ISSN 1598-0170 (Print)
ISSN 2287-1136 (Online)
http://www.jksii.or.kr

창의력 향상을 위한 로봇활용 교수 - 학습모형 개발 연구

A Study on Development of Robot - based Teaching-Learning Model for Improving Creativity

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요 약

현재 로봇은 교육적 목적으로 학교에서 점차 많이 사용되고 있다. 특히 로봇활용교육의 확산과 더불어, 로봇활용교육의 장점은 학생들에게 창의력과 논리적 사고력을 향상시키는 것으로 알려져 있다. 비록 로봇이 학생들의 수업활동을 위해 매우 유용한 도구임에도 불구하고, 로봇활용교육을 위한 교수-학습모형은 많지 않은 실정이다. 본 논문의 목적은 로봇활용교육을 위한 교수-학습 모형을 개발하는 것이다. 본 논문에서 제안하는 교수-학습 모형은 구성주의 교육철학에 기반을 두어 고안되었고, 6단계(준비, 디자인, 조립, 시범작동, 평가 및 적용 및 확장)로 구성되었다.

본 논문에서 제안하는 모형은 다음과 같은 특징을 지니고 있다. 첫째, 제안하는 모형은 학생들의 창의성과 논리적 사고력을 향상시키기 위해서 디자인되었다. 학생들은 자기주도활동을 해야 하며, 자신의 아이디어에 기초하여 결과물을 제작해야 한다. 교사들은 필요한 경우 학생들을 중재해야 한다. 둘째, 학생들은 본 모형을 통해서 다양한 상호작용을 통해 학습에 참여할 수 있다. 본 모형에서 제공하는 상호작용은 학생-학생, 학생-교사 및 학생-전문가 상호작용을 제공한다. 본 모형은 협력학습을 통한 문제해결을 권장한다. 교사는 필요한 경우 학생들을 안내하고 학생들의 활동을 모두 주시해야 한다. 셋째, 제안 모형은 학생들에게 동기부여를 학습 활동초기에 제공한다. 마지막으로 본 모형에서는 학습 결과뿐만 아니라 학습 과정까지 투명하게 볼 수 있어 학생들의 수업단계도 쉽게 확인할 수 있다. 또한, 학습과정은 최종단계에서 검증할 수 있다.

☞ 주제어 : 로봇활용교육, 교수-학습모형, 창의력, 구성주의

ABSTRACT

Currently robots are widely used in schools for educational purpose. With wide spread of robot-based education, it is known that major advantage of robot-based education is to enhance creativity and logical thinking of students. Although robots can be very useful tools for assisting students' study activities, there have not been lots of teaching-learning models for robot-based education.In this paper, a teaching-learning model is presented for robot-based education. The proposed model is designed based on constructivism. The proposed model consists of 6 stages: preparation, design, assembling, demonstration run, evaluation, and application & extension.

The proposed model has the following characteristics. First, the proposed model is designed to enhance creativity and logical thinking ability of learners. Learners are supposed to be involved in self-directed activities and required to provide results based on their own ideas. Teachers are supposed to mediate students only if necessary. Second, learners are encouraged to participate in activity via diverse interaction. The interaction in this model includes learner-to-learner interaction, learner-to-teacher interaction, and learner-to-expert interaction. The proposed model encourages learners to solve the problem with cooperating each other. Also, teachers are supposed to guide students if necessary and observe and monitor behavior of students all the time. Third, motivation is provided in the beginning stage of the instruction. Fourth, in the proposed model, both study results and study process are equally important. In the model, study process is reviewed at the final stage.

☞ keyword : Robot-based Education, Teaching-Learning Model, Creativity, Constructivism

1. Introduction

In the current industrial and knowledge-based society, robots have been used in many areas such as manufacturing industry and military applications. However, there has been no mutual agreement on the definition of robot. Robots can be classified into some categories as follows in Table 1[1].

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[Received 9 July 2015, Reviewed 23 July 2015, Accepted 1 October 2015]

(Table 1)Robot Classification

Category	Items
Manufacturing	-Shipbuilding -Electronics -Car Manufacturing
Personal Service	-Housework -Old People -The Disabled -Entertainment/Health -Service Robot
Special Service	-Medical Welfare -Military Service -Security -Special Environment -Logistics
Robot Sensor and Part	-Sensor -Material -Actuator -Battery
Robot Platform and System Integration	-Platform Technology -Robot Network -Robot System Integration

In education areas, robots are used in two different types. First, robots are used as a tool. In this type, as students can study while they are designing, assembling and controlling robots. A robot can be a helpful tool for students.

