Symposium

STEMization of Physics teaching: Effectiveness and challenges

Organizer: Nguyen Van BIEN

Abstract: STEM education has been implemented popularly since about 2005. STEM education fosters individuals in learning achievements, authentic problem-solving skills, interests in STEM sub-subjects, and pursuing STEM careers. Nowadays, many countries have deployed STEM education, including Asian countries, to achieve STEM values for students. With the development of STEM education, an ongoing challenge to pre-service science teachers (PST) is developing STEM teaching practice. Therefore, it is a significant concern to develop appropriate strategies for PST training programs in STEM education. We designed and implemented internationally the method course that strengthens modeling-based inquiry and integration of STEM education in Vietnam and Indonesia. The key features of the MII-STEM approach consist of real-world problems, constructing a STEM model, predicting, collecting data, testing solutions, and formulating hypothesis-proposal solutions. The results showed that PSTs positively changed perceptions of models and modelings. Besides, Indonesian PSTs had microteaching at acceptable levels.

However, successful STEM education required national conditions. One solution could be the implementation of specific subjects with the key features of STEM education, for example, innovative Physics teaching with STEM integration. In the following parts, we presented empirical studies of implementing STEM education in Vietnamese classes. Such empirical studies affirmed the successful implementation of STEM education in Vietnam.

Speakers:

Nguyen Thi To Khuyen: Impacts of method courses on Vietnamese pre-service teachers' perceptions and practices: From the perspectives of model and modeling in STEM education

R. Ahmad Zaky El Islami: MII-STEM Implementation in Indonesia: A Pilot Study

Nguyen Anh Thuan: Building STEM teaching materials for the topic “Energy and life” to develop scientific competencies of junior high school students

Tuong Duy Hai: The role of Coach 7 software in STEM education for primary and secondary school in Vietnam

Impacts of method courses on Vietnamese pre-service teachers' perceptions and practices: From the perspectives of model and modeling in STEM education

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Abstract. Model and model-based teaching need to be improved for pre-service teachers (PSTs) to implement STEM education successfully. We conduct two STEM-focus method course for 16 PSTs in Vietnam. The findings showed that the number of PSTs having a higher level of understanding of the model increased. PSTs gain a deeper understanding of STEM education and could transfer alternative perceptions of STEM education into STEM lesson plans. PSTs clarified and embedded Science and Engineering Practices in STEM lesson plans. In addition, PSTs had a positive view of the effectiveness of the STEM-focus method course.

1 Introduction

Vietnam is undergoing a critical nationwide education reform in which STEM education is emphasized as an essential factor. In this sense, the PST training program is a valuable means to contribute to the teacher resource in STEM implementation. According to Khan (2007), model-based learning is a theory in which students can learn from building, critiquing, and changing mental models of the way the world works. The modeling process in STEM education requires learners in transition between fields of study while engaging in science, math, and engineering design-practice activities. Accordingly, STEM disciplines become bound by a closely interrelated relationship (Gilbert et al., 2000). Nevertheless, few studies focus on model and modeling in integrated STEM education (Hallström, 2019). Presently, This study aims to address the following questions: (1) How is pre-service teachers' performance in model-based method courses? (2) How are pre-service teachers' feedbacks about the model-based method course?

2 Methods

We developed the method course, namely the MII-STEM course. Participants are 16 Vietnamese PSTs in Physics education. Most of PSTs (62.5%) were second-year students. The MII-STEM course included 6 lessons implemented in 10 classes (around 23 hours). We collected PSTs' journals for examining their performance and used videotape classrooms for triangulation analysis. Qualitative analysis was utilized to address research questions.

3 Results and findings

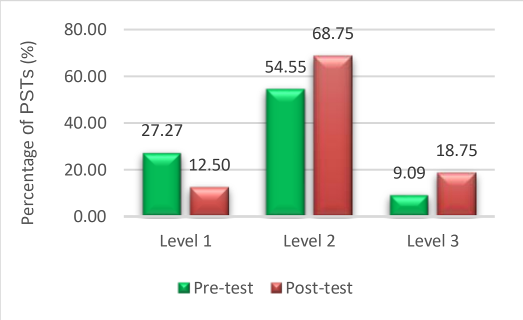

Figure 1. The percentage of PSTs' understanding about models following three levels

Pre-service Teachers' perceptions of models

The coding scheme development followed the ideas of Grosslight et al. (1991) as 3 levels of perceptions of models. PSTs mainly showed an understanding of models at level 2 (more than 50%). In comparison, there was a decrease of level 1 in pre-test (27.27%) to post-test (12.5%), PSTs' understanding of the model in levels 2 and 3 increase. The results affirmed that the MII-STEM course enhanced PSTs' understandings of models.

