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Research Article

Influence of Educational Robots on Learning Performance of Learners Majoring in Computer Science

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Abstract

Information technology and artificial intelligence have promoted the informatization development of education and made many changes in the teaching mode. Especially in the era of artificial intelligence, the combination of human-machine-assisted education teaching has become an optional and efficient teaching mode. As a teaching tool for the transformation of teaching methods empowered by artificial intelligence technology, educational robots have consistent influences on the learning effect of learners, which is the focus of educational technology. As the leading or auxiliary teaching, educational robots can meet the various educational needs of different groups of people and improve the learning performance of learners. This study conducts experimental research on learners majoring in computer science and explores the influences of educational robot-assisted teaching (the experimental group) and traditional classroom teaching (control group) on the learning performance of learners in C language programming. Results prove that no significance exists between different classes in pretest theory scores and pretest practice scores. A significant difference at 0.01 is observed between the pre-test and post-test theory scores in the experimental group (t=−3.891, p=0.001), and a significant difference at 0.01 exists between the pretest and post-test practice scores in the experimental group (t=−3.894, p=0.001). Findings of this study have important reference values for inspiring how educational robots and teachers collaborate to improve teaching effectiveness.

Keywords: educational robot, learners majoring in computer science, learning performance, comparative test

1. Introduction

The deep integration of information technology and education has increased the level of education informatization year by year, resulting in more new teaching methods in various disciplines and specialties. Particularly, the integration of artificial intelligence and robot technology has accelerated the development of education-al robots while also having a greater influence on the improvement of educational intelligence and the wider and deeper dissemination of knowledge. At present, China has promoted comprehensive education informatization. Through national policies such as "Internet + education," artificial intelligence, big data, and other technologies have been fully integrated into education and teaching. Currently, educational robots with intelligent functions appear in teaching as products and teaching aids. Information technology and big data have accelerated the integration of educational robots into the daily learning and working environment of learners. A large number of educational robot researches have been conducted in developed countries. Moreover, the current use of educational robots in China to participate in teaching has also shown a rapid growth trend, especially in engineering experiments, language learning, maker education, and other aspects of application, such that learners' innovative thinking, creative work, and other high-order thinking ability are developed rapidly.

Educational robots are specially developed and designed to serve the teaching process, with the characteristics of rich learning resources, intuitive teaching mode, intelligent communication, and wide application environment. In theory teaching, more abstract technical principles can be visualized by introducing educational robots, making it easier for learners to understand and remember knowledge points. In practical teaching, educational robots can transform more boring teaching contents in more disciplines, which can better stimulate learners' interest in learning, in-crease their learning interaction, and improve their practical ability and reflective critical ability. The introduction of educational robots into classroom teaching can become an effective supplement to teaching of teachers, such that learners can gradually enter the mutual promotion of learning and skill operation and realize their comprehensive application ability of cross-knowledge and multi-field skills. There-fore, the introduction of educational robots into teaching can further stimulate the learning motivation of learners and improve their learning performance.

2. Theoretical Basis and Literature Review

2.1 Theoretical basis

The two main educational theories closely related to educational robots are as follows. The first is the STEAM educational theory [1], which emerged in the United States in the 1990s. It is an educational concept that aims to integrate the teaching and learning methods of various disciplines. According to the characteristics of strong curriculum comprehensiveness, educators generally adopt

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similar teaching methods, such as project-based or situational teaching method. In actual situations, students acquire scientific, technical, engineering, and mathematical thinking modes and the ability to integrate them to solve practical problems, which lays a solid foundation for their in-depth study after entering colleges and universities, thereby improving their competitiveness in the field of science and technology. In the new era, artificial intelligence, Internet of Things, and other keywords are slowly emerging, which represents the development trend and requirements of new era. Therefore, computer technology must be an indispensable technology in the information age in response to the more developed science and technology information age. The current trend is that artificial intelligence, robots, and products of contemporary technology in the current STEAM education are becoming the main technical support. STEAM education concept for cultivating people requires giving students the ability to use science, mathematics, engineering, modern technology, and art to solve problems. The second theory is constructivism, which believes that the construction of knowledge originates from the interaction between subject and object. On the one hand, it is assimilation, and on the other hand, it is compliance. Assimilation indicates that new experience should be based on original experience, and compliance implies that the entry of new experience will adjust and transform the original experience or make the original experience richer, which is bidirectional constructivism. Constructive learning emphasizes learners' active construction of knowledge and develops more active learning through strengthening learners' endogenous motivation. Learners can undertake a far more efficient diagnostic and reflective learning process by using case-based and situational teaching methods. By strengthening the construction of self-knowledge, students can build a bridge between their knowledge and new knowledge to establish links and then improve their learning performance.

