DEVELOPMENT OF STEM-LCE (STEM-LOW CARBON EDUCATION) LEARNING PROGRAM TO CONSTRUCT PRE-SERVICE TEACHER'S 4C AND SUSTAINABILITY CONSCIOUSNESS

DISSERTATION

Submitted as requirement to obtain degree of Science Education Doctoral

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DEVELOPMENT OF STEM-LCE (STEM-LOW CARBON EDUCATION) LEARNING PROGRAM TO CONSTRUCT PRE-SERVICE TEACHER'S 4C AND SUSTAINABILITY CONSCIOUSNESS

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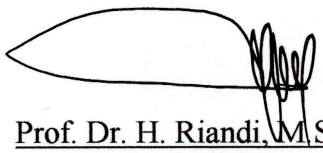

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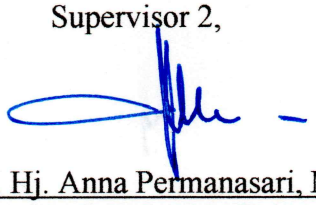

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Annisa Nurramadhani

PREFACE

All praise and gratitude to Allah SWT who has bestowed His grace, guidance, blessings, and support, always keeping this heart and providing all ease, and to the Prophet Muhammad SAW who brought the teachings that the author always believes in, so that the author can complete the dissertation titled "**Development of STEM-LCE (STEM-Low Carbon Education) Learning Program to Construct Pre-Service Teacher's 4c and Sustainability Consciousness**" as one of the requirements to complete the Doctoral Program in Science Education, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia.

The author realizes that this dissertation is still far from perfect. This is due to the limitations of knowledge and experience possessed by the author. It is also well understood that the completion of this dissertation is thanks to the assistance and guidance from various parties.

This dissertation is a study that can provide new references in the field of education in Indonesia, particularly in learning programs that emphasize sustainability, low-carbon education concepts, and STEM approaches, and is also expected to be beneficial for teachers, students, and stakeholders. Therefore, the author highly hopes for constructive feedback so that a scientific work of even better quality and accountability can be created.

Bandung, 29 Agustus 2025

Annisa Nurramadhani

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Lastly, it is for all the parties that the author has not been able to mention one by one and who have helped the author in the process of completing this dissertation on time.

DEVELOPMENT OF STEM-LCE (STEM-LOW CARBON EDUCATION) LEARNING PROGRAM TO CONSTRUCT PRE-SERVICE TEACHER'S 4C AND SUSTAINABILITY CONSCIOUSNESS

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ABSTRACT

The prevailing environmental challenges necessitate appropriate management, one aspect of which is the integration of the low carbon concept in education (LCE), a fundamental principle concerning environmental pollution and climate change for pre-service teacher. One of the implementations occurs through the STEM approach. This is undertaken to enhance their 4Cs' skills and sustainability awareness, equipping students to confront genuine environmental concerns in the future and to prepare them as educators. This research aims to develop and produce STEM-LCE learning program which are able to construct pre-service teacher's 4c (critical thinking skills, creativity, collaboration skills, communication skills) and sustainability consciousness. This research uses the Mixed-method, Exploratory design. The research subjects were 57 pre-service elementary school teacher education in the SETS course, divided into two classes: 28 students in the experimental class using the STEM-LCE learning program, and 29 students in the control class using the regular learning program, which included the SETS approach and environmental materials without the low-carbon education concept. The research instruments used were both tests and non-tests. The test instruments included critical thinking and creativity skills tests. Non-test instruments include observation sheets, questionnaires, collaboration rubrics, communication rubrics, and sustainability consciousness questionnaire. RASCH model analysis with the stacking method to observe differences in the improvement of critical thinking skills, creativity, collaboration skills, and communication, as well as sustainability consciousness quantitatively. These results are supported by qualitative analysis from observations, semi-structured interviews, and learning recordings. The results of this research indicate that the STEM-LCE learning program is feasible to implement in education and can construct 4C skills as well as students' sustainable awareness. It is explained that there are differences in critical thinking and creativity skills among students between the experimental class and the control class. Similarly, the results of students' sustainability consciousness showed differences, but improvements are needed for the final outcomes. Meanwhile, the results of students' collaboration and communication skills from the first topic to the third topic showed a gradual improvement in the experimental class. So, the STEM-LCE learning program is worthy of implementation in education and can construct critical thinking skills, creativity, collaboration skills, communication, and sustainability consciousness among pre-service teacher students.

