Using Robotic Arm as Sidekick to the Teacher in Classroom

Mona Esmat[1,*], Amira Atta[1]
[1]Computer Teacher Department, Faculty of Specific Education, Mansoura University, Egypt
Emails: monaesmat1980@gmail.com; Dr.amiraatta@mans.edu.eg

Abstract

The lack of practical teaching tools, such as a robotic arm, hinders students' understanding of complex concepts in robotics courses, where hands-on experience is essential for effective learning. This study introduced a 6DOF Robotic Arm as a teaching aid to address this issue, evaluating its impact through an experimental study with 30 computer science students. The findings revealed that the robotic arm effectively enhanced both basic and advanced Arduino programming skills, with students who used it performing better and expressing higher satisfaction than those who did not. The study also identified gaps in hardware control comprehension, leading to software development that could further aid in mastering programming concepts. The paper concludes with a discussion of the potential of the robotic arm as a valuable educational tool and its implications for future research and practical applications.

Keywords: Robotics; Sidekick; Human-Computer Interaction; Robotic Arm; Teacher in Classroom

1. Introduction

Robotic manipulators have been rapidly incorporated in different industries. The wide range of fields includes industrial (material handling, palletizing, inspection), medical (prosthetics, surgery, pathological settings), and other fields. This is due to their capacity to make difficult repetitive operations easier [1]. Over the past several years, robotic technologies have slowly made their way into the K-8 curriculum as a means of facilitating problem-solving, collaboration, and the development of information and ICT skills [2]. For their skills to be marketable, students must become proficient in the use of technology and demonstrate a sound understanding of the nature and operation of technological systems [3]. Robotics technologies hold a promising future for educational applications since these resources provide educators with opportunities for connecting curricular content to workplace skills and competencies [4].

Robot arms are programmable electro-mechanical devices designed to carry out specific tasks such as assembly, material handling, and loading of a tool for: welding, painting, spraying, etc. To understand the complexity of robots, engineering knowledge of design, manufacturing, mechanical, electrical, computer science, and mathematics is required. Applications and developments in the field of robotics have been increasing over time and demand trained graduates who must be proficient in all the technologies related to it [5]. In addition, it is well known that the more active and pragmatic the students are involved in applying a subject, the better the learning of its theoretical aspects. That is why laboratories are paired with theoretical classes to combine these two important learning aspects. Thus, when teaching a robotics course, it is recommended the use an experimental platform in the learning process [6] as it allows a practical experience demonstrating the basic concepts and keeping the students' interest and motivation. The use of robots in education or educational robotics has some advantages. One of the advantages is being able to attract the attention of students. According to [7], the use of educational robotics makes students more familiar with and proactive in participating in programming learning to make the learning process effective.

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

This paper explores the critical role of media, specifically a 6DOF Robotic Arm, in facilitating the learning of Arduino programming.

The research problem is represented in the following main question: What is the effectiveness of using robotic arms as an aid for the teacher inside the classroom? In addition, the following sub-questions branch out from it:

- How can codes be built to move the robotic arms?
- What is the effectiveness of using robotic arms as a Sidekick for the teacher in developing the achievement of computer students at the Faculty of Specific Education?
- What is the effectiveness of using robotic arms as an assistant for the teacher in the classroom in developing basic and advanced skills in the Arduino program among computer students at the Faculty of Specific Education?

2. Related Work

The field of robotic arm research has witnessed significant advancements across educational, medical, and technological domains. These studies collectively demonstrate the versatility and potential of robotic arm technologies in various applications, ranging from educational training to specialized surgical interventions. Researchers have explored multiple dimensions of robotic arm development, including kinematic analysis, design methodologies, control systems, and educational implementation.