On the other hand, in the second type, robots are used as in teaching aid. In this case, robots can provide study contents to students so that they are active helpers for students. Table 2 shows summarization of two types.

(Table 2) Two types of robots in education

Types	Roles
Tool	Students can learn mathematical and scientific principles and creative problem-solving ability while they are programming and assembling robots
Teaching Aid	Robots can provide study contents and more active interaction between students and teachers

In the literature, robot-based education has the following benefits [1]. First, robots can be used in any courses like art and science, etc. Robots can increase creative and logical thinking ability and problem-solving ability. Second, robots are strong tools to achieve learning by doing. For children, hands-on experience can provide great interest to students. Also, students can achieve study goals by direct manipulation of robots. Third, robots can be a strong tool to provide interaction. That is, robots are used to let students learn through interaction. Interaction can have introvert students to participate more actively. Also, it can encourage students to cooperate each other.

The main purpose of robot-based education is to enhance creativity. For creativity, robot-based education has the following characteristics [2]. First of all, it enables students to have open-mind. This is due to that robots are tools to provide endless imagination. Second, both self-directed study and cooperation work are possible in robot-based education. For example, assembling a robot is possible through individual work or cooperation work. Third, robot-based education can provide various forms of interaction. Through various types of interaction, students can increase his or her power of concentration, patience and satisfaction.

The rest of this paper is organized as follows. In Section 2, related works for robot-based education are introduced. In Section 3, a new teaching-learning model is presented. Also, design principles of the model are discussed. In Section 4, application of the proposed model is presented. Finally, in Section 5, conclusions and further works are discussed..

2. Related Works

2.1. Robot as an Educational Tool

Many robots have been developed and implemented so far. Usually research centers and company present curricula and study contents with their robots [3,4,5,6,7,8,9]. Types and contents of robot-based education can be classified into 4 categories [1].

- Robotics engineering

The purpose of robotics engineering is to enhance problem-solving ability and creativity through robotics. This purpose can be achieved by designing, assembling and programming a special-purpose robot.

- Robotics + STEM

STEM represents S (Science), T (Technology), E (Engineering), and M (Math), respectively. In this case,

students can learn basic theories of STEM, have opportunities to apply basic theories they have learnt to robot assembling.

- Robotics + Multi-discipline

In this case, robots are used to encourage students to participate in various study activities of arts, literature and language, etc. For instance, students can learn the concept of aesthetics for designing robot.

- Robotics + Computing

This type of category is used to increase programming ability. In this type, designing and assembling a robot is not main concern.

2.2. Literature Reviews

The teaching-learning models have been introduced in the literature works. We introduce some works as follows.

In [10]. A teaching model is introduced for STEAM activity. The model is designed based on PBL (Project-based Learning). The following table 3 shows the steps of the model.

(Table 3) A Teaching Model for STEAM Robot-based Education

Feature	Description
Introduction	Use an introduction that includes "The Big ideas"
Task	Guiding question or driving question what will be accomplished and embeds the content to be studied
Investigation	The process and investigation include scaffolding to complete the task and reinforcing participation
Resources	Resources provide data to be used and can include hypertext link, computer, scientific probes, robot, eyewitness, and so on
Scaffolding	Scaffoldings are needed at different levels for different students and may include resources help, student-teacher interactions, peer counseling, job aids, project templates
Collaboration	Many projects include groups or teams, especially when resources are limited, but cooperative learning may be helpful
Reflection	PBL offer an opportunity for closure, debriefing, assessment, or reflection

In [11], a model is presented using a robot called Pico-Cricket for elementary school students. The model is desinged based on the work in [10]. The following table 4 shows the model in detail.

(Table 4) A Teaching Model for Convergent Robot-based Education

Step	Process of Learning	Description
Introduction	Searching for around real-life	Motivaton, Idea drawn
Task & Investigation	Analysis of activity	Drawn & Use the background knowledge
Resources Scaffolding	Appointment with others	Providing resources of teacher Additional programming explanation
Collaboration	Problem Solving	Cooperative Learning
Reflection	Exhibition & Evaluation	Sharing & Presentation

In [12], development guidelines of teaching-learning models for elementary and middle school students. They proposed an overall conceptual design model for robot-based education. The following table 5 shows the proposed conceptual teaching-learning model.

