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The Impact of Robotic Activities on Secondary School Students' Interest in Physics in Kenya

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Abstract: Educational robotic activities can be used to support teaching of science subjects. Many secondary school students have little interest in Physics as a subject and hence only a few students select it in preparation of career progression. Robotic activities can be employed to facilitate practical learning in science subjects in general with the Physics subject benefiting the most. In Kenya, there is little research on the role robotic activities can play on learning of these subjects. This study developed robotic activities from educational robots fabricated by the researcher. The activities presented learners in secondary school with diverse opportunities of enriching their learning of Physics as a Science subject. The robotic activities were integrated into Physics topics to give the teaching and learning of this subject a new approach. The integrated robot activities were then introduced to Form 2 students in workshops carried out during weekends which included 3-day activities for the students. In this study 200, form 2 students were selected randomly from 20 schools in Kangema sub-county, Murang'a county in Kenya. The students were issued with questionnaires before and after exposure to the activities through the workshops for purposes of data collection. The quantitative data obtained was analyzed using descriptive statistics and inferential statistics. The findings of the study revealed that the robotic activities had a significant impact on students' interest in Physics. The study recommends that the government should facilitate the integration of educational robotic activities in the current secondary school Science curriculum in order to improve interest towards these subjects.

Keywords: Robotic activities, Science subjects, Educational robots, Integration, Exposure.

1. INTRODUCTION

According to Kopcha et. al, [1] robots have been beneficial in education and has yielded fruits in that it has led to motivating learners of all education levels to Science subjects. From their study they found out that use of robots through problem solving can support Science, Technology and Mathematics (STEM) in general. Jung and Won [2] indicated that activities around robots can be used to aid in education. According to them, some examples of robots that can support education include LEGO Mindstorms and other robot designs meant to aid the teaching process. They also noted that robot activities have been developed for learners in all education levels. The robot activities range from designing, programming and use of robots in education.

Science, Technology, Engineering and Mathematics careers are vital in providing manpower to a growing economy thereby enhancing innovation and greater productivity [3]. Students should go through the preparation process towards the STEM careers which calls for new perspectives to be adopted by schools to enhance the learning experiences, work integrity and interest in related career [4]. Research in STEM fields has grown immensely, with the priority of many researchers being contribution to the growth of the field, improvement in the STEM workforce and to maintain more students the fields in post-secondary institutions. Furthermore, the students are trained the STEM field in a way that they can compete in the global market [5]. According to Sadler *et al.* [6] students are prepared for the STEM related career long before they join post-secondary levels of education. This agrees with the findings of Malin, Bragg and Hackmann [7], who indicated that secondary school education prepares the learners for the future career. The preparation process is complex, in that technology advances rapidly and therefore there is need to ensure tomorrow's job opportunities and the corresponding work force look different from today's [8].

According to Mwangi et. al [9] robots employed in education have a great impact on the process of teaching and learning of STEM subjects. They further indicated that the use of robot activities in learning of STEM subjects could motivate them to pursue STEM related careers. The use of these activities had greater impact in the primary school levels as compared to other educational levels. They further noted that they could still be beneficial in higher educational levels with some improvements. The study showed that the use of robots has a promising future for use in educational purposes. In this study the effect of integration of robotic activities to science subjects in secondary school is investigated

2. LITERATURE REVIEW

Scaradozzi *et al* [10] suggested an innovative approach of teaching using robotics. The approach suggested was tested using learners in a select Italian primary school. The study involved robots that ran on LEGO WeDo and LEGO MINDSTORMS NXT hardware and software. The robots were integrated in teaching Science and Mathematics topics. The study found that robotics should be integrated in teaching Science and Mathematics in line with the school curriculum so as to witness an upgrade in learning of the subjects. While integrating the robotic activities in Science and Mathematics, the aim should be to expose learners to hands-on opportunities that engage them in applying the knowledge and skills they have learned across disciplines.

Mwangi et.al [11] developed robot activities and investigated how they could aid learners understanding abstract concepts in STEM and concluded they were indeed very effective. They noted that use activities developed around robots made learning fun, and interesting. It was noted that teaching and learning of STEM was more effective with improved participation of learners.

Robotics activities are helpful in that they make learning of STEM subjects fun and engages the learners in hands-on learning environment [12]. Khanlari [13] conducted a qualitative study with experienced robotics teachers where he wanted to establish whether robotics could have effect in teaching STEM subjects. The study concluded that robotics and related activities help learners understand STEM subjects and enhances learners' interest in STEM fields. Nugent et al. [14] conducted research where they collected data from 2409 campers, competition, and club participants during six years. The study revealed that robotics activities increased participants' awareness of STEM content perceived and problem-solving skills.

In Canada, Khanlari and Mansourkiaie [15] evaluated the perceptions of teachers on using educational robots in STEM education. One research questions involved teachers providing sample topics in Primary School Science subjects that would be easily taught using robotics. This was after the participants were exposed to functional robots that used hardware and software of LEGO MINDSTORM. From the findings, it was evident that the teachers indicated that robots can be used in teaching some Mathematics topics such as geometry, multiplication, addition, subtraction, division, measurement, shapes, orientation and movement of bodies. Teachers also stated that science topics such as circuits, force, motion, force, matter and structures. The exposure of the learners to the robots and related activities was very helpful in learning of Mathematics and other sciences. The learners were able to understand the link between scientific and mathematical theory with real life problems.

