Lesson Learned: Improving Students’ Procedural and Conceptual Knowledge through Physics Instruction with Media of Wave, Sound, and Light

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Abstract. This study aims to enhance students’ procedural knowledge in physics instruction focuses on wave, sound and light. Two classes at class XI of SMA N 1 Pakem are involved in the instruction as an experiment and control classes (conventional instruction). Each class consists of 32 students. This instruction is conducted with physics media which is developed to demonstrate phenomena of wave, sound and light. Assessment of procedural knowledge measures students’ skill on making of preparation, creating of design, and write down a way of data collecting in order to examine their hypothesis. Data are gathered through test, observation and documentation then analysed to achieve the improvement of skills descriptively with normalized gain. Findings reveal that physics media help students to initiate their skills on proposed the preparation of the experiment, design and determine a procedure to get the evidence. Moreover, students in the experiment class are better than control class in improvement of procedural knowledge. It can be inferred that physics media give more benefits in improving students understanding of wave, sound, and light concept.

1. Introduction

Physics instruction addresses to lend some skills for students in order to notice physics phenomena in daily life. Characteristics of physics as the basic science directs the students to practice the skill in finding the problem, identify the cause of the problem, design a solution and test solutions for problems as it finds answers to problems [1]. As a consequence, they perceive solution to work out some problems related into physics concept. Physics as part of science should be taught thoroughly both theoretical and practical aspects. Physics teachers arrange the materials which is combined theoretical and practical then present into physics classroom and physics laboratory. So as to, many teaching strategies are developed and implemented to enhance students’ achievement in physics concept and laboratory skills while doing experiment to make sure some physics concepts. Learning by doing in physics activities will facilitate the students to improve their physics understanding. Learning physics in high school/MA requires of experimental activities are supported by a good understanding of the concept [2]. Head on, most physics teachers have difficulties in initiative how to assemble theoretical and practical in the physics classroom which is attended the students in physics
understanding. Thus, the completion of physics laboratory does not hold up physics instruction so the creativity of physics teacher is needed to facilitate experiment activities in the laboratory. Hence, teaching and learning media are needed to demonstrate physics phenomena or to mock up physics concept. Moreover, the teacher should not be reliant on the government aid. They have to initiate and create by themselves.

It is customary for physics teacher to use physics media as a tool for teaching physics content and considering if that content has been acquired. As well, teacher often have a target of helping students put up physics knowledge [3] or improving their skills while studying in or out the classroom. Indeed, many media creators and physics teacher collaborate to design an appropriate physics media which is supported physics instruction. Unfortunately, for many teachers, creating physics media may pretend a tremendous challenge mainly because they have had little or no skill experiences during teacher preparation programs [4]. Weak skills in designing and choosing teaching methods or teaching media will lead to less learning process in accordance with the desired learning objectives. Media or learning resource is a helpful tool in teaching and learning. Teaching media can assist learners overcome difficulties in understanding the concept and also can generate good feedback from learners. By utilizing the media, teachers can make learning more engaging learners. However, in the use of media in the learning process, teachers also should not be arbitrary, must be in accordance with the objectives to be achieved by improving and maintaining the attention of students to teaching and learning, motivate, and encourage students to learn.

In general, teacher in teaching physics much emphasis on the provision of information and are reluctant to carry out learning activities using props or conduct laboratory activities. Physics teaching methods do not have to memorize, but need to have a method that can encourage learners to apply what is learned into daily life. Learning physics can not only do learners with listening activity, look, memorize, without experiencing it directly. Practical activities related to procedural and conceptual knowledge. Conceptual knowledge is knowledge that refers to an integrated and functional understanding. Students who have a conceptual understanding can see the relationship between concepts and procedures and can give an argument to explain why some facts are the result of the fact than others. Procedural knowledge includes various algorithms were created as a tool to find more specific results appropriately. Procedural knowledge is often reflected in the students’ ability to connect an algorithmic process with a given problem situation, to do the right an algorithms and communicate the results of the algorithm in the context of the problem [5]. Procedural knowledge is closed to science process skills that supporting the student for being better in laboratory activities. Science process skills into the necessary tools to learn and understand physics concept, is also an important goal in physics education. Not only scientists, but also of all individuals in society must have these skills in order to be literate in science (physics), and to solve problems encountered in daily life [6]. Learning of wave, sound and light in high school is designed to prepare the students being aware of physics problem in daily life according to those concepts. Moreover, teaching-learning process in the physics classroom especially for teaching wave, sound, and light with teaching media is interested to know.