2.2 Literature review

As for how educational robots affect the learning effect of learners, Chin et al. [2] found that educational robots are considered an effective teaching tool. The effect of the educational robot learning system on academic performance and motivation of students was examined. The results indicated that the learning system can improve the academic performance of students better than the learning system based on PowerPoint. Among the students who use the learning system, satisfaction and correlation are the highest-scoring motivation factors. In the classroom, the learning system based on educational robots is used to improve the overall learning interest and motivation. Cheng et al. [3] believed that robot technology had great prospects as a learning technology and found five basic applications of educational robots: language education, robotics education, teaching assistance, social skills development, and special education. Vandevelde et al. [4] selected three different construction systems created by students at the School of Industrial Design using small aluminum T-groove extrusion as research events, and the results demonstrated that the students were inclined in using a hybrid system for creation, which relies on its interlocking shape and thread connection to create a rapidly constructed and rigidly assembled robot frame. Reich-Stiebert et al. [5] surveyed college students and analyzed their preferences in educational robot design. The results further indicated that robots should interact primarily through language and display basic emotions, especially positive emotions. Ideal educational robots should be conscientious, easy-going, and open. Huang [6] developed an intelligent educational robot to be applied in English teaching practice in primary schools. The research found that the robot can complete functional teaching, role-playing English vocabulary, and free dialogue, which can further improve students' learning efficiency, attention, and initiative in classroom practice. Meghdari et al. [7] introduced a new robot platform, RASA, which demonstrated that the design and construction of this type of educational social robot aim to help children with hearing disabilities learn Persian sign language. Karaahmetoğlu et al. [8] investigated the influence of project-based Arduino educational robot applications on students' computational thinking ability and STEM skill level. The results showed that activities identifying block-based robotic programming tools did not have significant effects on the total scores and factor-related scores of students' STEM skills; however, their contributions were significantly higher than the total scores and problem-solving factors of block-based robotic programming tools when analyzing computational thinking skills. Hung et al. [9] believed that educational robots can stimulate the learning motivation of learners. Robot Teaching Assistant aims to enhance and maintain the learning motivation of English reading skills. It can significantly improve the learning motivation, performance, and persistence intention of learners by using the attention, relevant, confidence, and satisfaction model design system. Hong et al. [10] found that Robot Teaching Assistant language learning is a major trend design of Robot Teaching Assistant teaching materials for primary school students learning national English courses in Taiwan. The results after the test showed that the performance of experimental group was better than the control group, especially in improving listening and reading skills. In addition, the survey on the motivation of teaching materials indicated that the learning motivation of learners in the experimental group was positively affected. Tanaka et al. [11] described the introduction of a caring robot into a classroom at a Japanese children's English school (3-6 years old) and then experimented to evaluate whether the caring robot can facilitate their learning of English verbs. The results demonstrated that the idea of a caring robot is feasible and can help children learn new English verbs effectively. Merkouris et al. [12] recruited 36 middle school students to attend six robot courses to expand their learning in computational thinking. These findings found that rich physical interaction with remotely controlled robots may balance attractiveness and cognitive benefits. Sisman et al. [13] briefly introduced the implementation and validation process of the Educational Robot Attitude Scale (ERA), which was used to measure secondary school students' attitudes toward the use of humanoid robots in educational environments. The ERA consists of 17 items, representing four factors of students' attitudes: engagement, happiness, anxiety, and intention. The four factors accounted for 66% of the total variance of the scale, which was used to measure the attitude dimensions of middle school students toward humanoid robots in educational environment. Kubilinskiene et al. [14] systematically reviewed 16 relevant papers on the use of educational robots in schools. The systematic literature review has shown that robotics has been paving its way as a teaching aid more intensively and flexibly. Chew et al. [15] discussed the design research, operation, and interesting interaction of robots. The results found that educational robots played a catalytic role in formalizing international human rights in Malaysia, and the interdisciplinary synergy effect of educational courses applied the humanities of advanced robots to the participation of the next generation. De Haas et al. [16] studied the relationship between eye gaze and task engagement and robot engagement in children. The regression analysis showed that a relationship exists between children's eye gaze direction and participation. Eye gaze plays an important role in measuring engagement. Lee et al. [17] introduced intelligent robot teachers in Taiwan and Japan to study with students. The case study results found that the learning performance and feedback of students and teachers were highly positive, especially helping students. The existing research literature indicates that educational robots have been widely used in teaching of primary and secondary schools, innovative education of college students, and special education in foreign developed countries, which have a significant role in improving the learning performance of learners [18]. Educational robots have a positive role in promoting the understanding level and skill mastery of learners. At present, some educational robots have also been developed and applied in China, but problems such as poor application scope and insufficient application depth still exist. As one of the teaching equipment, educational robots should be fully integrated into the teaching environment with teachers and learners. Multiple abilities of learners can be improved by designing more efficient education strategies, which is conducive to the reform of curriculum teaching methods and plays a positive role in improving the cognitive level of learners at different latitudes.

