STEM-based Project for Everyday Life Created by Pre Service Students and Its Implication of Pedagogical Competence for Science Teacher.

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Abstracts, STEM Education has become framework of lifelong, life-wide, and life-deep across the word in Science Education. Some research investigated about how student comprehend science concept and its related into technology, engineering and mathematics lead to science conception in more deep insight. Pre service science teacher has important role to build and disseminate STEM approaches into science teaching practices. This study aims to investigate how preservice science teacher create STEM-based project concerning on essential science concepts. About 72 pre service students of Science Education Study Program in STEM course involved in this study who work in group of four students each. During eight weeks they begin with group discussion, group presentation to share their project idea, supported with journal review, preparing project, designed first project, peer review, improving project until finalizing projects. About eight from eighteen titles of their projects have been selected to be deeply analyzed further because of similar based science concept referred to changes in electrical energy into motion in some various project they created. The title projects are: a) electric broom; b) simple mixer; c) mini vacuum cleaner; d) Air conditioner recharge; e) blender; f) earth rotation; g) locomotive; h) mini generator. Based on group discussion, group review, and interview there were found seven kinds of their understanding of STEM begin with lack explanation of scientific reason, theoretical explanation only, good explanation of scientific reason, ability to apply STEM in daily life, lack implementation of Reduce-reuse-recycle, and good implementation of reduce-reuse-recycle. Implication of STEM-based project into science teaching learning material have been discussed.

Keyword: Pre service, STEM-based Project, everyday life, pedagogical competence.

1. Introduction

Research concerning on STEM Education has become framework of lifelong, life-wide, and life-deep across the word in Science Education. Its implication has become new insight into students, teacher and how the practice of science learning could be developed.

STEM Education give insight comprehensively in science learning because of practicing students reasoning to promote high order thinking skills. Reasoning is a crucial thinking skill in the growing interest of STEM across the globe. The improvement of increasing higher order thinking skills mainly in reasoning domain, has become main need in developing countries not only in Indonesia but also in Malaysia [1]. STEM Education has also promoting inquiry-based learning that is meaningful for science teacher. A survey to determine the effectiveness of Inquiry-Based Learning Program showed...
the benefits to teachers and their profession and all teachers agree that the program has been well-managed and meet the objectives set and successfully led to a change in attitude, motivation and enthusiasm for teaching and learning [2].

STEM is studied by students all over the world. White women perceived their STEM professors cared about them and their learning the most while women of color reported the least perceived care. Notably men, regardless of race, reported similar perceptions of professor care. Students commonly report their STEM courses were lecture-based but say they would prefer more active approaches. In particular, women who left STEM majors reported more lecture-based instruction while stating the highest preference for active learning environments. Perceiving their professors cared was related to a greater sense of belonging in STEM. Students who reported active classrooms also reported more professor care in their STEM field. Active teaching environments may positively impact students’ sense of belonging and desire to continue in STEM and that this impact may be higher for underrepresented students [3].

There is an interaction effect between news media and what is learned in “school science” about STEM disciplines and their practices. In general school science develops an understanding of science that the public “has” when it leaves school. Traditionally this has been a very structured or definitive view of science that little resembles science as it is engaged in by scientists. Thus as adult, the public encounter the news media representations of STEM issues in news media, even in science call-in shows, which also offer a description of research and knowledge growth in STEM disciplines that also doesn’t well reflect STEM research as it is practiced [4].

Students routinely developed chemistry-driven criteria within and across groups to explain the nature of dissolving ionic solids in water. Moreover, resultant sociochemical norms led to shifts in student understanding and the ways in which students reasoned about the causes of chemical phenomena under study. Group dialog influenced individual student conceptions of ionic compounds in solution and highlight the need to engage students in instructional activities that not only engage them in the multiple ways of representing chemical knowledge but also making public their views and participating in classroom discourse [5].