Keywords: STEM-LCE, Low-Carbon Education, 4C's Skills, Sustainability Consciousness

PENGEMBANGAN PROGRAM PEMBELAJARAN STEM-LCE (STEM LOW CARBON EDUCATION) UNTUK MEMBANGUN KETERAMPILAN 4C DAN KESADARAN BERKELANJUTAN CALON GURU

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ABSTRAK

Tantangan terkait isu lingkungan saat ini memerlukan manajemen yang efektif, terutama melalui integrasi konsep rendah karbon dalam bidang pendidikan (*LCE*), yang sangat penting untuk mengatasi pencemaran lingkungan dan perubahan iklim bagi mahasiswa calon guru. Salah satu penerapannya melalui pendekatan pembelajaran STEM. Hal Ini dilakukan untuk meningkatkan kompetensi 4C mereka dan kesadaran keberlanjutan, mempersiapkan mereka untuk menghadapi tantangan lingkungan yang nyata di masa depan dan mempersiapkan mereka sebagai pendidik. Tujuan penelitian ini adalah untuk menghasilkan program pembelajaran STEM-LCE yang mampu membangun 4c (kemampuan berpikir kritis, kreativitas, kemampuan kolaborasi, kemampuan komunikasi) dan kesadaran keberlanjutan calon guru. Subjek penelitian adalah 57 mahasiswa calon guru pendidikan guru sekolah dasar pada mata kuliah SETS yang terbagi ke dalam dua kelas, yaitu 28 mahasiswa kelas eksperimen yang menggunakan program pembelajaran STEM-LCE, dan 29 mahasiswa kelas kontrol yang menggunakan program pembelajaran seperti biasa, yaitu pendekatan SETS dan materi lingkungan tanpa konsep *low-carbon education*. Instrumen penelitian yang digunakan yaitu test dan no-test. Instrumen test meliputi test keterampilan berpikir kritis dan kreativitas. Intrumen non-test meilputi lembar observasi, kuisioner, rubrik kolaborasi, rubrik komunikasi, angket kesadaran berkelanjutan. Analisis RASCH model dengan metode stacking untuk melihat perbedaan hasil peningkatan keterampilan berpikir kritis, kreativitas, keterampilan kolaborasi, dan komunikasi, serta kesadaran berkelanjutan secara kuantitatif. Hasil tersebut dikuatkan dengan hasil analisis secara kualitatif dari hasil observasi, wawancara semi terstruktur, dan hasil rekaman pembelajaran. Hasil pada riset ini menyatakan bahwa program pembelajaran STEM-LCE layak diimplementasikan dalam pembelajaran dan dapat meningkatkan keterampilan 4c serta kesadaran berkelanjutan mahasiswa. Terjabarkan bahwa terdapat perbedaan keterampilan berpikir kritis dan kreativitas mahasiswa antara kelas eksperimen dan kelas kontrol. Begitu pula dengan hasil kesadaran berkelanjutan mahasiswa yang terdapat perbedaan hasil, namun perlu ditingkatkan untuk hasil akhirnya. Sedangkan hasil keterampilan kolaborasi dan komunikasi mahasiswa dari topik pertama hingga topik ketiga, mengalami peningkatan secara bertahap di kelas eksperimen. Jadi program pembelajaran STEM-LCE layak diimplementasikan di dalam pembelajaran dan dapat meningkatkan keterampilan berpikir kritis, kreativitas, keterampilan kolaborasi, komunikasi, dan kesadaran berkelanjutan mahasiswa calon guru.

Kata Kunci: STEM-LCE, *Low-Carbon Education*, Keterampilan 4C, Kesadaran Berkelanjutan

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