be used to evaluate the collaborative performance skills of students. Evaluation questionnaire comprises indicators of instrument and material preparation, experiment design, instrument construction, measurement, instrument manipulation, observation, data collection, and experiment testing. Collaborative performance skills indicators include communication, task provision, discussion, argumentation, contribution, and solution finding in the team.

Sixth is laboratory test, which is carried out at the prototype trial stage in order to gain accurate data from the induced electromotive force experiment. Seventh is expert validation, which is aimed at getting recommendation on the proper use of instruments, both theoretically and experimentally. Eighth is evaluation and revision, which is the stage of improvement based on laboratory results and expert recommendation(s). The last step is limited test, which is carried out on one specific group of students in order to

find out the proper description of collaborative performance skills of physics education students.

The method used during the limited trial stage is quasi-experiment using post-test-only control design. The research instruments use are validation sheet, concept understanding problems, observation sheet of collaborative performance skills of physics education student. The validation sheet consists of 15 statements containing expert opinion and recommendation on the proper instrument for induced electromotive force experiment. This validation sheet is developed based on the Likert scale. Analyses of validation results are descriptive-qualitative in nature.

Test for induced electromotive force laboratory work package is meant to prove that this set can show electromotive force for varied sets of coils. Observation is a technique involving thorough examination and systematic recording of the data obtained (Arikunto, 2013). Observation in this research is a technique of data collection in order to measure collaborative performance skills among students. The collaborative performance skills observed include determination of instrument and material, instrument design, instrument construction, observation, measurement, procedure planning, task provision, discussion, argumentation, data analysis, and decision making in the team.

3. Result and Discussion

Results of this research describes the design of laboratory work package for electromotive force, the effect of that laboratory work package on students' understanding, and on the collaborative performance skills among students.

3.1. Design on induced electromotive force laboratory work package

Laboratory work package for induced electromotive force is designed based on analyses of electricity and magnetism concepts. The topic of electricity and magnetism is very conceptual in everyday life. Hence, students need more provision to better understand the concept and application of electricity and magnetism. Other than that, teaching aids in most schools are also very limited. The laboratory work designed here includes some learning aspects of observation, verification, and simple experiment. The laboratory work design is meant to be finished in six (6) weeks involving stages of sub-topic determination, progress of varied usage of laboratory work package, and testing of the instrument, and also data collection.

The instrument for this laboratory work package uses some components, including AFG, coils of 180, 360, and 540 variations, parallel LED light, and a 24 ohm speaker. The first experiment made use of coil variations of 180, 360, and 540, which are connected in turns for long and short distances in order to figure out the tone of the speaker. The second experiment made use of coil variations of 180, 360, and 540, which are connected in turns for long and short distances in order to figure out luminance of the LED light. Other than those two variations, the students were given assignments in the form of questionnaire containing questions and data tabulation.

The questions in the questionnaire include, among others: (1) mention the instrument and material used for electromotive force experiment, along with the function of each component, (2) state the theoretical foundation that of electromotive force experiment, (3) describe the experiment design, (4) outline the experimental procedure for two data collection variations, (5) construct the experiment instrument and material, (6) tabulate observation data, (7) perform data collection, (8) analyze collected data, and (9) draw conclusions.

3.2. Expert validation on the induced electromotive force laboratory work package

The induced electromotive force laboratory work package is validated by an experts on experimental physics, Sigit Ristanto M.Sc. Results of this validation show that the package developed here is recommended for use by students of physics education to be used in their teaching in high school and students of physics education themselves. The indicators included in this validation include; (1) appropriateness of the instrument and the intended goal, (2) technical quality, (3) appropriateness with the learning environment, (4) practicability, flexibility, and durability, (5) relevance to the topic taught, (6) ease of use, (7) clear and net packing, (8) appropriateness with the target, (9) appealing appearance, and(10) simplicity.

3.3. Induced electromotive force laboratory work package and students' conceptual understanding

Students' conceptual understanding after using the laboratory work package is represented with a score of 73. Students' conceptual understanding after studying the concept of electromotive force is represented with a score of 45. The average scores

for students' understanding on the topic of electromotive force for each indicator are given in Table 1.