Related to learning STEM, participating in a community of practice is related to the use of student-centered and active learning techniques. Instructors who were members of a community of practice were much more likely to employ student-centric practices, such as asking questions, following up, and engaging in discussion, and much less likely to use instructor-centered practices, such as lecturing. In addition, students in these classes were more likely to be actively engaged in problem-solving activities rather than passively listening. Communities of practice are a potentially effective mechanism for enhancing student learning and retention by increasing the use of active learning practices by STEM instructors. These communities are particularly effective when they consist of small, disciplinary teams working on the same course(s) and are linked with other individuals or groups that use evidence-based instructional practices [6].

STEM is very crucial for pre-service science teacher. The effects of both pre- and post-matriculation academic achievement on the likelihood and timing of high-achieving student departures from STEM majors at elite universities. While there has been robust research on persistence in STEM as a whole, survival analysis to investigate the timing of events is still a novel tool to investigate departure from STEM majors. Using longitudinal data collected at Harvard, secondary analysis was conducted to examine the research questions using discrete-time survival analysis. The researcher found that demographic characteristics of the students in the sample were not significant in predicting time-to STEM major attrition. However, verbal achievement was found to be the most significant predictor of STEM major attrition, with higher levels of verbal achievement leading to higher levels of attrition from STEM majors to non-STEM majors [7]. By considering science teacher competence, STEM role in daily life, this research aims to investigate STEM-based Project for Everyday life Created by Pre Service Science Teacher and Its Implication for Science Teacher Competence.
2. Methodology
About 72 pre service science students of Science Education Study Program in STEM course involved in this study who work in group of four students each. During eight weeks they begin with group discussion to review some STEM Projects exhibited by Elementary students and Secondary students then prepared and designed first project. Each group presented and demonstrated their 1st project idea based on you tube, home tools, and their own idea. Others group made assessment to respond to group project by using rubrics [8]. Then discussed and analyze each project based on component of science, technology, engineering, and mathematics. Almost each group assumed that their project created based on one science theory such as Pascal Law, or Faraday Law, or Newton Law.

Based on suggestions from group assessment, each group continue to improve project by reviewing some relevant journals to complete each project theory. Each group use information from 4 journals. These journal were discussed during two meetings to revise and finalize their project. Review Journal aims to select, consider, and determine which meaningful information from previous researches that can be meaningfully used for revising each project. Next week later they presented and demonstrated their 2nd revised project through displaying short creative video.

3. Findings and Discussion
About eight from eighteen titles of their projects have been selected to be deeply analyzed further because of similar based science concept referred to changes in electrical energy into motion in some various project they created. The title projects are: a) electric broom; b) simple mixer; c) mini vacuum cleaner; d) Air conditioner recharge; e) blender; f) earth rotation; g) locomotive; h) mini generator.

Description of these STEM Project selected are as follow. Each STEM Project is referred to science theory, technology implemented, engineering designed, and mathematics formula measured.

As one of essential science concepts, energy and its changes into various shape of energy [9] have attracted student to review, discuss, create, and design various STEM projects. They designed some electrical household appliance and other electrical devices by modifying some secondhand material into useful and functional devices.

3.1 Electrical Broom
This electrical broom is designed based on science concept of electrical energy changes into motion energy. By adding battery capacity students learned that the more battery capacity the faster broom spin. Refered to vacuum cleaner robot, students learned about integrated six subsystems that produce optimum system to detect environment, sweeper, sucker, controller, lap counter, and power supply, that allowed it easier and more efficient rather than ordinary broom. Simply by stringing switches and dynamo, manipulating broom material, students can create electrical broom that improves conventional broom that will make easier used at home.

3.2 Vacuum cleaner
Referred to concept of electrical energy changes into motion energy, students modified plastic bottle, putting dynamo inside, adding dust filter, dynamo move the propeller then suck out dust particles outside. Students also learned additional information came from filter, simple vacuum cleaner suction, Maze and PID method on automatic vacuum cleaner robot.