Pre-service Teachers' perceptions of STEM education

Vietnamese PSTs well-designed STEM activities containing STEM characteristics, such as relating to real-world problem solving and engineering design process (Bybee, 2013b; Moore et al., 2014), even before the MII-STEM course. However, most PSTs concerned about the range of integration of STEM sub-fields and followed the product-oriented teaching process. There were changes of PSTs' STEM lesson plan after the MII-STEM course: (1) product-oriented to process-oriented; (2) make Engineering more apparent; (3) focusing on developing students' science and engineering practices; (4) define how STEM sub-fields integrated into STEM lesson plans; and (5) using model and modeling in STEM activities.

PSTs adapted the effective instructional models in STEM education such as T-GEM (Khan, 2007a) and 6E (Burke, 2014). The engineering design process was more apparent when PSTs intended in students' learning process. Also, two SEPs (NRC, 2012), namely using math and computational thinking (SEP5) and Constructing explanations (for science) and designing solutions (for engineering) (SEP6), were frequently focused in PSTs' lesson plans. PSTs could point out how S, T, E, and M are integrated into lesson plans. For example, in the STEM lesson plan of "Anti-thief laser device", PSTs clarified knowledge in all STEM sub-fields. Also, PSTs pointed out the STEM education model in a lesson plan, which Science(S) as the home with separate rooms of T-E-M that are used as needed (Bybee, 2013a).

4 Conclusion

The MII-STEM course contributed to such a purpose in higher education. This current study affirmed the effects of the MII-course on PSTs’ perceptions and practices in STEM education. The embedding of modeling-based inquiry and integration in the method course as a framework for future research in higher education in Asian countries.

Acknowledgements

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MII-STEM Implementation in Indonesia: A Pilot Study

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Abstract. This study aimed to investigate the effectiveness of the model-based integrated inquiry in science, technology, engineering, and mathematics (MII-STEM) curriculum implementation to pre-service science teachers (PSTs) in Indonesia. Data were collected from observation, journal reflections, microteaching assessment results, and interview results. These results showed that the MII-STEM curriculum implementation in Indonesia effectively impacts PSTs' ability and attitude in the MII-STEM approach.

1 Introduction

Model and modeling can stimulate scientific inquiry (Wang et al., 2016). STEM Education refers to Science, Technology, Engineering, and Mathematics Education (Bybee, 2010). In this study, we combined model and modeling, inquiry, and integrated STEM approach to model-based integrated inquiry in science, technology, engineering, and mathematics (MII-STEM) (University of British Columbia, 2019). This study aimed to investigate the effectiveness of the model-based integrated inquiry in STEM (MII-STEM) curriculum implementation to PSTs in Indonesia. The key features of the MII-STEM approach consist of real-world problems, constructing a STEM model, predicting, collecting data, testing solutions, and formulating hypothesis-proposal solutions.

2 Methods

Mix methods are used in this study (Cresswell and Clark, 2006). This research was conducted at one state university in Indonesia. The instruments include observation notes, journal reflections, semi-structured interviews, microteaching assessments. The participants were 25 PSTs divided into five groups. One member in each group practiced MII-STEM approach through microteaching in 30 minutes. Data from microteaching were collected through an assessment instrument of eight aspects, including teaching purpose, science, and engineering practices, modeling, inquiry, the integration between S-T-E-M, overview and sequence of learning management, learning management steps according to MII-STEM and methods of measurement, assessment, and evaluation. The criteria of this microteaching assessment consisted of three categories; need improvement (mean < 2), acceptable (mean = 2 and mean < 3), and complete (mean = 3).

