Research on the Influence of STEM Curriculum on Ecological Consciousness for Primary School Students

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Abstract. As a new field of key competencies in the 21st century, environmental competencies have been increasingly focused by social. People also pay more attention to ecological education. This study proposed a kind of STEM curriculum framework and teaching model that aims at cultivating ecological consciousness. This study designed and achieved the “STEM + Ecological Consciousness" Curriculum including four projects: natural ecology, social life, economy and technology, Participation and decision-making. Then, this study investigated the ecological consciousness of fifth-grade students through a single set of pre-and post-test experiments and linear regression analysis of influencing factors, from the perspectives of four projects. Study results show that ecological-oriented STEM teaching improves students’ ecological consciousness, and ecological consciousness is an important factor in the formation of ecological behavior. This study provides a STEM teaching case, which is committed to developing ecological consciousness, in order to serve as a reference for researchers and practitioners.

Keywords: Ecological Consciousness, STEM Curriculum, Primary School Students

1. Introduction

Environmental literacy is among the nine domains of literacy identified as emerging domains of literacy in the world[1]. Under this context, the education sector also needs to pay attention to recognizing the importance of environmental literacy in education in order to create future citizens with environmental awareness and sustainable development skills. Ecological education is especially important in this era of green development concepts, and how to cultivate ecological consciousness has become a topic that needs to be deeply thought about by educators.

At present, research on ecological education mainly focuses on the field of higher education[2], with relatively weak research on ecological consciousness in primary education, thus the current forms of ecological education are not diverse enough. Accordingly, this study examines the STEM curriculum as a new form of curriculum for promoting ecological consciousness. With ecological consciousness as the main line of curriculum construction, a comprehensive curriculum integrating science and technology, engineering, mathematics, and a teaching mode based on problem-solving as the path, we will explore the impact of STEM education on primary school students' ecological consciousness. The research questions are as follows: What is the framework and pedagogical model of a STEM curriculum dedicated to raising ecological consciousness? Can the "STEM + Ecological Consciousness " program based on this model be

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effective in raising students' ecological consciousness? Next, clarification of terminology was used to define the conceptual orientation of this literature review.

1.1 Ecological consciousness education

In terms of disciplinary attributes, Biryukova[3] argued that ecological consciousness is a field that involves multiple disciplines, located at the crossroads of developmental psychology, environmental psychology, and social psychology. In terms of internal structure, Cherdymova[4] believed that ecological consciousness can be divided into four structures, namely ecological knowledge, ecological attitude, ecological focus, and ecological intention. Ecological knowledge is the result of human environmental cognitive processes; Ecological attitude is the psychological reflection of human beings on natural objects in the natural environment; Ecological focus is the perceived tendency or readiness of individuals to approach future events and actions in the natural environment; Ecological intention is the subjective will to accomplish environmental activities according to the expected plan, generated by the target behavior.

Ecological education involves creating an ecological culture for individuals and society through spiritual experiences of interacting with nature[5]. Generally speaking, ecological consciousness education is to educate for the protection of nature and the environment by means of both educational theory and educational practice, guided by the worldview and methodology of the holistic theory of ecological philosophy.

1.2 Impact study of STEM curriculum

Research on the impact of STEM curriculum has focused on many main areas. one of which is the impact of the STEM curriculum on subject-matter achievement, which is mainly related to academic achievement, test performance, and subject-matter grades[6]. Given that evaluations of STEM curricula have become more diverse, curriculum implementation has become more advanced, and the concept of STEM+X has gained widespread acceptance. Alex[7] proposed the idea of “Neodisciplinary”, which immerses the learner in exploring the "X" discipline to a greater extent. Expanding the impact of STEM curriculums, and integrating new perspectives are new ways for better implementation of STEM curriculums in the future.

2. Curriculum framework and pedagogical model

2.1 Curriculum framework of "STEM + Ecological Consciousness" curriculum

This study relies on the four factors of ecological consciousness[4] and combines them with the Guidelines for the Implementation of Environmental Education in Primary and Secondary Schools[8] to develop and design an ecological consciousness STEM curriculum for primary schools. Eventually, the curriculum modules of "Natural Ecology; Social Life; Economy and Technology; Participation and Decision-making" will be formed, constituting a model for the construction of the ecological consciousness STEM curriculum in elementary schools (see **Figure 1[1]**). The curriculum design relies on the “STEM+X” concept, with ecological consciousness as the core of the curriculum and becoming the first layer of the entire model. Ecological knowledge, ecological attitudes, ecological focus, and ecological intention as the four branches of the "X" of curricular development as the second layer of the model. Integrate the four branches into the STEM curriculum to form the four modules of the curriculum as the

third level of the model. Finally, the ultimate goal of improving ecological behavior is formed as the fourth layer of the model.