3.3 Air Conditioner Recharge
Referred to science concept of changes of electrical into motion energy and changes of solid form into liquid and gas. By reusing used helmet, put on ice cube, conditioning temperature inside and small fan which can be recharged, allow to create movable, saving electricity air conditioner recharge. The air conditioner absorbs hot air from outside, then experiences condensation inside the AC machine [10].
3.4. Blender
Blender also implement science concept about electrical energy changes into motion energy. It refines food ingredients easier and fast. The stringing tools consist of used bottle, zinc shaped like knife, dynamo, battery, switch, then adjusting the battery voltage to move dynamo. It accommodates physical kit of circular motion and food blender machine [11].

3.5. Power Generator
This project referred to science concept of Faraday Law: if there is a change in the magnetic field connected to a closed loop wire, it will cause an electromotive force. Technological aspect implemented in this project dynamo 5.9 volt connected to CD through manpowered, it changes motion energy into electrical energy then produce light energy by LED 2 volt. This project showed using secondhand materials into mini electric power. Students found that if dynamo voltage is larger than LED voltage, LED lights on. Electric motor & hydroelectric power plant have enhanced students understanding about the miracle of Lorentz-Faraday Law [12-14].

3.6. Locomotive Train
Another students project that referred to science concept of changes electrical into motion energy is locomotive train. Using dynamo to move kits made of some secondhand material such as can tire, switch, paper boxes, controller wheels made from bottle caps. In mathematical aspect, students count train speed per second, fix body of boxes train. Students also learn about its maintenance information system helped by web and gateway, making more precise calculation to minimize locomotive damage, and create better locomotive operation [15-16].

3.7. Earth Rotation
This project referred to science concept about electrical energy changes into circular motion energy and electrical energy changes into light energy. Begin with series electrical circuits completed by lamp and dynamo. Paper boxes resembles outer space, black paper, white paint splash resembles stars and others celestial bodies, added by layers of the earth’s atmosphere, then aligning the position of sun and earth.

Calculating body mass on top of the dynamo in order to round the earth not so fast. Students found that there is relationship between body mass and the speed at which the earth rotates resulted from dynamo.

Students also have learned from journal literature that inquiry method to analyze the occurrence of day and night can increase early childhood understanding of science. Earth rotation and revolution is very important in formulating and determining pray time too [17-18].

3.8. Simple Mixer
This project referred to science concept of changes electrical energy into motion energy. Battery is a voltage source that can flow electricity in dynamo so that it can spin. Used pipes enabled as electronic mixer holder by using battery as current source. Dynamo component 5.9 V is changed into 9V in order to spin faster, while wire mass is enlarged. Students found that the more voltage source the greater the current generated to spin direct current motor, the stronger the round to mix. They also understand better by reviewing information from literature about controlling the direction of motion of drilling machine blades using computer, dough mixer for fiberglass arts craftsmen, design of a microcontroller based biogas mixer MCS51, and design of liquid soap mixer based on ergonomic principles [19-21].

Some students show good ability and creativity to create project by using secondhand materials especially plastic. Only a few students still have difficulty to identify technological aspect of STEM project, and differentiating between technological and engineering aspect of STEM. In all of the theme sessions it was apparent that for STEM education to improve, it will take an inter-disciplinary, if not trans disciplinary approach. Most faculty are not sufficiently trained to address the complex issues of equity, problem-solving, and computational thinking in the STEM classroom; much has entered the
different disciplines in a piecemeal and almost ad-hoc fashion and is overdue for a more systematic exploration within and across disciplines. Equity and inclusivity are generally not components of a graduate student’s education. STEM faculty are experts in their disciplinary content and methods, but rarely in the sociology of their scientific community.

Similarly, while STEM faculty are generally very good problem-solvers or coders, they have not been educated in how to unpack these large skill sets for students as much of their own learning happened by doing and in an unstructured fashion. Studying the role of meta-cognition in or common misconceptions in computational thinking is key for aiding students, in particular, those that come equipped with fewer skills, support, or confidence but no less ability. By having conversations across the disciplines, especially the social sciences, STEM faculty may be able to make advances in research on equity, problem-solving and computational thinking.