2. Research Method

Physics media to show physics phenomena in wave, sound and light is developed through ADDIE model then implemented into physics classroom with pre-test and post-test design as implementation step. This study conducted with analysis, design, develop, implementation and evaluation phases. In the analysis phase, instructional problem’s clarified, the instructional goals and objectives are established and the learning environment and learner’s existing knowledge and skills are identified. The design phase deals with learning objectives, assessment instruments, exercises, content, subject matter analysis, and lesson planning or media selection. Then, in the develop phase, physics media is created and assembled including the content assets. Physics media is developed and/or integrated technologies. Hence, it is reviewed and revised according to any feedback and suggestion given. Two classes at class XI of SMA N 1 Pakem are involved in the instruction as an experiment (EC) and control classes with conventional instruction (CC) in the implementation phase. Each class consists of 32 students. This instruction is conducted with physics media that is developed
to demonstrate phenomena of wave, sound and light. Additionally, formative and summative evaluation conducted in the evaluation phase. Both of them designed for domain criterion-related referenced items and provided opportunities for feedback from students (users) [7].

3. Results and Discussion

Physics media of wave, sound and light is created based on findings in the analysis phase. So, characteristics of high school students, the instructional goals and objectives, and learning environment are identified. Additionally, design of the media is created including assessment instruments, exercises, content of subject matter, and lesson plan. All of these teaching materials are developed and reviewed by experts (media, pedagogical and content experts). Expert judgment states that all of instruments are valid and appropriate to implement in the physics instruction for teaching wave, sound and light.

According to determine an earliest baseline of students’ conceptual and procedural knowledge, a preliminary test of procedural knowledge is given to experimental and control class in the implementation phase. Two sets of test are designed, namely test section A and B. Test section A is used to determine the conceptual knowledge of students in the sound waves and light materials, in particular the concept of resonance in the air column enclosed organ pipe, grating diffraction and polarization on the selective absorption. Then, test section B is used to determine the science process skill of students in the sound waves and light materials, in particular the concept of resonance in the air column enclosed organ pipe, grating diffraction and polarization on the selective absorption.

| TABLE 1. Level of conceptual and procedural knowledge of students |
|---------------------------------------------------------------|
| Value/Percentage | Rate |
|------------------|------|
| 80-100           | Excellent |
| 60-79            | Good |
| 40-59            | Adequate |
| 20-39            | Weak |
| 0-19             | Very weak |

Students’ achievement in the test of section A indicates that both of two classes have similarities ability in conceptual knowledge about wave, sound, and light. Table 2 reveals these achievements in adequate and good category for conceptual understanding of wave, sound, and light.

| TABLE 2. Students’ achievement on conceptual knowledge (pre-test) |
|---------------------------------------------------------------|
| Concept                                         | Scores/ Percentage | Level of |
|                                                | CC  | EC  | CC   | EC   |
| The air column resonance in a closed organ pipe | 45  | 55  | adequate | adequate |
| Diffraction Grating                               | 67  | 65  | good  | good  |
| Polarization on the selective absorption of        | 60  | 67  | good  | good  |

Previously, students have not done a test of procedural knowledge while doing experiment in the physics instruction. It can be inferred from the result of procedural knowledge test as shown in Table 3. Both of two classes (CC & EC) are in weak category of ability such as classifying, doing experiment, formulate a hypothesis, control variables, planning investigation and collecting data.


### TABLE 3. Students’ achievement on procedural knowledge (pre-test)

| Ability Type                      | Procedural Knowledge                              | Percentage of students answered correctly (%) | Average Percentage (%) | Category |
|-----------------------------------|--------------------------------------------------|---------------------------------------------|------------------------|----------|
|                                   |                                                  | CC  | EC | CC  | EC | CC  | EC |               |
| basic science process skills      | classifying                                      | 30  | 35 |     |    |     |    |               |
|                                   | doing experiment                                 | 45  | 40 |     |    |     |    |               |
| integrated science process skills | formulate a hypothesis                           | 20  | 30 |     |    |     |    | weak          |
|                                   | control variables                                | 25  | 30 | 37  | 38 | weak | weak |               |
|                                   | planning investigation                           | 60  | 55 |     |    |     |    |               |
|                                   | collecting data                                  | 42  | 40 |     |    |     |    |               |

All evidences show that there is a lack of skill in doing experiment, and so this has an effect on conceptual knowledge. Regarding the achievement on procedural knowledge, for example, classifying, formulate a hypothesis, and control variables, only a minority of students have a good ability while doing some activities in the physics laboratory. And so, the findings highlighted diversity among the students in conceptual and procedural knowledge.

Bringing about physics media in the learning process will make a new academic atmosphere in the classroom. Directly, students will disclose some phenomena and record them into their memories. It is effective to improve the students’ motivation and enables them to be active during the learning process. As a result, the laboratory activity can be used as an alternative to activities in the literature [8]. It is better for the teachers to appraise and experiment with the media instead of they bring and demonstrate the media in the classroom or laboratory. By this step, more difficulties and resistances could be diminished. Thus, teacher can construct and identify some skills that will be trained to the students.

Teaching-learning about wave, sound, and light in the physics classroom and implement these concepts into daily life will have an effect on students’ motivation in physics learning. Thus, physics media enhance physics instruction being more comprehensive. Students will be more aware on conducting experiments look like the scientists do. They can classify kinds of physical quantities as variables (controlled, dependent and independent variables), conducting experiment, formulate a hypothesis and test it, planning investigation, and collecting data. For that reason, physics media is needed as a bridging tool to address the learning objectives, conceptual and procedural knowledge are involved. Physics media of wave, sound, and light can demonstrate some physics occurrence such as air column resonance in a closed organ pipe, diffraction grating, and polarization on the selective absorption.