(Table 5) A Teaching-Learning model for Robot-based Education

Step	Step in detail	Activity
Preview	Study Preparation	Let students remind of specific experience
	Project Guide	Guide students to learn the basic principles
Study Activity	Activity Plan	Checking ideas and procedures for problem-solving
	Activity	Individual or group activity
	Reflection and Introspection	Check monitoring results from other students
Study Arrangement	Analysis	Check concepts and principles from study process
	Practice	Practice of Concepts and Principles
Experience Extension	Application	Carrying additional activity

3. A Teaching-Learning Model of Robot-based Education

3.1. Constructivism

The proposed model is based on constructivism. The basic principles of constructivism can be summarized as follow [13]. First, constructivism is a psychological theory of knowledge which argues that humans generate knowledge and meaning from their experiences. In other words, constructivism respects students' own experiences and their conclusions. Constructivism emphasizes on study process rather than study outcomes. Second, constructivism emphasizes on social interaction among learners. That is, learners with different skills and backgrounds should collaborate in works and discussions to reach a shared understanding of the truth in a specific area. Finally, constructivism concentrates on real-world problem-solving ability. In other words, learners' problem-solving ability can be maximized when they are experiencing and solving real-world (or called authentic) problems.

3.2. Considerations for Designing Model

In [14], considerations for designing robot-based class education are presented.

First, appropriate educational robots for study objectives should be selected. That is, detailed study objectives must be defined and robots must be selected.

Second, exclude any educational robots that are hard to be assembled or programmed. For elementary school students, too complex robot assembling or programming may lead students to loose interests.

Third, trouble-free robots must be selected. For example, robots with rechargeable battery is better than robots with wire.

Fourth, gender difference must be considered. According to [15], male students like aggressive study contents while female students like cooperative contents.

3.3. Design Principles

The proposed model in this work has the following design principles.

First, the proposed model is designed to enhance creativity of learners. Learners are supposed to be involved in self-directed activities and required to provide results based on their own ideas. Teachers are supposed to mediate students only if necessary.

Second, learners are encouraged to participate in activity via diverse interaction. The interaction in this model includes learner-to-learner interaction and learner-to-teacher interaction. The proposed model encourages learners to solve the problem with cooperating each other. Also, teachers are supposed to guide students if necessary and observe and monitor behavior of students all the time.

Third, motivation is provided in the beginning stage of the instruction. It is known that, for motivation, the most effective time for a class is an early stage of class [16]. In the proposed model, motivation is provided in the first stage.

Fourth, in the proposed model, both study results and study process are equally important. In the model, study process is reviewed at the final stage. Reflecting study process makes learners review their study so that they can reduce the same mistakes in the next study.

3.4. The Proposed Model

The proposed model has the following 5 stages as in Table 6.

(Table 6) Stages of the Proposed Model

Stages	Description
Preparation	-Provide motivation -Let students find study goals -Provide the basic references
Design	-Design robot based on instruction or manual
Assembling	-Write a program -Assemble parts
Demonstration Run	-Drive the robot -Find and correct any errors
Evaluation	-Evaluate performance -Make conclusions
Application & Extension	-Extend any ideas -Apply further ideas to robots

3.4.1 Preparation

In this stage, the overall study objective is given by a teacher. However, a teacher recommends students to find as many detailed objectives as they can. Providing detailed instructions or study objectives given by a teacher may distract students.

Another important role of this stage is to provide motivation to students. A teacher can provide motivation by showing videos or any interesting web sites. On the other hand, a teacher reminds students of study deadline so that students should not miss their deadline.

A teacher is also supposed to provide some references to students in this stage. However, teachers are not supposed to provide many references at one time. Only basic references must be provided. The further references can be found as study proceeds via internet or book.

3.4.2 Design

In this stage, students are required to design their robots based on instruction or standard manual. In this case, a teacher does not have to intervene unless students ask questions or help. However, students are encouraged to exchange their ideas and opinions each other. Sometimes this kind of communication can be done using online tools such as email or chat.

In this stage, the main role of a teacher is to observe students' study progress. Also, a teacher needs to have students record their own study diary for later use. A teacher is supposed to encourage students to exchange their ideas.