Several key themes emerge from this body of research. First, there is a strong emphasis on developing cost-effective and adaptable robotic arm platforms that can serve multiple purposes. For instance, Shubh Shrey, Shraddha Patil, et al. introduced the forward and reverse kinematic analysis of Lynxmotion's (LSS) − 5 DOF Robotic Arm using D-H Parameters. Workspace for general condition and Minimal Invasive Surgery – Laparoscopy is generated using MATLAB Software. As an outcome of this study, they found that the Lynx-6 robotic arm can be used in robot-assisted laparoscopy and its effectiveness can be further increased with few modifications. A dedicated robot for Laparoscopy made by modifying Lynx6 will cost less and be equally effective [1]. Antoinette P. BRUCIATI evaluated educators' ability to independently master advanced computer programming concepts using the OWI Robotic Arm Trainer and PC Interface Kit. The findings uncovered gaps in student comprehension, prompting the creation of additional instructional support materials. The software employed in this study shows potential for helping educators master programming concepts. In post-test interviews, participants expressed satisfaction and pride in their ability to program the robotic arm, and they enjoyed witnessing the robotic arm operate autonomously by the end of the study [5]. David Sáenz Zamarrón, Nancy Ivette Arana de las Casas, et al. proposed the design and construction of a 4-DOF robotic arm, utilizing CAD, CAM, electronics, and MATLAB's Robotics Toolbox for solving kinematics. The project results in a low-cost platform, continuously improved, designed for laboratory courses in design, manufacturing, electronics, and robotics—core components of many engineering curricula. It can be employed in both graduate and undergraduate robotics courses to effectively bridge the gap between theoretical concepts and the practical execution of robot manipulator movements in real time [8]. Martı´n Herna´ndez-Ordoñez, Marco A. Nuño-Maganda et al. demonstrated the implementation of a robotic platform integrated with augmented reality technology, aimed at enhancing the interactivity and comprehension of robotics topics in an educational setting. The platform is designed for teaching robotic arm manipulation concepts and consists of a homemade robotic arm, a control system, and the RAR@pp (Robotics through Augmented Reality Application). RAR@pp is specifically focused on teaching robotic arm manipulation algorithms by detecting markers on the robotic arm and providing real-time visualization of the angles of each joint using augmented reality [9]. Jakkrit Kwantongon, Wuttiporn Suamuang, and Kanyuma Kamata developed a teaching demonstration using a PLC-controlled 5-axis robotic arm, evaluate the efficiency of this PLC-controlled robotic arm demonstration set, assess learners' academic achievement when using the set, and explore students' satisfaction with it. The results showed that students who used the robotic arm teaching demonstration set outperformed those who did not and reported high levels of satisfaction with its use [10]. Gusti Putu Asto Buditjahjanto and Pramudya Ardi et al. analyzed the relationship between the latent variables of assembling, operating, and evaluating with the latent variable of psychomotor skills in the context of robotic arm concepts. The Partial Least Squares (PLS) path analysis method was employed to analyze and predict theoretical models related to robotic arm concepts. The research findings indicate that the latent variables of assembling, operating, and evaluating positively influence the development of psychomotor skills [11]. Mohamed Hosni, Mostafa Rostom, and Farid Abdel Aziz presented a novel supervised learning technique for programming

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

a 4-degree-of-freedom (DOF) welding arm robot with an automatic feeding electrode. The technique involves developing a three-dimensional (3D) machine vision system to capture the welding position and speed along a complex path, based on the monitoring of an expert welding instructor. The collected data are then used to create the robot's movement program. Compared to traditional methods, this approach requires fewer steps and less time and does not necessitate an expert programmer. The vision system, supported by a custom-developed image-processing program, is utilized to assess the accuracy of the robot's path [12]. Albert M. Cook, Brenda Bentz, et al**.** introduced a robotic arm system designed for children with severe motor disabilities and varying cognitive and language abilities. The children interacted with the robot by performing a three-task sequence routine to retrieve objects from a tub of dry macaroni. All the children responded positively to the robot, finding the robot-generated tasks more engaging and stimulating compared to single-switch tasks like toys, appliances, or computer-based activities [13]. Laura Malinverni and Cristina Valero et al. conducted two studies conducted with primary and secondary school students to explore their perceptions of robots. An art-based approach was employed, involving children in creating audiovisual narratives about robots. The findings revealed five key themes that suggest ways to expand Educational Robotics (ER) beyond technical skills, using it as a tool to engage children in discussions about the ethical, social, and cultural implications of emerging intelligent technologies [14]. Luis Grau, MD, Max Lingamfelter, DO, et al. have pointed out the fundamental concepts and detailed workflow used to enhance operating room efficiency and consistently achieve robotic arm-assisted total knee arthroplasty (RTKA) with surgical times under 60 minutes. While robotic technology is not essential for performing a technically proficient total knee arthroplasty (TKA), they believe it is a valuable tool for the arthroplasty surgeon. Based on our experience, RTKA has transformed how we balance knees by providing numerical values for balancing and enabling precise adjustments [15]. H. Kareemullah, D. Najumnissa, et al. designed and developed a remotely controlled robotic arm for use in hazardous environments, such as quarantined rooms with COVID-affected patients. This has led to the creation of a B-rover, a robotic arm controlled remotely by technicians to minimize direct contact with dangerous environments. The robotic arm has various applications, including health monitoring, sample collection, and medication delivery to COVID-affected patients without direct human interaction. The proposed design features a 3DOF (degrees of freedom) robotic arm with a stepper motor, controlled via Wi-Fi using the BlynkIoT App with widgets like Joystick and Sliders. This arm can move objects from one location to another. Results indicate that the robotic arm exhibits a 3% deviation between simulated and actual results when adjusting the slider. Practical tests have demonstrated that the wireless control connection reduces delay and enhances stability [16].