3. Methodology

In this study, the quasi experimental method was used to verify the effect of educational robots on the learning performance of learners majoring in computer science. Two classes with similar computational thinking level were selected. In the course of C Language Programming Design, the experimental class carries out the learning method of educational robots, and the control class carries out the traditional theory teaching and learning method for comparative experiments. According to the results of theoretical knowledge test and practical skill test, verify the effect of educational robots on the learning performance of learners majoring in computer science.

3.1 Experimental subjects

In this study, 48 college students majoring in computer science in four universities from Wenzhou of China were selected to conduct experimental research on the C language Programming Design course in the fall semester of the 2021-2022 academic year. Among them, 24 students were included in the experimental group and used educational robots as the C language programming platform; whereas the other 24 students were included in the control group, teaching traditional theory in classroom and explaining the knowledge of C language programming. The experimental subjects all received the same years of professional basic knowledge learning, and the college students' abilities in all aspects were similar. Among the 24 college students in the experimental group, there are 13 males and 11 females. Among the 24 college students in the control group, 12 were male and 12 were female.

3.2 Experimental process

The research design of this paper follows the basic principles of educational experimental research. The action research includes three links, namely, planning, implementation, and reflection evaluation.

The main task in the preparatory stage is to familiarize students with educational robot products. Before the experiment, two teachers introduced and demonstrated the functions of the educational robot products to the students in the experimental group, so that the experimental subjects can adapt to the new teaching methods. At the same time, according to the feedback information of the experimental subjects, the educational robot equipment was debugged and optimized to ensure the normal experiment.

In the implementation stage of C language programming activities, educational robots mainly analyzed the difference in pretest scores between the control and the experimental groups to determine whether obvious differences exist in learning individual quality between the experimental and control groups. Then, 15 weeks of teaching process were implemented, and a comprehensive test was conducted in the 16th week.

The comprehensive test was divided into theoretical knowledge test and practical skills test. The scores of theoretical knowledge were obtained by correcting papers by teachers (percentage system), and the scores (percentage system) of practice skills were given by an educational robot using the C language programming design test platform in the experimental group. The control group adopted the computer test under the supervision of teachers, and the test results were given by teachers after review (percentage system).

4. Results Analysis

4.1 T-test for pretest score

Table 1 shows that the t-test (independent sample t-test) was used to study the differences between the scores of pretest theory and pretest practice in different classes. The results indicated that no significant difference existed between them ($p>0.05$). Therefore, different classes had no significant difference in the scores of pretest theory and pretest practice. Thus, the foundation of this experiment was relatively balanced, and no obvious difference was observed in individual factors of learners.

Table 1. T-test for pre-test score

	Class (average value ± standard deviation)		*t*	*p*
	Control group (n=24)	Experimental group (n=24)		
Scores of pretest theory	72.08±13.71	77.29±12.29	-1.386	0.172
Scores of pretest practice	75.79±16.63	80.96±14.87	-1.134	0.263

4.2 Correlation analysis

Table 2 shows that the correlation coefficients of the pretest and post-test theory scores, as well as the pretest and post-test practice scores, in the control and experimental groups, were obvious at 1%. Thus, the post-test scores were highly correlated with the pretest scores through educational robot teaching mode or traditional classroom teaching mode.

