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Global Citizenship Education(GCED) and Engineering for Non-Majors Convergence D-SteamRobot(DSR) Educational Model

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Abstract

This study aims to enhance the engineering education for non-majors by incorporating the concept of Global Citizenship Education and addressing the need for education that responds to climate and ecological changes. The study uses robot programming as a tool to foster the development of global citizens. Non-majors often struggle with producing more than just motionless forms or solid productions, due to a lack of understanding of mechanisms and coding. The study proposes the use of the Convergence D-SteamRobot (DSR) to address this issue by blending humanities and engineering. This is achieved by presenting problems through books to increase empathy, integrating simple machine mechanisms, and creating prototypes to solve self-defined problems. Through this process, learners determine the SDGs topic they want to solve and learn about the simple mechanical mechanism involved in producing the prototype. The educational model provides a constructivist learning environment that emphasizes empathy and exploration, encourages peer-learning, and improves divergent thinking and problem-solving skills.

Keywords: *Robot Education, Ecological Transformation Education, SDGs, Problem Solving, Divergent Thinking*

1. INTRODUCTION

These days, creativity and problem-solving skills are required to reconstruct new perspectives and ideas based on existing knowledge. Global Citizenship Education (GCED) is a global education agenda included in the sustainable development goals (SDGs), and many countries are reflecting it in their curricula [1][2]. Also, the demand for digital education and ecological transformation education is increasing. The Ministry of Education announced that the values included in the 2022 revised curriculum, such as ‘sustainable development’, ‘climate crisis response’, and ‘ecological transformation’, be reflected in the educational goals [3]. Basic concepts and new technologies are constantly changing and become the foundation of intellectual ability. Since intellectual abilities cannot be easily learned or transferred in problem situations, they should be regarded as life skills in the context of information technology [4]. For non-majors, coding, machines, and robots are difficult and even difficult to try. In an era where the flow of technology permeates our daily life and our daily life is changing, everyone needs to understand the flow of technology. In physical education,

Robot shape is easily accessible, but the range of application is narrow, and it goes against the learning

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principle of constructivism. In SW education for non-majors, education to produce creative ideas and produce meaningful results by applying a design-based learning process to improve CT is being conducted, and it has been reported to be effective in education [5] [6]. In the study of this thesis, a tool that can be explored and manufactured is used.

In this paper, we propose a D-SteamRobot (DSR) educational model that combines GCED and engineering for non-majors. It provides learners with an intuitive and hands-on learning experience through robot production centered on technology education on SDGs topics. The composition of this paper is as follows. Review of Literature in Chapter 2, in chapter 3 describes the DSR Educational Model. Chapter 4 describes curriculum application, and finally Chapter 5 describes conclusions.

2. RELEVANT RESEARCH

The international community recognizes the importance of global citizenship education and emphasizes the role and obligations of global citizens. The core values are 'learning to live together' and 'teaching respect for all'. Education for sustainable development (ESD) and global citizenship education (GCED) are both adopted as global education agendas in the UN SDGs [7]. ESG (Environmental, Social, Governance) Framework of the Association for Supporting the SDGs for the UN. Particularly, since the outbreak of COVID-19 in 2019, “eco-friendly,” “social value,” and “ethical behavior” have become the main policies of governments and parliaments. ESG has become a significant element that consumers, businesses, and civil societies look for in a product, and the demand for ESG management is ever-growing[8]. Environment consists of SDGs Goals 12 to 15, Social consists of SDGs Goals 1 to 11, and Governance consists of SDGs Goals 16 and 17.

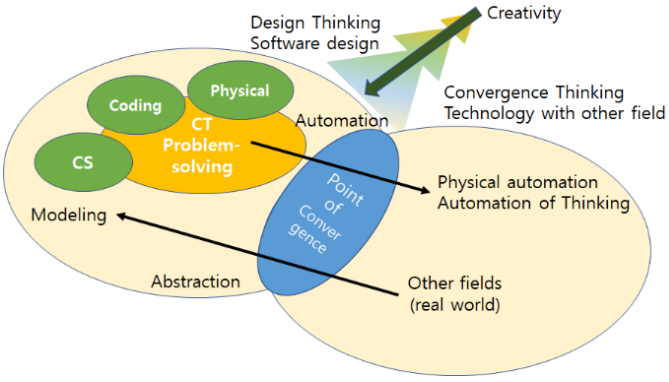


Figure 1. CT for Creative Problem Solving

CT is creative logical thinking or problem-solving ability based on digital information. As shown in [Figure 1], CT can be divided into abstraction and automation. Coding abstracted using CS is made into SW in the digital space, which is used for automation in the analog domain. Physical computing is calculated as a hardware result and can be used to solve real-world problems. Learners can learn CS knowledge such as technology and engineering elements. And apply it to humanities and social fields such as language, society, and art, and in this process, convergence can occur and creativity can be expressed. It should be designed to design the convergence of computing processes and real life.