3. Methods

3.1. Objectives

The research objectives are:

- **Evaluate the Effectiveness*:*** Assess the effectiveness of using robotic arms as an aid for teachers in the classroom.
- **Develop Coding Skills**: Investigate how to build and implement codes to control the movement of robotic arms.
- **Measure Achievement Impact**: Determine how effectively robotic arms, as a teaching tool, contribute to the achievement of computer science students at the Faculty of Specific Education.
- **Assess Skill Development**: Examine how robotic arms assist in developing both basic and advanced skills in Arduino programming among computer science students at the Faculty of Specific Education.

3.2. Research Hypotheses

1. There is a statistically significant difference at the level of significance (≤0.05) between the mean scores of the students - the research sample - in the pre and post-applications of the achievement test in Favor of the post-application.
2. There are statistically significant differences at the level of significance (≤0.05) between the mean scores of the experimental group students in the pre and post-applications of the observation card (dimensions and total score) in Favor of the post-application.

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

3.3. Experimental System

The implementation of the robotic arm involves several key aspects, including:

1. Connecting and programming the 6-DOF robotic arm using the Arduino microcontroller.
2. Developing the necessary software and control algorithms to enable the teacher to seamlessly integrate the robotic arm into classroom activities.
3. Designing the physical setup and integration of the robotic arm within the classroom environment.
4. Evaluating the effectiveness of the robotic arm as a teaching aid through empirical studies with students.

The robotic arm in this study utilizes a 6-DOF (Degrees of Freedom) robotic arm as a sidekick to the teacher in the classroom. Figure 1 shows the 6-DOF robotic arm used in this research.

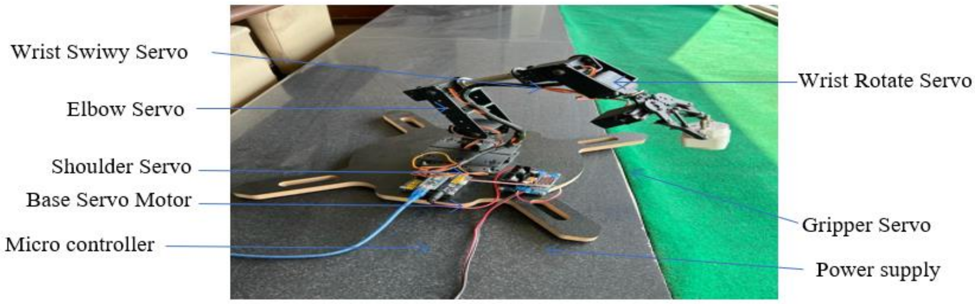

Figure 1. 6DOF Robotic Arm

Figure 2 illustrates the concept map of the educational robotic arm. It outlines the main components, including manipulators, grippers, arms, and servo motors.

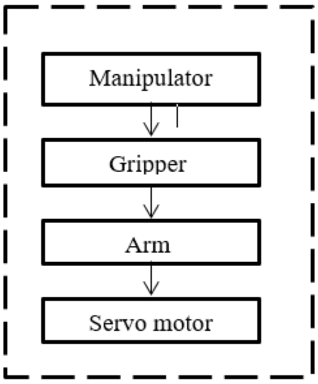

Figure 2. Concept Map of Education Robot Arm

Figure 3 displays the block diagram of the robotic system. The main components include the robotic arm, control module, power supply, and the interface connected to the teacher's computer.