Table 2. Related coefficients

Related coefficients	Control group		Experimental group	
Theory score				
Pretest theory	1	-	1	-
Post-test theory	0.981**	1	0.900**	1
Practice score				
Pretest practice	1	-	1	-
Post-test practice	0.966**	1	0.645**	1

Note: **p*<0.05, ***p*<0.01

4.3 T-test for post-test score

Table 3 shows that the t-test (independent sample t-test) was used to study the difference between the scores of post-test theory and post-test practice in different classes, which indicated a significant difference between them ($p<0.05$). According to the specific analysis, a significant difference existed at 0.05 in the post-test theory score ($t=-2.027$, $p=0.048$). The average value of post-test theory in the control group was 74.50, which was significantly lower than that in the experimental group at 81.57. A significant difference at 0.01 was also observed in the post-test practice score ($t=-3.060$, $p=0.005$). The average value of post-test practice in the control group was 80.9, which was significantly lower than that in the experimental group at 90.33. Therefore, a significant difference existed between post-test theory scores and post-test practice scores for educational robot teaching mode. The main reason was that educational robots can present the knowledge of C language programming through massive code resources, language teaching, and emotional interaction, such that learners can increase the sense of teaching presence and build a more efficient learning environment. By interacting with educational robots, learners can realize the C language programming design through problem-based learning. When obvious errors in the design process are discovered, educational robots can give provide helpful advice. After completing the design, the code effect of learners can be evaluated in real-time, and the scores can be given to increase the learning efficacy. Conversely, educational robots can also pay attention to the change in the facial expressions of learners, accurately portray the whole learning process of learners, and give teachers more personalized teaching strategies.

4.4 T-test for paired samples

Table 4 indicates a significant difference between pretest and post-test theory scores in the experimental group using educational robot learning mode at 0.01 ($t=-3.891$, $p=0.001$). According to the specific comparison, the average value of pretest theory score was 77.29, which was lower than that of post-test theory score at 81.57. A significant difference existed between the pretest and post-test practice scores at 0.01 ($t=-3.894$, $p=0.001$). According to the specific comparison, the average value of pretest practice score was 80.96, which was significantly lower than that of post-test practice score at 90.33. The results show that the educational robot learning mode could significantly improve the post-test theory score and post-test practice score of learners. The main reason may be that educational robots could stimulate the learning motivation of learners. Particularly, educational robots can conduct a multi-dimensional search for questions raised by learners by using big data and artificial intelligence and answer questions through real-time language communication. The educational robots use the deep learning method to model and analyze the learning process of learners, analyze the learning behavior and learning emotion expression of learners, make scientific diagnosis of the learning process of learners, judge the weak links of knowledge points, and propose suggestions to strengthen learning. Educational robots can automatically judge language expression and emotional changes through long-term contact with learners. For example, when learners study for a long time, educational robots will prompt them to take a rest and use a more personalized language expression, such as using the name of learners and other ways, to increase the intimacy of communication.

Table 4. T-test for paired samples in experimental group

Item	Paired (average value ± standard deviation)		Deviation (Pair1-Pair2)	*t*	*P*
	Pair 1	Pair 2			
Pretest theory score paired with post-test theory score	77.29±12.29	81.57±10.44	-4.28	-3.891	0.001**
Pretest practice score paired with post-test practice score	80.96±14.87	90.33±6.48	-9.37	-3.894	0.001**

Note: **p*<0.05, ***p*<0.01

4.5 Covariance analysis

Table 5 indicates that no significant difference existed between the scores of post-test theory and post-test practice, taking gender as a covariate Thus, no significant difference was observed in the learning effect of learners. The main reason was that educational robot teaching mode is a relatively new way of education in the course of C language programming. Boys and girls have maintained a high level of learning motivation and had a good impression of the participation of educational robots in the learning process. This conclusion has important enlightening value for college teachers. In traditional education, girls have more learning motivation and better learning performance in engineering, such as computer design. However, the introduction of more intelligent educational robots can significantly improve the difference in learning performance between boys and girls.