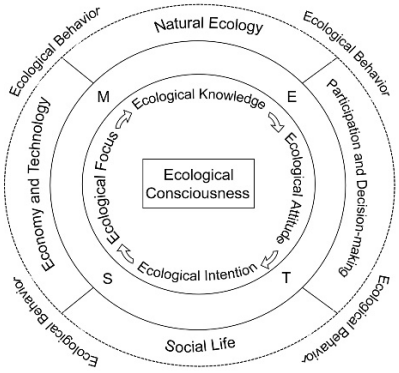

Fig. 1. The model for the construction of "STEM + Ecological Consciousness" Curriculum.

In order to increase the applicability of the model and further explore the effect of the curriculum, this study proposes a "STEM+Ecological Consciousness" curriculum for the fifth grade as a basis for further practice in combination with the Guidelines for the Implementation of Environmental Education in Elementary and Middle Schools[8] and the contents of science and mathematics subjects. The curriculum cases cover four curriculum areas, and each area covers two project themes (see **Figure 2[2]**). The implementation time of each theme depends on the actual situation of the school, and the recommended time credit hour is 4 hours.

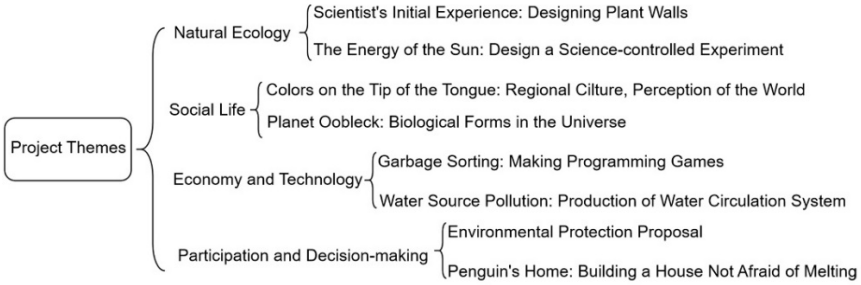

Fig. 2. Project themes of "STEM + Ecological Consciousness" Curriculum.

2.2 Pedagogical model of "STEM + Ecological Consciousness" curriculum

The pedagogical model of the curriculum is an important basis for its implementation. This study incorporates Honey's[9] design of the instructional process for a STEM curriculum and has redesigned and fleshed out each of these components (see **Figure 3[3]**).

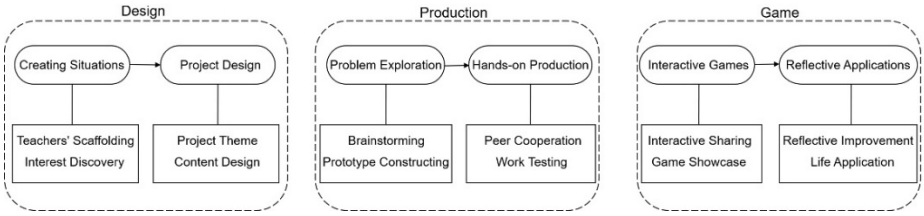

Fig.3. The pedagogical model of "STEM + Ecological Consciousness" Curriculum.

The design stage includes two stages: creating situations and project design. The teacher provides real-life scenarios to stimulate students' interest and guide them to discover the problems to be solved in the context and students need to determine the project theme under the guidance of the teacher, collect information, and conduct preliminary design of the content. The production stage includes two stages: problem exploration and hands-on production. These stages require students to brainstorm, exchange problem-solving ideas.The hands-on production process mainly adopts the form of cooperation, and trying to create with the help of teachers and students. The game stage includes interactive games and reflective applications. Interactive games allow students to share and showcase their works through games, evaluate and reward outstanding works, and continue to stimulate students' interest through the game process. In the reflective application process, teachers mainly provide a relaxed atmosphere for students to report and showcase their work. Students need to exchange insights and insights from the design and production process, and then the teacher summarizes and raises questions or suggestions. Finally, the teacher needs to organize the good student works and put them in a file bag or display cabinet, or hand them over to the students themselves for safekeeping.

3. Methodology

In this study, a single-group pre- and post-test comparison experiment was conducted, and fifth-grade students in a Chinese school were selected as the subjects of the study. Separately, a pre-test was administered to this elementary school's fifth year, class 2 on September 1, 2022, followed by the implementation of a STEM+ ecological consciousness curriculum, and a post-test was administered on November 22 nd. The experimental class consisted of 36 students who were instructed by the teacher to fill out questionnaires during class, and a total of 72 pieces of data were obtained validly. Finally, this study analyzed the questionnaire data using Pre- and post-test analysis of variance and linear regression analysis of influencing factors in experimental classes using SPSS 26.

The dimension of the questionnaire was based on the model of ecological consciousness proposed by Cherdymova[7], on the basis of which specific questions were derived according to the actual situation. Five dimensions of ecological consciousness were surveyed, with four questions per dimension for a total of 20 questions. The questionnaire was based on a five-point Likert scale with positive and negative scoring. It was validated that Cronbach's Alpha on all five dimensions was above 0.7 and the Alpha on the total scale was 0.872, indicating that the questionnaire has good reliability.