TABLE 1: Students' Average Conceptual Understanding.

Concept Understanding Indicator	Experimental Class	Control Class	Score Difference
Translation	79	52	27
Extrapolation	75	39	36
Interpretation	67	44	23

Conceptual understanding in the experimental class show that the highest score is for translation indicator, whereas the lowest score is for interpretation indicator. Conceptual understanding in the control class show that the highest score is for translation indicator, while the lowest score is for extrapolation indicator.

3.4. Induced electromotive force laboratory work package and students' collaborative performance skills

Data of students' collaborative performance skills were treated with normality and homogeneity tests in order to find out whether the sample comes from a normally distributed population or the other way around, as depicted in Table 2.

Results of *pre-test* normality test for control class $L_0 < L_{table}$ is $0.12 < 0.14$ and therefore, H_0 is accepted. Hence, it can be concluded that the control class comes from a normally distributed population. Results of *pre-test* normality test for experimental class $L_0 < L_{table}$ is $0.13 < 0.14$ and therefore, H_0 is accepted. Hence, it can be concluded that the experimental class comes from a normally distributed population.

TABLE 2: Students' Collaborative Performance Skills.

Class	N	L_0	L_{table}	Conclusion	χ^2_{hitung}	χ^2_{tabel}	Note
Control	25	0.12	0.14	Normal	0.034	3.84	Homogeneous
Experimental	25	0.13	0.14	Normal	$t_{calculated} = 4.60$ $t_{table} = 1.67$		

Homogeneity test is used to find out whether the sample comes from a homogeneous population or the other way around. Homogeneity test is carried out using the Bartlet test. Results of homogeneity calculation show values of χ^2_{hitung} 0.034 and = 3.84. Therefore value < value, which is $0.034 < 3.84$ for 5% error of both group samples have the same variant or homogeneous.

Results of parametric statistical test using t-test show values of $t_{calculated}$ 4.60, compared to t_{table} 1.67 dk 48 for 5% error. Comparison of $t_{calculated}$ and t_{table} yields $t_{calculated} \geq$

t_{table} at $4.60 \geq 1.67$, which means that there is a significant effect of the use of induced electromotive force laboratory work package on students' collaborative performance skills. A description of collaborative performance skills between the experimental and control groups are given in Figure 1.

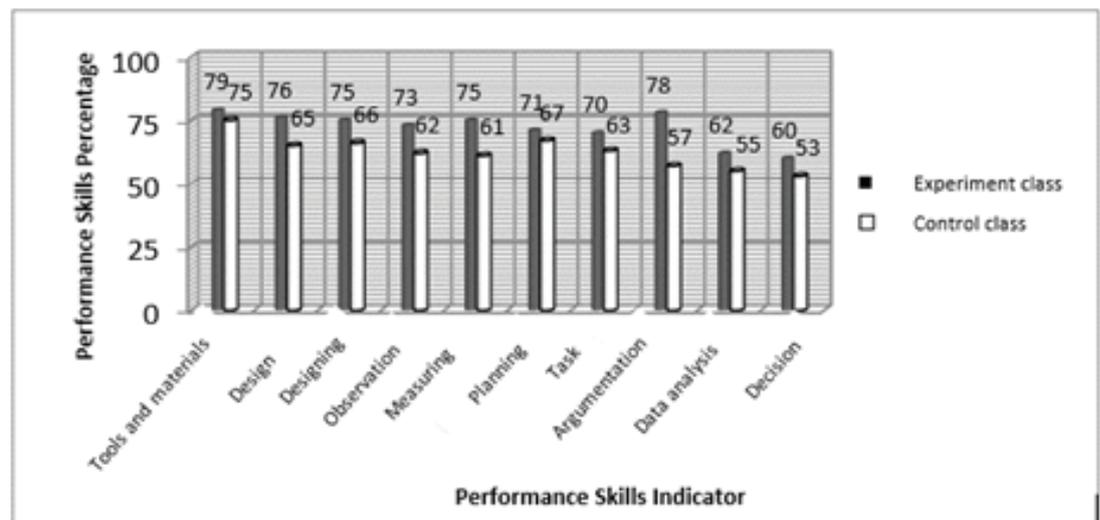


Figure 1: Description of Collaborative Performance.