3 Results and findings

The data from journal reflections showed that PSTs gave positive responses in 13/15 meetings. However, they gave a negative response to two meetings, namely Teaching approach in MII-STEM, and without journal reflection on meeting for designing lesson plan. The example of the journal reflection from students with the interpretation positive is in the lesson of learning SEPs through scientist and engineer views. Students suggested that it needs good class management for this activity and needed a conclusion in the last meeting. PSTs are impressed that innovative learning can improve critical and creative thinking skills and fruitfulness and can increase the ability to design technology for learning. The example of the journal reflection from students with the interpretation negative is in the teaching approach lesson in MII-STEM. Students suggested that it needs deep thinking and more detail for explanation. Students are impressed that they are a little bit confused.

Furthermore, the data from the interview results of two PSTs indicate that they felt excited during MII-STEM curriculum implementation. They thought that this is a new teaching model that they learned. Another data from quantitative data showed that microteaching assessment results indicate all five PSTs were in the acceptable category for practicing the MII-STEM approach. The rubric score for all five PSTs conducting microteaching is more than 2.0, locating in the acceptable category.

These findings are supported by the MII-STEM curriculum's learning process that consisted of six lessons, including the nature of science and modelling, Science and Engineering Practices (SEPs), Integrated STEM, teaching approach for MII-STEM, assessment of modeling competencies, and microteaching practice. These six lessons that tought in 15 meetings consisted creating bubble wands, seed sort and growth, black box as a metaphor for nature of science, moon phase, learn SEP through Scientist and Engineer Views (period I and II), right the light LED to integrated STEM,; teaching approach in MII-STEM for pre-service or in-service teachers (period I, II, and III), assessment of student's competencies at modeling (period I and II), and microteaching (period I, II, and III).

All processes in the MII-STEM Curriculum help pre-service science teachers to have the ability to teach the MII-STEM approach because all processes from the beginning of the implementation until the end use the MII-STEM approach. So, they can implement the MII-STEM approach using microteaching well. The learning process uses constructivism so pre-service can find the concept by themselves (Vigotsky, 1978). It is important to make the learning more meaningful.

4 Conclusion

The MII-STEM curriculum implementation in Indonesia is effective towards PSTs ' ability to teach the MII-STEM approach and has generally got positive responses from pre-service science teachers. However, the MII-STEM curriculum needs revision in some parts. Future studies need to develop the online MII-STEM curriculum for in-service science teachers to respond to the COVID-19 outbreak and advance this developed MII-STEM curriculum from pre-service to in-service teachers.

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Building STEM teaching materials for the topic "Energy and life" to develop scientific competencies of junior high school students

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Abstract. The role of teaching materials is indispensable in every phase of the teaching process. Hence, developing and implementing systems of appropriate teaching materials are essential for organizing teaching activities that can support the students' competence development. Recently, STEM has been being an appropriate orientation in teaching Natural Science at junior high schools. The article presents the theoretical framework of STEM teaching materials and a system of STEM teaching materials built based on that for the topic "Energy and life" in the Natural Science subject of grade 6 in Vietnam curriculum 2018. We also conducted a case study to assess the development of students' scientific competencies.

Keywords: STEM teaching materials, scientific competencies; junior high school students, Vietnam

1. Introduction

Natural Science is a subject in the General Education Program 2018 to contribute to the formation and development of main qualities, general competencies, and specific competencies of the subject (MOET, 2018). The scientific competencies of junior high school students (grade 6-9) consist of three components: cognition of natural science, investigation of the natural world, and application of comprehended knowledge and skills. Hence, the selection and implementation of appropriate active teaching methods along with building and using appropriate teaching materials are also essential in achieving the mentioned goals of the curriculum. The Natural Sciences are characterized by experimental science (MOET, 2018); therefore, STEM education is an encouraged approach (Bank & Barlex, 2021). A STEM topic will have effective impacts on students when it is linked to solving practical problems through which students acquire knowledge and develop skills, especially the scientific enquiry and engineering design competencies (Nguyen, et al., 2019)

We mainly used theoretical research based on reviewing the literature on teaching materials in STEM education. At the same time, we analyzed the topic "Energy and life" in the 2018 curriculum of the 6th grade Natural Science in terms of content as a basis for building a corresponding STEM teaching materials system. After that, we designed STEM lesson plans to develop six indicators of students' scientific competencies. Then, we executed empirical evaluation on 40 6th grade students to evaluate the suitability and effectiveness of using STEM teaching materials in two STEM lesson plans. We also conduct a case study to assess the development of scientific competencies of four junior high school students through the rubric tools.