Recently, while applying design-based learning in STEAM (Science, Technology, Engineering, Arts, and Mathematics) convergence education, education that designs and implements one's own ideas based on engineering and technology in scientific subjects is being attempted. Bers and Marina used LEGO Mindstorms to improve technical literacy and design ability in lower elementary school students [9]. The young students

were not good at abstract activities of assembly and programming, they played an active role in design activities. during participated with interest in gears and mechanical operation. Novel Engineering is a comprehensive subject that combines reading education, STEAM education, and SW education, and was referenced to combine literature and engineering [10].

3. PROPOSAL EDUCATIONAL MODEL OF D-STEAMROBOT(DSR)

In the previous study, a study on the basic learning of programming for non-majors based on WEDO + Scratch [11] was effective in education as a process of producing creations through simple tools or programming which learners imagined. The feedback process of design-coding-execution-redesign proceeded very quickly, and the learners accepted this process with pleasure. However, more time was spent on prototyping, focusing more on solutions than on finding the real problem in the design-based empathy phase. In the process of prototype, there were limitations in manufacturing actuators and sensors, or modules with a robust exterior due to the lack of understanding of machine mechanism.

In this paper, the design thinking process and literature and engineering are combined. In order to solve self-defined problems, design a robot that applies a simple machines mechanism and control it manually or with a sensor. As shown in [Picture 2], a manual electric machine set and WEDO2.0 upgraded in 2016 are used. LEGO Simple and Powered Machines set 9686 enables exploration of real-life machines. It promotes learners' basic STEM understanding of simple, powered machines, structures, and mechanisms. WEDO2.0 can produce various models using motors and sensors, and it can integrate with the programming [12].

Figure 2. LEGO Simple and Powered Machines set 9686 and LEGO WEDO2.0

In modern times, education is needed to think critically and think about problems to be solved in the flood of various information. Also with globalization, global citizenship has become important. Accordingly, we propose the D-SteamRobot(DSR) education model, a convergence of design-based learning that sympathizes with SDGs as global citizenship education and produces prototypes.

Table 1. Step for Learning based on Design

Concepts of CT	***Novel Engineering***	***Design Thinking***	***D-SteamRobot (DSR)***
Abstraction	Reading a book	Empathy	Presenting Situation
	Identify Problems		
Decomposition Algorithm	Design Solution	Define	Design Solution
Algorithm Abstraction	Building	Ideate	Ideate
Abstraction Logical Analysis	Feedback	Prototype	Prototype

Abstraction Generalization	Improve Design		
Logical Analysis	Reconstruct Stories	Test	Improve, Share

As shown in [Table 1], the proposed D-SteamRobot(DSR) combines the empathy stage of the design thinking process with Novel Engineering to read books, improve understanding of STEAM elements to find and solve problems on their own, and go through the process of solving problems. This process is repeated, and the last step is to rewrite and share the story of how the robot prototype came out about self-defined problems. DSR is a design-based learning that incorporates Novel Engineering and proceeds in 5 stages.

The creative problem-solving techniques considered in DSR are Design Thinking, Algorithm Thinking, and Deep-Learning Thinking. Design Thinking starts with empathy. It is a way of thinking that finds the root cause of the problem the user is facing, redefines the problem, and presents a solution in a creative way. Algorithm Thinking is a CT-based logical thinking process. This is a logical, repeatable, and step-by-step solution to the self-defined problem of the preceding Design Thinking. Deep-Learning Thinking is divergent thinking that approaches problems from a new perspective and creatively solves problems by combining various ideas. Deep-learning Thinking is a combination of Design Thinking and Algorithm Thinking.