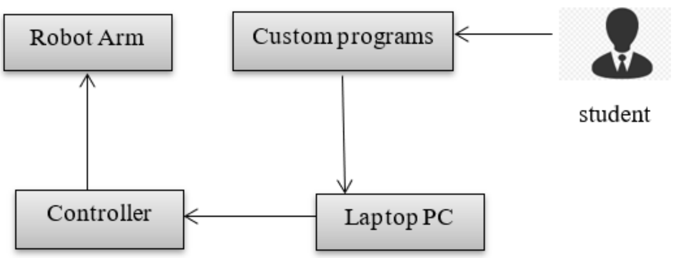

Figure 3. Block Diagram of Robotic System

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

Figure 4 shows the control module of the robotic arm, which is the central component that allows the teacher to program and control the arm's movement. It features a microcontroller (Arduino), motor drivers, sensors, and communication interfaces.

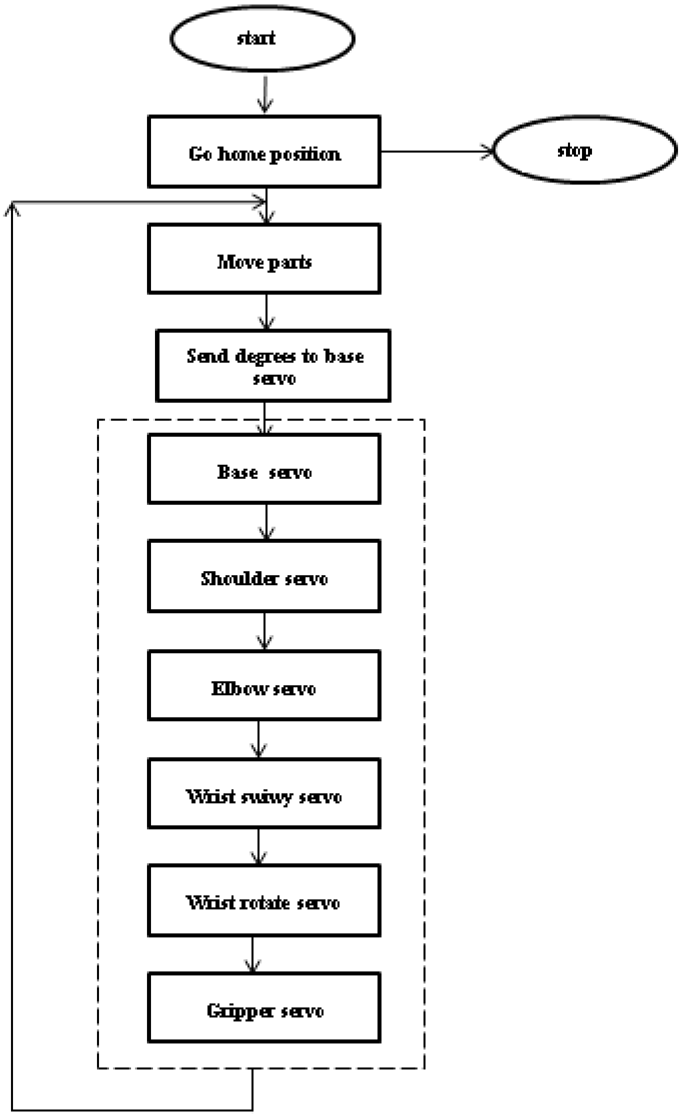

Figure 4. Main blocks of robotic arm control module

3.4. Concepts & Skills

We use the 6DOF Robotic Arm to facilitate learning Arduino programming, covering Basic Arduino Skills, Advanced Arduino Skills, and Mechanical Engineering Skills, as detailed in Sections 1, 2, and 3.