Tested an adapted version of social-cognitive career theory (SCCT; Lent et al., 1994, 2000) with a self-selected, diverse sample of middle-school students attending a Saturday STEM Academy through regression model showed that math/science motivation (T1), family support for engineering (T1), outcome expectancies (T2), and interest (T2) were significant predictors of (T2) goal intentions; whereas self-efficacy was non-significant as has been shown in much previous research [22].

![Figure 1. Pre Service Science Students Competence of STEM Concept categorized into excellent, good, average, and weak.](image)

The competence is measured based on these aspects of STEM: a) The Important of STEM in science teaching learning; b) Project-based Learning syntax, c) analyzing basic competence and formulating learning objectives; d) STEM components of each technological device; e) Designing project to solve problem in a village without electricity; f) Identifying and analyzing STEM learning scenario about environment changes; g) Designing STEM learning scenario about environment changes; h) designing relevant worksheet; i) designing appropriate media; and j) designing evaluation tools.

Based on group discussion, group review, and interview there were found seven kinds of their understanding of STEM begin with lack explanation of scientific reason, theoretical explanation only, good explanation of scientific reason, ability to apply STEM in daily life, lack implementation of Reduce-reuse-recycle, and good implementation of reduce-reuse-recycle. Implication of STEM-based project into science teaching learning material have been discussed.
Figure 2. STEM-based Worksheet created by Pre Service Science Students categorized into excellent, good, average, and weak based on assessing these aspects: objective and worksheet activity, STEM-based worksheet designed, grammatical structure of worksheet, measured operational activity, updated references for design worksheet, and worksheet layout.

Figure 3. STEM Lesson Plan created by Pre Service Science Students categorized into excellent, good, average, and weak based on assessing these aspects: School Identity, formulating learning objective, developing and organizing sources and learning material, integrated scientific approaches Learning syntax and STEM syntax, and designing and preparing evaluation procedure, type, and tools.

Such progress can help to increase the number and diversity of students in STEM pathways and improve students’ skill sets that can be utilized in all STEM disciplines and careers. Such conversations between individuals in different fields have to be slow and in-depth as there are many challenges to productive interdisciplinary or trans-disciplinary collaborations. While the atmosphere for the day provided ample opportunity for participation, it still was challenging to promote interaction of faculty beyond the day of the course.

Working groups were perhaps the most important in stimulating STEM projects, while the observation sheet offered a good way to present a variety of ideas. Because of the variety, however, it
was challenging to solidify emerging themes. We encourage group work to foster their interdisciplinary connections both within and outside their own STEM project and inquiry-based learning for enhancing their pedagogical competence.

STEM Education has important contribution into 21st century skills that enable students to have various abilities such as critical thinking, collaboration, creativity, communication [23],[24]. So that all components of STEM education need improving and increasing on support, material, efficacy, and teaching as well. There are many tools around us made and created based on basic science about changes from electrical energy into motion energy. Through STEM courses students are aware of some devices at home they found, that they consist of application of that energy changes like vacuum cleaner, power generator, blender, air conditioner, mixer. Beside as household appliance at daily life, blender and mixer can be useful media for teaching concept circular motion at High School [25], [26].

Based on their technological devices, better understanding about STEM, students can create through imitating, manipulating, and creating some simple or mini devices by using recycle materials around them: plastic, paper boxes, adding battery, dynamo into STEM creative projects

4. Conclusion

Most STEM-project selected and created by pre service science students referred to basic science about changes energy from electrical energy into motion energy and mathematical aspect to calculate its efficiency. All projects created, have good implication into teaching materials for Pre Service Science Students. It is proven that students who have good understanding about STEM concept can design STEM worksheet and Lesson Plan better than those with lack of STEM understanding.

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