4. Results and discussion

4.1 Analysis of differences between pre and post-tests in experimental classes

Elementary school students demonstrated significant differences in the five dimensions of their ecological knowledge, attitude, focus, intention, and behavior after completing a STEM curriculum aimed at promoting ecological consciousness. Moreover, the means for each of these dimensions increased. The data results are shown in **Table 1[1]**.

Table 1. Analysis of differences between pre and post-tests in experimental classes.

Dimensions	Pre- Test			Post- Test		
	N	M	SD	M	SD	t
Ecological Knowledge	36	2.99	1.13	3.75	0.95	-3.11**
Ecological Attitude	36	4.38	0.45	4.57	0.37	-2.00*
Ecological Focus	36	3.98	0.46	4.28	0.36	-3.14**
Ecological Intention	36	4.19	0.58	4.53	0.32	-3.09**
Ecological Behavior	36	4.26	1.13	3.75	0.95	-3.25**

*P<.05 **P<.01 (two-tailed test)

In terms of the ecological knowledge dimension, students enriched their knowledge base with more ecologically relevant knowledge (M pre= 2.99, M post= 3.75, t = -3.11). On the ecological attitude dimension, students were more positive about ecological activities and believed that "environmental protection is close to them" (M pre= 4.38, M post= 4.75, t = -2.00). On the ecological focus dimension, students held a stronger focus on ecological conservation, focusing on issues such as environmental destruction and environmental pollution (M pre= 3.98, M post= 4.28, t = -3.14). On the ecological intention dimension, there was a significant increase in students' willingness to participate in environmental protection activities, indicating that they were very willing to participate in and publicize ecological knowledge activities (M pre=4.19, M post=4.53, t=-3.09). While the analysis of the ecological behavior dimension reveals that after the course, students' ecological behavior has also improved significantly (M pre = 4.26, M post= 4.58, t = -3.25).

4.2 Analysis of the influence of ecological consciousness on ecological behavior

Ecological consciousness is a prerequisite for ecological behavior and an important factor in effectively improving it. In this study, linear regression analysis was conducted with four dimensions of ecological consciousness as independent variables and ecological behavior as dependent variables to verify the effect of ecological consciousness on ecological behavior.

The results are shown in **Table 2[2]**, R^2=0.987>0.6, which means that the results of this operation can reflect the influence of ecological knowledge, ecological attitude, ecological focus, and ecological intention on the ecological behavior of primary school students in a very real and reliable way. The regression equation is significant, F=2806.959. Except for the ecological knowledge factor, all significance values are less than 0.05, meaning that at least one of the three independent variables can significantly influence the dependent variable of student ecological behavior. Therefore, the resulting regression equation between the variables is

"Ecological Behavior = 0.210*Ecological Attitude + 0.115*Ecological Focus + 0.669*Ecological Intention".

Table 2. Linear regression analysis of influencing factors

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R^2	F
	B	Std. Error	Beta				
Ecological Knowledge	0.326	0.182	0.051	1.784	0.076		
Ecological Attitude	0.210	0.071	0.205	2.956**	0.004		
Ecological Focus	0.115	0.058	0.099	1.990*	0.048	0.987	2806.959
Ecological Intention	0.669	0.077	0.645	8.717***	0.000		

*P<.05 **P<.01 ***P<.001(two-tailed test)

5. Conclusions and implications

After research and exploration, the following conclusions have been drawn from this study (1) The findings show that the "STEM+Ecological Consciousness" curriculum constructed in this study can help primary school students develop ecological consciousness, and the curriculum can significantly improve their ecological knowledge, ecological attitude, ecological focus, and ecological intention. (2) Ecological consciousness is an important factor in the formation of ecological behavior. It can be seen that except for ecological knowledge, the other three factors can significantly and positively influence ecological behaviors, and such findings also provide an important basis for reflection on the setting and implementation of traditional ecological consciousness curriculum.

Also, this study provides the following implications for the design and implementation of this type of STEM curriculum. (1) teachers can consider integrating multidisciplinary content for ecological consciousness STEM curriculum design and implementation. Integrate themes and contents suitable for ecology and STEM from traditional subject curricula with current ecological topics. (2) In order to effectively improve students' ecological behavior, a deep exploration of students' ecological consciousness is a strategy that can be used as a reference. Future curriculum design should focus more on the cultivation of interest in the ecological environment and the intention to participate in ecological environmental protection activities. (3) In the specific implementation process, the game stage often faces potential challenges such as deviation from learning objectives and difficulty in controlling classroom discipline. Therefore, the design and implementation of games cannot be separated from the guidance of learning objectives. Proper monitoring by teachers and group self-management are effective ways of classroom management at this stage.

This study also has certain shortcomings due to the limitations of the research target, implementation hours, and teacher guidance. This study only verified the experimental effect through single-group pre-and post-tests, and a more scientific methodological design, such as a dynamic collection of students' ecological consciousness during teaching and learning, will be carried out in future studies, with increased qualitative analysis and more in-depth research.

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