2. Contents and Results

Teaching materials are material means used by teachers and (or) students under the instruction of teachers in the teaching process, which create necessary conditions to achieve the teaching purposes (Le, 2008). The construction of teaching materials needs to meet the requirements of technological science, pedagogical science, aesthetics, and economics. The use of materials in teaching should follow the principle of using them at the right time, in the right place, and with appropriate intensity to maximize the effectiveness of those teaching materials. To support the process of organizing learning activities in teaching Natural Science, teaching materials play a very important role. Ideally, the teaching materials must have the functions of (1) presenting to the student the object of study (the processes or phenomena) in the original form or the form of various models, (2) collecting information about the study object, (3) presenting the information collected from the study object in different forms such as tables and graphs, (4) analyzing the information collected from study subjects according to different purposes of students, (5) supporting students to investigate research object, to test proposed scientific predictions (hypotheses), or to verify the deductions derived from the scientific hypothesis. In this study, we have classified teaching materials in Natural Science into (1) Pictures, Maps, diagrams; (2) Models and specimens; (3) Radio and television (audio tapes, cassettes, and video clips); (4) Equipment, experimental instruments, (5) Modern teaching facilities (projector, computer, smartboard (6) Worksheet (Nguyen, et al., 2003; Nguyen, et al., 2019)

The topic "Energy and life" in grade 6 includes the following main knowledge contents: (1) Energy definition; (2) Forms of energy; (3) Energy transformation; (4) Wasted energy; (5) Renewable energy; (6) Energy saving (MOET, 2018). From that, a system of STEM teaching material has been built, including: (1) Pictures: 9 sets; (2) Experimental apparatuses: 3 sets; (3) Videos: 5 videos; (4) Worksheet: 3 including *Forms of energy; Energy transformation, Learning how to use energy.*

We built an assessment scale for six indicators of the scientific competencies of junior high school students with 3 levels of quality criteria assigned 1 point, 2 points, and 3 points: (TC1) Presenting objects, phenomena, concepts, laws, and natural processes; (TC2) Proposing problems, asking questions about problems; (TC3) Making judgments and building hypotheses; (TC4) Proposing a hypothesis testing plan; (TC5) Performing hypothesis testing and processing experimental results; (TC6) Reporting presentation and discussing (MOET, 2018). By comparing six indicators of scientific competencies, we conducted a case study through the construction of two STEM lesson plans (including *Forms of energy* and *Conversion and conservation of energy* - Natural Science grade 6) using the system of teaching materials built. In addition to the system of pictures, videos, there are 3 more experiments: (1) Energy transfer; (2) Conservation of energy in the collision between two balls; (3) Conservation of energy in the collision of the ball with the table. Then we conduct an in-depth analysis of the development of six indicators of scientific competencies on four students (coded as HS1, HS2, HS3, HS8) based on assessment rubrics to assess scientific competencies. Figure1 shows the significant development of students' scientific competencies through two STEM lesson plans.

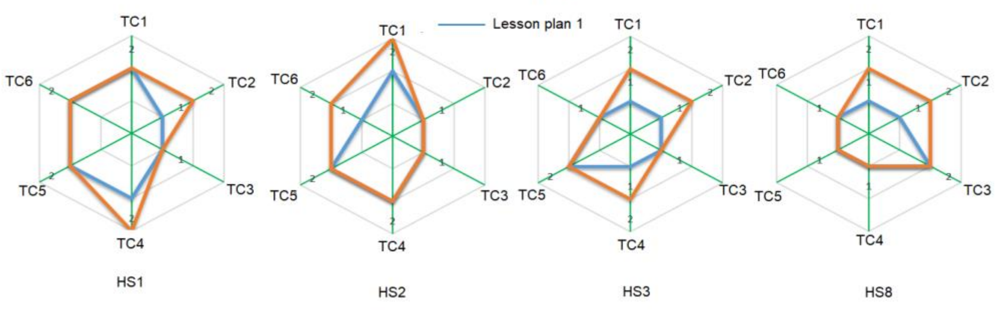

Fig.1: Radar charts show the assessment of scientific competencies of 4 students in 2 STEM lesson plans.

3. Conclusions

The article presented the theoretical framework of STEM teaching materials in teaching natural science. We built a system of STEM teaching materials in the topic "Energy and life" including pictures, videos, practice-experiment instrument, worksheets. The study also conducted empirical experiments and hence evaluated the development of scientific competencies of junior high school students through two STEM lesson plans under using the built STEM teaching materials. Thus, we have shown the necessity of this system of STEM teaching materials in improving the effectiveness of STEM education as well as developing students' competencies.