Table 1: Section 1, Basic Arduino Skills

Basic Concepts	Sub-skills
Connecting Circuits and Components	- Understanding basics of electricity and electronic circuits - Using breadboards and connecting components - Knowing types of electronic components and how to connect them - Understanding digital and analog ports on Arduino and their uses

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

Basic Concepts	Sub-skills
Reading Sensors and Writing to Outputs	- Understanding principles of different sensor types (temperature, light, motion) - Reading data from sensors using Arduino - Knowing how to use different outputs (valves, motors, displays)- Programming Arduino to control outputs
Using Loops, Conditionals, and Functions	- Understanding programming basics and program structure - Using loops (for, while, do-while)- Using conditionals (if, else if, else)- Using functions and creating/passing arguments

Table 2: Section 2, Advanced Arduino Skills

Advanced Concepts	Sub-skills
Motor Control via PWM	- Understanding working principles of DC motors and stepper motors - Using PWM to control motor speed - Using motor driver circuits (H-bridge) - Programming Arduino for motor control
Implementing Control Algorithms	- Understanding control theory basics and different algorithms - Coding these algorithms in Arduino programs
Sensor Verification and Decision Making	- Interpreting data from sensors - Using conditionals and logic for appropriate actions - Applying decision-making logic in Arduino programs

Table 3: Section 3, Mechanical Engineering Skills

Basic Concepts	Sub-skills
Designing Mechanical Parts	- Understanding mechanics and engineering dynamics
Assembling and Joining Mechanical Structures	- Manual skills and mechanical assembly
Installing Motors and Connecting to Control	- Mounting motors to mechanical structures - Connecting motors to driver circuits and Arduino - Electrical and mechanical connection skills.

3.5. Implementation

To answer the first question, the following procedures were carried out:

First: The series of commands for moving the arm and using it inside the classroom was built using the Arduino program Thus, the answer to the first question of the research questions, which states, "How can codes be built to move the robotic arm?

Second: the research tools were developed as outlined below:

1- Building and adjusting the achievement test:

- The achievement test was initially built consisting of (35) items, and to ensure its validity, it was presented to a group of (3) reviewers. The reviewers suggested making some modifications, including modifying the wording of some items and deleting some items due to their unsuitability for first-year students. These modifications were made, and the achievement test in its final form included (30) items suitable for application.
- The reliability of the achievement test was calculated using the test-retest method. The test was administered to a pilot sample of (30) students from the first year of the Computer Science Department, Faculty of Specific Education, Mansoura University. After two weeks, the achievement test was re-administered to the same

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

sample. After recording the results and statistically processing them using the Pearson correlation coefficient, the reliability coefficient value was as shown in the following table:

Table 4: Reliability Coefficient of the Achievement Test (Dimensions and Total Score

Reliability Coefficient	Significance Level
0.87	0.01

It is clear from Table (1) that the reliability coefficient of the achievement test as a whole is (0.87), which is significant at (0.01), and this is a good reliability coefficient for this method.

2- Building an observation card for students' skills in dealing with robotic arms:

- The observation card was initially built including three skills, each skill containing five performances.
- The card was presented to a group of (3) reviewers and the reviewers suggested making some modifications to the linguistic wording of the items. The researcher modified the initial version of the observation card, and it became in its final form suitable for application.
- To ensure the reliability of the observation card, it was applied to a pilot sample of (30) students from the first year of the Computer Science Department, Faculty of Specific Education, Mansoura University. After two weeks, the observation card was re-applied to the same sample. After recording the results and performing statistical processing using the Pearson correlation coefficient, the reliability coefficient values were as shown in the following table:

Table 5: Reliability Coefficients (Correlations) of the Observation Card (Dimensions and Total Score)

Dimensions	Reliability Coefficient	Significance Level
Basic Arduino Skills	0.84	0.01
Advanced Arduino Skills	0.68	0.01
Mechanical Engineering Skills	0.81	0.01
Total	0.88	0.01

It is clear from Table (2) that the reliability coefficients of the observation card dimensions ranged between (0.68) and (0.84), while the reliability coefficient of the observation card as a whole was (0.88), and all of them were significant at (0.01), which are high-reliability coefficients for this method.

Third: The research sample was chosen from the first-year students of the Computer Science Department, Faculty of Specific Education, Mansoura University, with a total of (30) students.

Fourth: The research tools (achievement test/observation card) were pre-administered to the research sample.

Fifth: The research sample was taught using a robotic arm as an aid in the Decision Support Systems course in the second semester of the 2023/2024 academic year, with total of (12) hours at a rate of two hours per week.