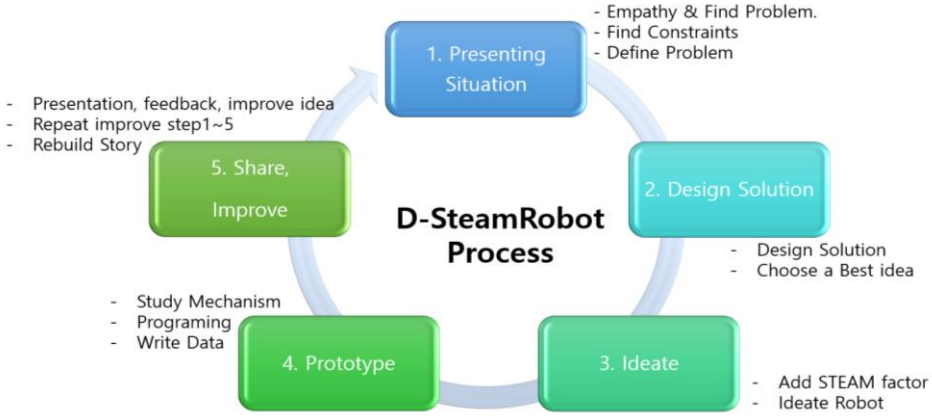


Figure 3. Educational-Model of D-SteamRobot (DSR)

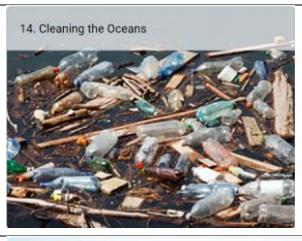
As a first step, to understand and empathize with real-world problems related to the SDGs by using books that present the issues. Learners find the problem, identify constraints, and define the problem they want to solve. In the second step, to design a solution about self-define problem. Learners create the best possible idea for a robot that addresses the issue. The third step is the Ideate step, to add a STEAM factor to their design by exploring them to ideate the robot they have designed. In the fourth Prototype stage, learners study the mechanism of their robot, program the robot, and write data to make it functional. Through this, learners learn real-life machines and mechanisms and develop logical thinking skills. Fifth, in the stage of improvement and sharing, to present their robots and receive feedback from their peers. they can the feedback to improve their ideas and rebuild the story of their robot. In this process, it can be a step to naturally peer-learning among colleagues. Steps 1-5 can be repeated.

4. CURRICULUM APPLICATION

In this paper, the D-SteamRobot (DSR) curriculum was conducted for 12 non-majors. Learners' opinions on the selected books were shared for each lesson, and prototypes were produced using LEGO Machines set 9686

and WEDO2.0. The main themes of the curriculum were AI, Road Kill, Plastic Island, Sense of Animal, Environment & Research. The book was selected as a book that can think of problems from the character's point of view and is related to the SDGs theme. The titles of the books is ‘crash!’, ‘Plastic Island’, ‘Super Hero’, and ‘Sinkhole Lab of Dr. Hole’. In the Presenting Situation stage, as shown in Table 2, the stage of sympathizing with the main character was carried out by reading the book, feeling emotions, finding out what kind of problem it was. At the Design Solution stage, learners define the problem they want to solve on their own in the presented situation. Also discussed what problems were in the book, organized and shared ideas for choose a best idea.

Table 2. D-SteamRobot(DSR) curriculum and Novel engineering

	Title	Novel	Theme
Lesson 1	Road Kill		
Lesson 2	Plastic Island		
Lesson 3	Sense of Animal		
Lesson 4	Environment & Research		

SDGs do not designate each lesson, but present situations through selected books. In order to solve the self-defined problem through the story, a prototype was produced by selecting what to solve in the proposed SDGs. As shown in [Figure 4], the SDGs topics for DSR prototype design are as follows. 3.Good health and well-being, 6.Clean water and sanitation, 8.Decent Work and Economic Growth, 9.Industry, innovation and Infrastructure, 12.Responsible consumption and production, 13.Climate Action, 14.Life below water, 15.Life on land.

Figure 4. SDGs topic selection for D-SteamRobot(DSR) prototype design

Figure 5. Wheel and Axle, Pulley, Lever, Gear

At the Ideate stage, create a simple machine project to explore and understand the mechanism as shown in [Figure 5]. Roles were naturally divided, such as finding and exploring basic models, writing reports, and finding parts during assembly, and peer learning and collaboration took place.