Acknowledgements

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The role of Coach 7 software in STEM education for primary and secondary school in Vietnam

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Abstract.

In Vietnam, Ministry of Education and Training suggests to implement STEM education in three forms as STEM Lessons, STEM Experiences, STEM Fairs, Science and Engineering Competitions. The article presents the role of Coach 7 software in implementing STEM education according to the Vietnamese general education curriculum corressponding to the engaging ability of informatics as between subjects in STEM topics to find the answers to research question " How to design processes intergrated to Coach 7 in STEM education".

1. Introduction

In Vietnam, Ministry of Education and Training suggests to implement STEM education in three forms as STEM Lessons, STEM Experiences, STEM Fairs, Science and Engineering Competitions. In which, STEM lessons can be organized at the primary level through subjects as Maths, Nature and Society, Science, Informatics and at secondary like Maths, Natural Science, Technology and Informatics.

The form of STEM experience is associated with design activities, modeling and scientific and technical research contests held annually from schools to international levels. Then, scientific knowledge is applied to create physical products based on the progress of technical design.

In Vietnam's general education curriculum, informatics is compulsory from grade 3 to grade 12, elective from grade 1 to grade 2 and plays a central role in connecting subjects for STEM education. At the 3rd grade, this curriculum has indicated that students need to show programming thinking and use the branching statement "Use the statement "If...Then..." to express the decision based on whether a condition is satisfied". So, how to design STEM topics to satisfy the criteria of STEM lessons, STEM experiences, scientific and technical research aimed promote the central role of Informatics in STEM education?

2. Processes intergrated Coach 7 software in STEM Eudcation

We had analysed the competency framework in the Vietnam national education curriculum including Creative problem solving, natural science inquiry, math, science and technology competence to determine how informatics can be applied in STEM Education. As a results, it has confirmed 5 functions in connecting the subjects: 1) Analyzing videos of real-life phenomena 2) Collecting datas by sensors 3) Creating models, simulating dynamics phenomena in real life 4) Design the programming and control 5) Building digital learning portfolio. The above functions are shown in the Coach 7 software researched and developed by the CMA center, indicating the conformity with the characteristics of STEM education in Vietnam.

Based on features of Coach 7 software and the requirements in implementing STEM education, we have built a library of Coach 7 activity files associated with STEM lessons from primary to secondary level. In which, two features used popularly in STEM education activities are measuring - collecting data by sensors and controlling actuators through programming according to the characteristics of students. For primary students, they can experience collecting data of Coach through testing activities such as measuring brightness, pH, loudness of sound, turbidity and running control automatic systems through simple programming commands on Coach software such as automatic feeding systems in animal cages, smart fans to automatically identify people …. , for secondary students, the Video and image measurement, creating dynamic models are used in the process of scientific research such as analyzing and creating real models to determine the speed in uniform motion of the vehicle, image measurement of the famous suspension Bridge bridge in Vietnam to learn about the structure of tension in cables and study the curve in capillary phenomena via analyse images.

3. Results

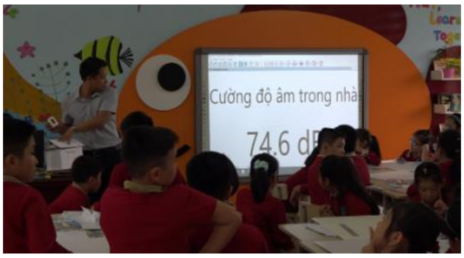

Fig. 1 Collecting data by using sound sensors

Fig. 2 Write programming to control electric fan

Fig. 3 Showing the model of greenhouses via digital learning portfolio

The primary and secondary students in Vietnam has been taken part in the processes corresponding to the above lessons, the obtained results show that many students are very interested in using the measurement and control function to explore and inquiry natural processes and phenomena. Specifically, some students asked questions such as "Is the pH of the toothpaste measured as 9" okay, teacher?"; Those who are passionate in Informatics also edited sample commands to write extended programming. Many students use Coach's results file to report, operate and present their's product. This proves that the processes designed with the support of Coach are appropriate and have played a central role in connecting the subjects of Informatics in STEM education.

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