Sixth: The research tools were post-administered to the research sample students.

4. Results And Discussion

After recording the results and statistically processing them, the results were as follows:

Testing the validity of the first hypothesis, which states: "There is a statistically significant difference at the level of significance (≤0.05) between the mean scores of the students - the research sample - in the pre and post-applications of the achievement test in Favor of the post application."

Table 6: T-value and Significance of the Difference between Mean Scores of Students - Research Sample - in Pre and Post Applications of the Achievement Test

Application	Number of Students	Mean	Standard Deviation	Degrees of Freedom	T-value	Significance Level
Pre	30	13.06	2.46	29	23.39	0.01

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

Post	30	22.56	2.26			

It is clear from Table (3) the following:

- There is a statistically significant difference at the level of (0.01) between the mean scores of the students - the research sample - in the pre-and post-applications of the achievement test in Favor of the post-application.
- The level of the students - the research sample - in the post-application of the achievement test increased significantly compared to their level in the pre-application.
- The dispersion of the scores of the students - the research sample - in the post-application of the achievement test decreased, and this indicates an increase in the level of most students, the proximity of their level, and the homogeneity of the scores they obtained after studying the basic and advanced concepts of the Arduino program using a robotic arm, as well as the skills related to mechanical engineering.

These results indicate the achievement of the first hypothesis of the research, and the results can be interpreted as follows:

- It attracted the attention of the students, as the robotic arm attracted the students' attention during the explanation of different concepts, and made the students active and positive while using the robotic arm.
- It helps to consolidate information in the minds of students.
- It facilitates the educational process for students and brings meanings closer to them, which helps them understand.
- It motivates students to participate, engage, and interact with the teacher.
- It leaves a lasting effect on learning in the students' minds and stimulates their activity.

These results agree with the results of studies [5] [8] [10] [13], which confirmed the effectiveness of using the robotic arm as an assistant for the teacher in the classroom in developing student achievement.

To measure the effectiveness of using the robotic arm as an assistant for the teacher in the classroom in developing student achievement, the t-value and correlation coefficient between the student's scores in the pre-and post-applications of the achievement test were calculated, and the effect size of using the robotic arm as an assistant for the teacher in the classroom on the achievement of the students - the research sample - was calculated. Table (4) illustrates this:

Table 7: Effect Size of Using the Robotic Arm as an Assistant for the Teacher in the Classroom in Developing Student Achievement

Tool	T-value	Correlation Coefficient	Effect Size
Achievement Test	23.39	0.56	4.21

It is clear from Table (4) that the effect size is (4.21), which is a large effect size [17] and this indicates that using the robotic arm, as an assistant for the teacher in the classroom is effective in developing students' achievement of the basic and advanced concepts of the Arduino program.

Thus, the researcher has answered the second question of the research questions, which states: "What is the effectiveness of using the robotic arm as an assistant for the teacher in the classroom in developing the achievement of first-year students of the Computer Science Department, Faculty of Specific Education, Mansoura University?"

Testing the validity of the second hypothesis: The second hypothesis states: "There are statistically significant differences at the level of significance (≤0.05) between the mean scores of the experimental group students in the pre-and post-applications of the observation card (dimensions and total score) in Favor of the post application."

To verify the validity of this hypothesis, the researcher used the t-test for paired groups, where the mean and standard deviation of the scores of the students - the research sample - in the pre-and post-applications of the observation card (dimensions and total score) were calculated, the corresponding t-value for the difference between the means was calculated, and the significance level corresponding to the t-value was determined. Table (5) shows these results:

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

Table 8: T-value and Significance of the Differences Between Mean Scores of Students - Research Sample - in Pre and Post Applications of the Observation Card (Dimensions and Total Score)

Dimensions	Application	Number of Students	Mean	Standard Deviation	Degrees of Freedom	T-value	Significance Level
Basic Arduino Skills	Pre	30	1.46	1.19	58	8.24	0.01
	Post	30	3.50	1.07			
Advanced Arduino Skills	Pre	30	1.46	0.89	58	6.01	0.01
	Post	30	2.90	0.92			
Mechanical Engineering Skills	Pre	30	1.00	0.94	58	8.99	0.01
	Post	30	2.86	0.86			
Total	Pre	30	3.93	2.54	58	10.49	0.01
	Post	30	9.26	1.68			

