

CHAPTER VI

CONCLUSSIONS AND SUGGESTIONS

A. Conclusions

Based on the research conducted regarding the implementation of STEM-LCE (low-carbon education) learning program to improve students' 4c's (critical thinking skills, creativity, collaboration skills, and communication skills) and sustainability consciousness, several findings have been obtained that are expected to address the formulated problems that have been presented. So that, several conclusions are revealed this research, namely:

1. STEM-LCE learning program is feasible to be implemented in higher educations, especially for preservice science teachers. STEM-LCE learning program has two general characteristics, namely in learning process and in learning material or topics. Learning process of STEM-LCE using scientific inquiry activity and engineering design process (EDP). The approach that is used is STEM learning approach to solve issues related to low-carbon education in each topic. Integrating STEM learning approach also emphasize to constructivist learning, integration learning, and contextualized learning. Contextualized learning means that students learn pertaining contextual issues and they solve the problem by integrating concept regarding low carbon education. The learning strategy in STEM-LCE learning program is divided into classroom-based activity and home-based activity. Classroom-based activity is face-to-face strategy in classroom for all activities except identification activities is conducted outside classroom (home-based activity). Face-to-face learning (in classroom) and hands-on activities to the field learning (outside classroom) provides a meaningful learning experience as students are required to use higher order thinking skills and hands on activities, collaboration and communication in completing projects related to low-carbon education in each topic. STEM-LCE learning program also implemented by using discussion method and field observation related to SETS course and the concept of low-carbon education.

Thus, students to be active and lecturers only act as facilitators in learning to help students when experiencing difficulties. For learning material, SETS courses with the STEM-LCE learning program is contextual issues pertaining environmental problem regarding indirect low carbon concept. This material consisting low carbon in education concept, one of them is how to calculate carbon emission footprint conversion from energy and food, also the general information of carbon emissions footprint of waste management for each type of waste which are written in e-module through worksheet in each topic to guide students' discovery and there is a "challenge" as the criteria that students has to meet in their product to make their product directed and also students motivated to solve the problem by their unique idea.

2. The STEM-LCE learning program can enhance students' critical thinking skills. This is evidenced by there is a differences improvement of preservice elementary science teacher in experimental class and in control class on SETS courses. The experimental class has significance differences before and after learning SETS course, while control class has no significance differences before and after learning SETS courses. The implementation of STEM-LCE (low-carbon education) learning program in experimental class play significance role to the improvement of the critical thinking skills of preservice elementary science teachers. The results are demonstrating criteria in general, demonstrating criteria for knowledge construction and decision making, while developing criteria for evaluating reasoning. Critical thinking skills and creativity in this study, in general, the results show that critical thinking skills have better logit values.
3. The STEM-LCE learning program can enhance students' creativity. The experimental class has no significance differences in creativity with control class. The value of effect size is in medium criteria which described that there are differences result in creativity for both of class, but in medium criteria. The experimental class is outperformed than control class. In the experimental class, the aspect of creativity that was best, flexibility, while originality had the lowest results among the three aspects of creativity. STEM-LCE learning program also

could enhance students' project creativity results from topic 1 until topic 3 gradually. Project in topic 1 is the most difficult than the rest of two projects.

4. The STEM-LCE learning program can cultivate students' collaboration skills. This is evidenced by the results for collaboration skills in each topic of the SETS learning with the implementation of the STEM-LCE learning program improved. collaboration skills have already met the good logit value criteria from topic 1. This explains that from the beginning, students already possess good collaboration skills. The aspect of collaboration skills that is the best is perspective taking, while the lowest among the three aspects of collaboration skills is social regulation.
5. The STEM-LCE learning program can cultivate students' communications skills. This is evidenced by the results for communication skills in each topic of the SETS learning with the implementation of the STEM-LCE learning program improved gradually. These skills have already met the good logit value criteria from topic 1 until topic 3. This explains that from the beginning, students already possess good communication skills. The aspect of communication skills that has the best logit value criteria is opinion, while the lowest is the gesture aspect. However, the technology skills aspect, especially in multimedia skills describes that students already have very good multimedia skills from the very first topic.
6. The STEM-LCE learning program also could develop students' sustainability consciousness. This is evidenced by the results of sustainability consciousness between the control class and the experimental class showed significantly different outcomes. The experimental class showed a better improvement in sustainability consciousness. The aspect of sustainability consciousness that has the highest value is sustainability knowledge (SK), while the lowest is sustainability behavior (SB). The improvement of sustainability consciousness has not quite optimal, because generally in experimental class the criteria of students' sustainability consciousness is only in emerging and in control class is beginning, especially the behaviour domain has not improved too much in logit value in both of class. Because sustainability consciousness requires time and a considerable amount of habituation to achieve optimal results.

B. Implication and Suggestions

1. Implication

The implications of this research indicate that the integration of STEM learning approaches based on the concept of low-carbon education (LCE) can effectively enhance students' consciousness towards sustainable environmental issues, and also improve students' critical thinking skills, creativity, collaboration skills, and communication skills which include in important skills in 21st century to face the real-world problem. This learning program not only provides a deep understanding of the relationship between science, technology, engineering, and mathematics in the context of climate change mitigation but also encourages students to adopt a low-carbon lifestyle through learning activities relevant to everyday life.

In this study, the subjects were also pre-service teachers. Through STEM-LCE programs, they are expected to understand the concepts and context of low-carbon education, as well as how learning is integrated with the STEM approach. This experience will be internalized within them, so that when they take courses on learning strategies and participate in field practice programs at schools, they will already understand and grasp learning with the STEM approach and the concept of low-carbon education. Therefore, it is recommended that teachers and education policymakers consider integrating the STEM-LCE learning program that emphasizes low-carbon concepts into the education curriculum, to prepare a generation that is environmentally conscious and competent in facing future sustainability challenges.

2. Suggestions

The first suggestion is that in future STEM-LCE learning for prospective elementary school teachers, an application can be used for calculating carbon emission footprints to make it easier to calculate carbon footprints. Thus, it can reduce students' mathematical anxiety. This opens up opportunities for further research to develop a simple carbon emission footprint calculation application for local use in Indonesia. After reviewing the results of this research, it turns out that

the calculation of the carbon emission footprint, which is too complex, is more suitable for prospective high school teachers because it can also be implemented in school learning. The second suggestion is to foster sustainability consciousness, which can be achieved through habituation and the continuous provision of materials related to the low-carbon education concept, so that students' sustainability consciousness is optimally achieved.