3.4.3 Assembling

In this stage, the main role of students is to implement their ideas via programming. This stage is also a main part of the proposed model. Logical and creative thinking can be enhanced by programming. Before programming, a teacher needs to check that students have the basic programming skills.

A teacher needs not to take care of programming results. Instead, a teacher must check if students' logical thinking or algorithm is right or not.

3.4.4 Demonstration Run

In this stage, main concern is to check the assembled robot works or moves correctly according to the design. The test has to be done thoroughly. Either mechanical problems or logical errors in program need to be checked and corrected. In mechanical problems, assembly process needs to be checked. On the other hand, for logical errors in program, they can be corrected with aid of any debugger if available.

3.4.5 Evaluation

In this stage, students need to know that the robot works correctly and performs well based on the initial design. In this stage, students are required to reflect their study process. Usually they need to check design process and program codes for validation.

Also, through discussion with other students, any kinds of conclusions or suggestions need to be made. For sound conclusions, students need to be active for exchanging their opinions and comments with other students.

3.4.6 Application & Extension

In this stage, students are supposed to make further ideas from their original conclusions. Based on the further developed ideas, student can apply the ideas to robots.

If a student finds a simple and new idea, it is better to apply the idea to robot immediately. Also, students are supposed to record their discussion history for later use.

4. Application of the Proposed Model

In this section, a teaching-learning curriculum is introduced based on the proposed teaching-learning model for robot-based education. The following Table 7 shows the entire information.

5. Conclusions and Further Works

As robots become very helpful tools in the current information and knowledge-based society, robots also become essential tools in our daily life. Nowadays robot market is growing very fast. It is expected that robots become very useful and strong tools for helping students' study.

(Table 7)Application of the Proposed Model

Study Title	Let's Make My Own Robot		
Stages	Activities		Remarks
	Teacher	Student	
Preparation	-Play video or websites for motivation	-Discuss own favorite robot	-Show various robots for students
	-Present study goals	-Find detailed study goals during study	-A teacher need to introduce only main goals
	-Provide guide	-Read guide carefully	-A teacher needs to provide only basic references
Design	-Observe students' progress and behavior	-Think about structures and functions of my robot toy	-A teacher needs to check if cooperating works fine
	-Monitor students and try to make every student get involved in cooperation	-Design robots based on the instruction	Instead of verbal discussion, keep their ideas to be recorded
Assembling	-Observe students in terms of logical and creative thinking	-Program based on their ideas -Assemble parts as instructed	-Guide only if necessary -Do not intervene students
Demonstration Run	-Check if the robots work correctly	-Check if their robot works correctly based on the original design -Correct any mechanical or programming errors	-Let students to check motor and tires, and other parts
Evaluation	-Let students present their products	-Make conclusions	-Let students make own conclusion
	Give any kinds of comments on robots	-Find pros and cons of their robot	-Let students discuss performance
Application & Extension	-Let students find any improvements	-Exchange their experience and opinions	-students are supposed to reflect study process
	-Give comments to students	-Extend their ideas	-Let students participate and give ideas
	-Let students apply their ideas to robot	-Record ideas and apply ideas to robot immediately	-Check if ideas are practical

In education, robots are used in two forms, tool and teaching aid, respectively. Also, there are four types of robot-based education, robotics engineering, robotics + STEM, robotics + Multi-discipline, Robotics + Computing, respectively. Also, robots are strong tools for STEAM education and convergent education.

The proposed model has the following characteristics. First, the proposed model is designed to enhance creativity and logical thinking of learners. Second, learners can participate in activities via diverse interaction through the proposed teaching-learning model. Third, the proposed model provides motivation for students as early as possible. Fourth, in the proposed model, study process as well as robot product is monitored so that study steps of learners can be checked easily.

The proposed model can be extended as follows. First, for different types of robots, the more detailed models should be developed. Some robots are developed to increase learner's programming ability. For those kinds of robots, assembling parts may be easy. On the other hand, some robots are developed for assembling parts. For those kinds of robots, writing a code is little easy, however, assembling parts may require logical thinking and creativity. For two different types of robots, teaching-learning models should be developed with different study purposes. Second, the proposed model should be applied to class and check its effectiveness and usefulness. Our concern is to verify effectiveness of the proposed model by applying robot-based classes.

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