According to constructivism, new understanding and knowledge are constructed through experiences and social discourse, and new information is integrated with what is already known. Even if you learn the same content, each person understands it differently, and you can grow through feedback. Philosopher 'Karl Popper' said that 'life is a series of problem solving'. This problem-solving ability can be said to be a must-have ability to live in the present age. Here, I will define it as the difference between the goal and the current result. The problem to solve could be a story in a book, a gap in prototype implementation, or SDGs.

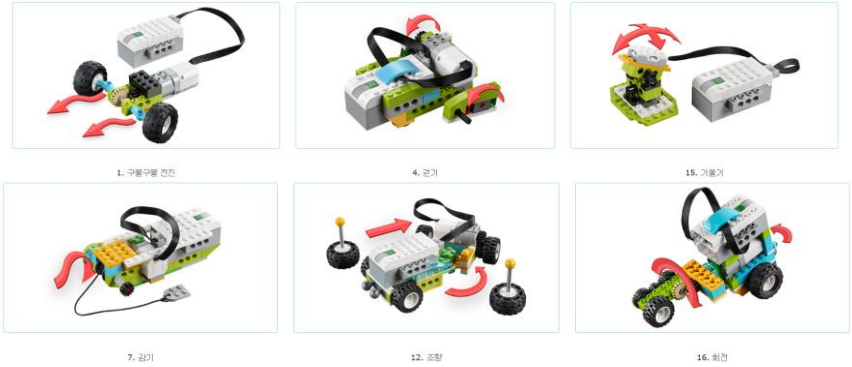


Figure 6. Design Library

In the prototype stage, a design library was provided for learners unfamiliar with the mechanisms of wheels, pulleys, levers, and gears for reference as shown in [Figure6].

(a) (b) (c) (d) (e)

Figure 7. (a) define problem and ideate (b) prototype test (c)(d) data recording (e) idea share with selecting SDGs

<Figure 7>(a) is the define problem and idea stage. (b) is a picture of testing the completed robot in the environment set by the person's hypothesis. (c), (d) summarized the appearance of the robot and why it was designed for the model. In (e), the robot was demonstrated by sharing ideas about the background and intention of selecting ideas related to SDGs in the share and improvement stages, the main functions and operation methods of manufactured robots, and finally expected effects.

5. CONCLUSION

The proposed educational model aims to provide a comprehensive learning experience for non-majors in robot education. By incorporating the SDGs and sustainability into the education method, learners can develop an understanding of the impact of technology and engineering on the world, and their role in creating a more sustainable future. Robot education has great effect because the programming results appear as physical movements. There are many unexpected trials and errors in the process of coming up with ideas, designing, and making them yourself. The process of resolving these trials and errors and experiences gives me a chance to grow more. In general, female non-majors had less confidence in machine mechanism and engineering and felt a lot of pressure. The SDGs sympathy and alternatives to problem solving were quick. They said that the mechanism was complex, but making it through LEGO Simple Machine and Wedo2.0 was easy, fun, and possible to try.

The advantages of the proposed educational model are as follows. First, global citizenship value education was conducted with a topic related to ecology transformation. Second, the problem definition part of design thinking was supplemented by linking the empathy stage of the topic and the problem definition part to the book. Third, through reading topics in various fields, modern people with a small amount of reading were provided with an opportunity to read books. Fourth, in the process of reading books and defining problems, frequent discussions were induced in the middle of the class, and differences in thoughts were experienced. Fifth, constructivism learning was carried out to design and learn according to one's own thoughts. Sixth, learn simple machine mechanism and control movement and sensor through coding and express your idea. Seventh, the burden of simple machine learning was reduced because it was made like play using LEGO. Eighth, looking at the recent trends in robots, it is possible to expand AI and science and technology together. Ninth, the elements of story, design, empathy, play, meaning, and integration were composed during the class as the six conditions that future talents should have.

The proposed DSR education model improved non-major learners' technical literacy, creative problem solving, and design abilities. This model provides a constructive learning environment that promotes creativity, divergent thinking and problem-solving skills by encouraging hands-on learning and collaboration. And considering learners' feedback that they have broadened the scope of various ideas, such as awareness of

current social problems, it is expected to become a meaningful educational model that fits the future global citizenship education trends. By this study, learners will learn about the role of robots in creating a more sustainable future and how they can contribute to making the world a better place through their work in robotics and computational thinking, using books as a tool for empathy and problem solving. As a further study, continuous curriculum and applied research are needed to think about the global social problems the social impact centered on technological engineering, and the positive impact of engineering on society.

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