Teacher arranges the class into a small group of 4 to 5 students while conducting laboratory activities. Thus, each group is given a set of physics instruction media to investigate some evidence related into physical concept of air column resonance in a closed organ pipe, diffraction grating, and polarization on the selective absorption. They are not only observe, measure, record data but also formulate hypothesis, designing and planning investigation before doing the experiment. At that
moment, they have to interpret facts with supported literature they can reach online and/or offline. These data should be informed and narrated in oral presentation. Additionally, their scientific literacy abilities are kept in shape. It is essential because of although physics teacher at all levels have focused on teaching students scientific literacy for nearly five decades, studies point at that the average student remains outlying from scientifically literate [9].

Physics instruction with media has motivated student for doing better in learning process. Thus, it brings a good impact for learning goals and learning objectives. According to the achievement at post-test of conceptual knowledge about physical concept of wave, sound, light, it indicates that there is a significant improvement of students’ achievement as shown in Table 4.

### TABLE 4. Students’ achievement on conceptual knowledge (post-test)

| Concept                                      | Scores/Percentage | Level of |
|----------------------------------------------|-------------------|----------|
|                                              | CC    | EC    | CC    | EC    |        |
| The air column resonance in a closed organ pipe | 77    | 85    | good  | excellent |
| Diffraction Grating                          | 80    | 90    | excellent | excellent |
| Polarization on the selective absorption      | 75    | 89    | good  | excellent |

Furthermore, all activities which are accomplished by the students, address them being better in the improvement of their abilities for procedural knowledge. As shown in the Table 5 below.

### TABLE 5. Students’ achievement on procedural knowledge (post-test)

| Ability Type              | Procedural Knowledge | Percentage of students answered correctly (%) | Percentage (%) | Category |
|---------------------------|----------------------|---------------------------------------------|----------------|----------|
| basic science process skills | classifying          | 70                                          | 75             | CC  | EC  | CC  | EC  |        |
|                            | doing experiment     | 70                                          | 80             |        |        |      |      |
| integrated process skills  | formulate a hypothesis | 75                                          | 85             |        |        |      |      |
|                            | control variables    | 65                                          | 75             |        |        |      |      |
|                            | planning investigation| 70                                          | 70             |        |        |      |      |
|                            | collecting data      | 75                                          | 80             |        |        |      |      |

According to students’ performance while doing procedural knowledge test, both of classes are still inadequate in planning investigation. Utilization of physics media in physics instruction give
more impacts on conceptual and procedural knowledge. As shown in the Figure 1 below, students’ achievement at experimental class is better than controlled class.

![Figure 1](image-url)  
**Figure 1.** Students’ achievement on conceptual knowledge of wave, sound, and light

Physics media also lead the students on improving their procedural knowledge. It contributes better than conventional instruction as shown in the Figure 2 below.

![Figure 2](image-url)  
**Figure 2.** Students’ achievement on procedural knowledge of wave, sound, and light

According to the improvement of conceptual and procedural knowledge at EC and CC for pre and post-test, hence it can be inferred there is a rising improvement of both abilities. Normalized gain for EC and CC in the improvement of conceptual and procedural knowledge as shown in the Table 6 below.

| Aspect          | Normalized gain (%) |
|-----------------|---------------------|
| Conceptual knowledge | CC (Controlled Class) | 11,11 50 |
|                | EC (Experimental Class) | 15,40 44,4 |

Table 6. Percentage of normalized gain for CC & EC
As said by the normalized gain, it makes clear that physics media facilitates students to commence their skills on proposed the preparation of the experiment, design and determine a procedure to get the facts. Teacher who treats the media for physics instruction will enthuse and encourage other in developing media or teaching strategy. So, the students are assisted to achieve more than 80% of all competencies in the curriculum of physics for Senior High School student [10].

4. Conclusion

Physics instruction delivers some skills to grant the students in problem solving of obstruction in their daily life. Students will treat all competence while teaching-learning process accommodates their abilities with the medias. Hence, the impact of this students achieve learning goals and learning objectives including (1) improved understanding of the physics concept, scientific process and the nature of science; (2) improved understanding of procedural knowledge looks like scientist does; and (3) improved understanding of the applicability of scientific methods to real-world problems in daily life activities. Additionally, percentages of normalized gain for conceptual and procedural knowledge are 50% and 44.4% in EC. Importantly, the findings suggest that the integration of physics media into introductory subject matter, in a scientific process context, is an effective way to promote conceptual knowledge, procedural knowledge and scientific literacy as well as to provide opportunities for students to understand and apply the knowledge and skills necessary to perform scientific research. This example of physics media redesign provides a model that can be transferred to other physical concept as well as to other teaching materials in physics.

5. References

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