It is clear from Table (5) the following:

- There are statistically significant differences at the level of (0.01) between the mean scores of the students - the research sample - in the pre-and post-applications of the observation card (dimensions and total score) in favor of the post-application.
- The level of the students - the research sample - in the post-application of the observation card (dimensions and total score) increased significantly compared to their level in the pre-application of the observation card (dimensions and total score).
- The dispersion of the scores of the students - the research sample - in the post-application of the observation card (dimensions and total score) decreased, and this indicates an increase in the level of most students in the observation card, the proximity of their level, and the homogeneity of the scores they obtained after studying everything related to mechanical engineering for the Arduino program using a robotic arm.

These results indicate the achievement of the second hypothesis of the research, and the results can be interpreted as follows:

- The students have the freedom to apply using the robotic arm, which contributed to their acquisition of skills related to mechanical engineering.
- All the students' senses are involved in the learning processes, which leads to the consolidation of this learning.
- Increased positive student participation in acquiring experience and developing their ability to reflect, observe accurately, and follow scientific thinking to solve problems.
- It saves time and effort for the learner.

These results agree with the results of studies: [5] [8] [10] [13] which confirmed the effectiveness of using the robotic arm as an assistant for the teacher in the classroom in developing mechanical engineering skills among the research sample students:

To measure the effectiveness of using the robotic arm as an assistant for the teacher in the classroom in developing mechanical engineering skills in the Arduino program for the research sample students, the t-value and correlation coefficient between the student's scores in the pre and post applications of the observation card were calculated, and the effect size of using the robotic arm as an assistant for the teacher in the classroom in developing the basic and advanced skills and mechanical engineering skills in the Arduino program for the students - the research sample - was calculated. Table (6) illustrates this:

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

Table 9: Effect Size of Using the Robotic Arm as an Assistant for the Teacher in the Classroom in Developing Basic and Advanced Skills in the Arduino Program for Research Sample Students

Dimensions	T-value	Correlation Coefficient	Effect Size
Basic Arduino Skills	8.24	0.29	1.81
Advanced Arduino Skills	6.01	0.02	1.56
Mechanical Engineering Skills	8.99	0.21	1.98
Total	10.49	0.18	2.31

It is clear from Table (6) that the effect size for the dimensions of the observation card ranged between: (1.56), and (1.98), while the effect size for the card as a whole was (2.31), which is a large effect size, and this indicates that using the robotic arm as an assistant for the teacher in the classroom is effective in developing the basic and advanced skills, Mechanical Engineering Skills in the Arduino program for the research sample students.

Thus, the researcher has answered the third question of the research questions, which states: "What is the effectiveness of using the robotic arm as an assistant for the teacher in the classroom in developing the basic, advanced and Mechanical Engineering Skills for the first-year students of the Computer Science Department, Faculty of Specific Education, Mansoura University?

5. Conclusion

This paper aimed to design and implement a robotic arm as an assistant to teachers in the classroom. The study, conducted with 30 first-year computer science students, showed significant improvements in their achievement and skills in Arduino programming after using the robotic arm. The robotic arm effectively engaged students, reinforced learning, and simplified complex concepts. The findings suggest that integrating robotic arms in teaching can enhance the learning of computer programming and related skills, offering valuable insights for educators and researchers.

6. Future Work

This study demonstrated the effectiveness of using a robotic arm as a teaching assistant in enhancing student achievement and skills in Arduino programming. Future research could explore its integration into online teacher preparation, its use with disabled students for inclusive education, expansion across various subjects, long-term impacts on students' skills and career paths, and comparisons with other educational technologies. These avenues aim to further understand and maximize the potential of robotic arms in education, especially in STEM and computer science.

Funding: “This research received no external funding”

Conflicts of Interest: “The authors declare no conflict of interest.”

References

[1] Shrey, S., Patil, S., Pawar, N., Lokhande, C., Dandage, A., and Ghorpade, R. R., "Forward kinematic analysis of 5-DOF LYNX6 robotic arm used in robot-assisted surgery," ScienceDirect, vol. 72, Part 3, pp. 858-863, 2023. [Online]. Available: https://www.sciencedirect.com /science/article/abs/ pii/ S22 1478532205893X.