In the experimental class, high performance skills indicator is the ability to determine the instrument and material as well as the argumentation skills in the team. Low performance skills indicator is the ability to make decisions and analyze data. In the control class, high performance skills indicator is the ability to determine the instrument and material. Low performance skills indicator is the ability to make decisions and analyze data.

The use of induced electromotive force laboratory work package to evaluate students' collaborative performance skills is observational. Other than that, the test is given to get a description of students' conceptual understanding concerning both the material content and the performance skills. During laboratory work, the observer examines some skills indicators performed by students.

Students' conceptual understanding indicators include translation, extrapolation, and interpretation skills. Both experimental and control classes show high scores of translation skills, which is to explain physical concepts. Translation skills in the experimental class is higher than that of the control class as it is influenced by examination and argumentation activities during laboratory work (Brazdeikis & Masaitis, 2012). Students' collaborative performance skills indicators cover the ability to determine instrument and material, to design the instrument, to construct the instrument, to examine, measure, plan, and execute procedures in the team, to provision assignment in the team, to argue

in the team, and to analyze data and to make decisions (Trilling *et al*, 2009; Wattimena *et al*, 2014; Wycliffe & Ayuya, 2013, Andersson, J. *et al.*, 2017).

The highest score for collaborative performance skills in the experimental class is the skills to determine instrument and materials. This due to the fact that the instrument and materials used are easy to obtain and very much known by most students that they can even make the instrument themselves. In the experimental class, indicator of instrument and material determination has higher score compared to that of the control class as students here are more skillful as they have carried out the experiment during their learning process. Students can easily choose and make sensors, galvanometer, AFG, connecting wires, bar magnets, varied coils, ruler, speaker, and LED lights to use. Students are able to explain the function of each instrument and material, and they can pick the proper variations of those instrument and material.

Some obstacles found in students' collaborative performance skills is the difficulty in distributing assignments related to collaborative skills. It is hard to control the role of each group member, who is dominant. Some group members also have limitations in their understanding of the induced electromotive force concept, and the measurement devices are mostly digital, which hampers the development of some basic skills.

Other than that, during discussions to nurture students' argumentative ability, only some dominant students take the roles. Time for data collection is also limited that students only understand their own part of the experiment. The arguments put forward during the many discussions are about planning for instrument and material, experimental design, instrument design, planning for experimental procedure, difficulties in data analyses, and decision making.

Laboratory work involves the process of constructing conceptual understanding, and applying the concept using proper skills (Susilawati & Khoiri, N., 2014). Induced electromotive force laboratory work promotes students' collaborative performance skills. Differences in the description of examination results between the experimental class and the control class show the effect of induced electromotive force laboratory work on the collaborative performance skills of physics education students. Conceptual understanding and collaborative performance skills of the class performing induced electromotive force laboratory work package is higher compared to the class only shown the demonstration of induced electromotive force and having discussion on that subject.

4. Conclusion and Suggestion

The design of induced electromotive force laboratory work package makes the use of easy to obtain and affordable electronic components such as wire for coil, magnet, multimeter, DC ampere meter, DC voltmeter, power supply, and connecting wires. This prototype of induced electromotive force is used to show the concept of induction by electromotive force. Application of induced electromotive force laboratory work package can improve students' understanding, as evident from results of initial and final tests on their understanding of the induced electromotive force concept. Application of induced electromotive force laboratory work package can improve students' collaborative performance skills. The collaborative skills and performance observed include determination of instrument and material, instrument design, instrument construction, observation, measurement, procedure planning, task provision, discussion, argumentation, data analysis, and decision making in the team.

Suggestion for further research in the field is to design an instrument that can directly be planned by students for one laboratory work purpose and equipped with some supporting laboratory work variations. Collaborative performance skills can further be developed by integrating some collaborative performance skills indicators into creative production of ready to use instruments. Furthermore, understanding of the induced electromotive force concept will certainly lead to its applications.

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