Table 5. Covariance analysis of post-test theory score and post-test practice score

Post-test theory score					
Source of variance	Quadratic sum	*df*	Mean square	*F*	*p*
Intercept	34092.531	1	34092.531	230.92	0.000**
Training mode (experimental/control group)	617.984	1	617.984	4.186	0.047*
Gender	79.193	1	79.193	0.536	0.468

Residual	6643.716	45	147.638	-	-
Post-test practice results					
Source of variance	**Quadratic sum**	***df***	**Mean square**	***F***	***p***
Intercept	34092.531	1	34092.531	230.92	0.000**
Training mode (experimental/control group)	617.984	1	617.984	4.186	0.047*
Gender	79.193	1	79.193	0.536	0.468
Residual	6643.716	45	147.638	-	-

Note: *p<0.05, **p<0.01

5. Discussion

Educational robots can become auxiliary teaching equipment in the teaching process or an experimental platform for teaching interaction. To ensure the scientific nature of educational robots participating in the teaching process, teachers must repeatedly check the educational robot equipment before class and do a good job in daily maintenance. The background data and store data of educational robots are updated regularly. Teachers shall do a good job in the design of the whole classroom teaching link, incorporate the educational robot into the teaching process, and design its appearance time and operation process. In classroom teaching, educational robots should be placed in the scientific position of teaching. Teachers should control the master control system of educational robots and control the time and rhythm of playing teaching materials. They shall properly design the proportion of educational robots playing pictures, text, video, audio, and other content. When learners encounter problems in the course learning, educational robots can conduct massive searches according to the questions raised by learners, keep close communication with learners, transform language style according to the identities of different learners, and improve the emotional perception of learners. After class, teachers should fully utilize educational robots to control the whole course of teaching, analyze the learning state of each learner, scientifically sort out the teaching process, and accurately evaluate the learning effect of learners. Then, they should also optimize the overall setting of educational robots, continuously improve and adjust their teaching methods, and ensure that educational robots play their due role in classroom teaching.

Learners have a certain sense of novelty in the teaching process of educational robots, and many students actively participate in the learning process. The educational robot-assisted teaching mode also affects how to better stimulate learners' enthusiasm. Educational robots use more task-driven teaching methods, which require learners to adopt more autonomous learning methods, and learners use educational robots to obtain massive auxiliary learning resources. Learners need to operate by themselves or interact well with educational robots. They need to pay more attention to careful observation, continuous attempt, repeated trial and error, and other learning processes, which can significantly improve their high-order thinking ability and realize the transfer of learning knowledge. For example, in the design of C language programming, learners need to operate educational robots and adjust and modify the program code in real-time according to the feedback on the screen of educational robot. Educational robots can also give appropriate tips to comprehensively judge the learning state of learners according to the code input speed and accuracy of learners and then achieve more efficient knowledge transfer of learners. At the same time, learners can search for learning questions and find answers in educational robots through language. Educational robots can also actively send language information when discovering that learners face learning disabilities, encouraging learners to explore and increase learning interaction.

6. Conclusion

The intelligent technology represented by artificial intelligence, blockchain, cloud technology, and big data has been promoted via in-depth reform of education and teaching methods. With the support of artificial intelligence and big data, the participation of educational robots in classroom teaching has become an important development trend and an important representation form of intelligent education. The participation of educational robots as educational auxiliary equipment in theoretical teaching and practical skills can significantly improve the learning efficiency of learners, increase the interest and interactivity of classroom teaching, enhance their learning motivation, and improve their learning performance. This study conducts experimental research on students majoring in computer science from Wenzhou in China and explores the influences of educational robot-assisted teaching (experimental group) and traditional classroom teaching (control group) on the learning performance of C language programming design of learners. The results demonstrated no significance for the pretest scores of theory and practice among different class samples. In the experimental group, a significant difference existed between the pretest and post-test theory scores at 0.01, and the same significant difference existed between the pretest and post-test practice scores at 0.01. Further research should be conducted on the influence mechanism of educational robots on student team cooperation and the optimization design of the teaching process under the background of educational robot-assisted teaching.

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