[2] Bers, U. M., Ponte, I., Juelich, K., Viera, A., and Schenker, J., "Teachers as designers: Integrating robotics in early childhood education," Information Technology in Childhood Education, pp. 123-145, 2002. [Online]. Available: http://www.aace.org/dl/files/ITCE/ITCE20021123.pdf.

[3] Workforce Excellence Network, "Using skill standards & certifications in WIB programs," 2003. [Online]. Available: http://www.careerinfonet.org/crl/CRL_R RSearch.aspx?docn =9476&LVL1 =& LVL2=16&LVL3=n&CATID=478&PostVal=1.

[4] "Learning a living: A blueprint for high performance," SCANS Report for America 2000, U.S. Department of Labor, Washington, D.C., 2002.

[5] Bruciati, A. P., "Using a robotic arm to evaluate the programming ability of K-12 educators," Computación y Sistemas, vol. 24, no. 4, pp. 1387-1401, 2020.

[6] Greenwald, L., and Kopena, J., "Mobile robot labs," IEEE Robotics & Automation Magazine, vol. 10, no. 2, pp. 25-32, 2003. DOI: 10.1109/MRA.2003.1213613.

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024

[7] Ohnishi, Y., Honda, K., Nishioka, R., Mori, S., and Kawada, K., "Robotics programming learning for elementary and junior high school students," Journal of Robotics and Mechatronics, vol. 29, no. 6, pp. 992-998, 2017.

[8] Sáenz Zamarrón, D., Arana de las Casas, N. I., García Grajeda, E., Alatorre Ávila, J. F., and Uday, N. A. J., "Educational robot arm development," Computación y Sistemas, vol. 24, no. 4, pp. 1387-1401, 2020.

[9] Hernández-Ordoñez, M., Nuño-Maganda, M. A., Calles-Arriaga, C. A., Montaño-Rivas, O., and Bautista Hernández, K. E., "An education application for teaching robot arm manipulator concepts using augmented reality," Mobile Information Systems, vol. 2018, Article ID 6047034, 8 pages, 2018. DOI: https://doi.org/10.1155/2018/6047034.

[10] Kwantongon, J., Suamuang, W., and Kamata, K., "A teaching demonstration set of a 5-DOF robotic arm controlled by PLC," International Journal of Information and Education Technology, vol. 12, no. 12, Dec. 2022.

[11] Buditjahjanto, G. P. A., Ardi, P., Munoto, M., and Samani, M., "Evaluating and analyzing of robotic arm as learning media based on partial least square method," TEM Journal, vol. 9, no. 2, pp. 672-679, May 2020. DOI: 10.18421/TEM92-33.

[12] Hosni, M., Rostom, M., and Abdel Aziz, F., "A supervised learning technique for programming a welding arm robot using vision system," Engineering Research Journal, vol. 162, pp. M50-M64, Jun. 2019.

[13] Cook, A. M., Bentz, B., Harbottle, N., Lynch, C., and Miller, B., "School-based use of a robotic arm system by children with disabilities," IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 13, no. 4, pp. 452-460, 2005.

[14] Malinverni, L., Valero, C., Schaper, M. M., Garcia de la Cruz, I., "Educational robotics as a boundary object: Towards a research agenda," International Journal of Child-Computer Interaction, vol. 29, Article 100305, Sep. 2021. DOI: 10.1016/j.ijcci.2021.100305.

[15] Grau, L., Lingamfelter, M., et al., "Robotic-arm assisted total knee arthroplasty workflow optimization, operative times, and learning curve," Arthroplasty Today, vol. 5, pp. 465-470, 2019. [Online]. Available: http://www.arthroplastytoday.org/.

[16] Kareemullah, H., Najumnissa, D., et al., "Robotic arm controlled using IoT application," Computers and Electrical Engineering, vol. 105, pp. 108539, Jan. 2023.

[17] Murad, S. A., Statistical Methods in Psychological, Educational and Social Sciences, Cairo, Anglo-Egyptian, 2000, p. 253.

DOI: https://doi.org/10.54216/FPA.180102
Received: June 15, 2024 Revised: September 17, 2024 Accepted: December 21, 2024