From the review of literature on the effects of educational robotic activities, it is evident that use of educational robots in STEM is beneficial in learning process. The learners are exposed to problems in STEM that are real-life [16]. This makes them feel like scientists in the course of learning which in turn affects their career choices in the future [17]. Further, educational robotics provides enormous benefits to students at different levels. Some of the benefits include; development of critical thinking skills, STEM process skills, acquiring skills problem solving, growing in creativity, persistence, social interactions, and skills in teamwork [18], [19].

The literature reviewed reveal a lot of benefits of the use of robotic activities in STEM education. This study investigated the effect of robotic activities to secondary school students' interest in STEM subjects where the activities are integrated to Physics and Mathematics.

3. METHODOLOGY

In this study, students and Physics teachers were exposed to a 3-week workshop which was conducted at Murang'a university of technology where learners interacted with educational robotic activities. The activities were integrated in Physics topics with the aim of investigating their impact in learning of the subjects.

This study adopted constructivism in developing educational robots, a form of manipulating artifact [20], which was key for the learners in knowledge construction. Through the robots, teachers offered learners with opportunities to engage on explorations that are hands-on and provided tools for learners to construct knowledge in a learning environment. Through the theory, robotics activities were integrated in teaching Physics thus providing the learners to cultivate skills in Physics.

3.1 PARTICIPANTS

The study was conducted among 200 Form 2 students selected randomly from 20 schools in Kangema Sub-County: 3 girls' schools, 4 boys' schools and 13 mixed secondary schools. This implied that, 30 girls were selected from girls' only secondary schools, 40 boys from boys' only secondary school and 130 from mixed secondary schools as shown in Figure 1.

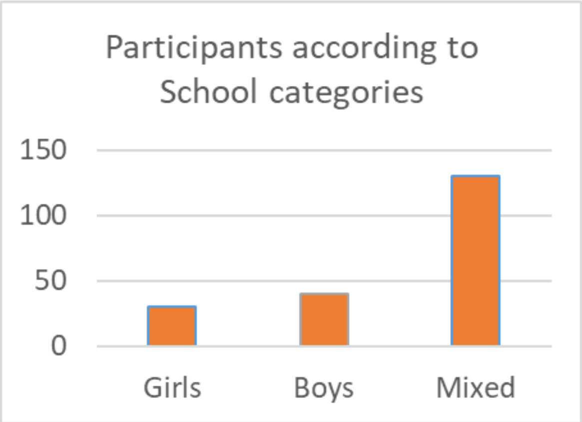

Figure 1 Participants by School Categories

In terms of gender, 90 girls and 110 boys participated in the study as shown in Figure 2.

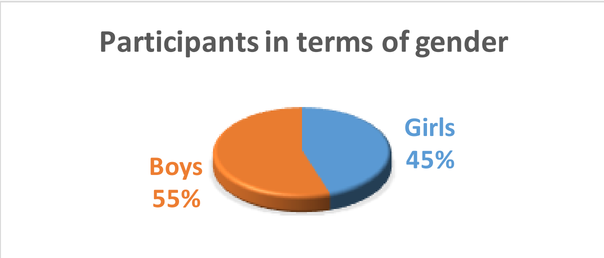

Figure 2: participants by gender

3.2 IMPACT OF THE ROBOTIC ACTIVITIES

Robotic activities were developed based majorly on the two main robot designs which included car and arm. The robots fabricated by the researcher were used for the development of the activities after which the selection of the most suitable and relevant activities were selected for a workshop. A workshop was then organized where Form 2 students and Physics teachers were taken through the activities. The robot designs fabricated are shown in figure 3 and 4 respectively.

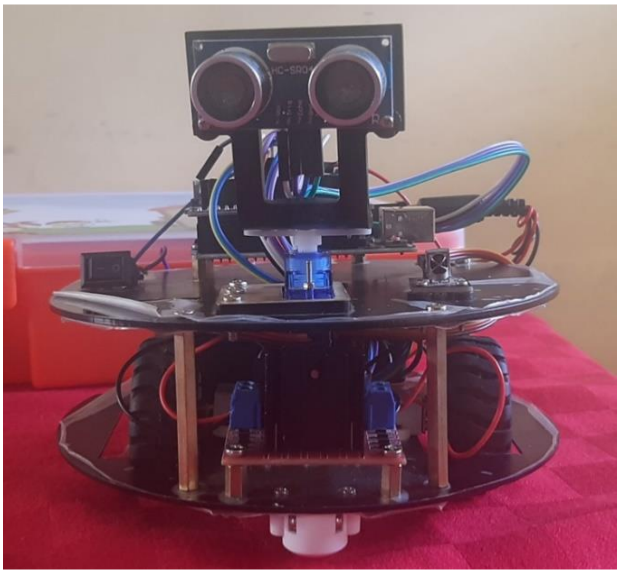

Figure 3: Robotic Car

Figure 4: The Fabricated Robotic Arm

Some of the activities employed in the workshop are shown in Table 1

Table 1: Robotic Activities integrated in Physics

Robotic activities	Topics Integrated
Basic electronics activities	Measurements of values of components, basic electricity
Robot part identification and assembly	Sensors and transducers, work and energy
Line following robot activities.	Reflection of light, Linear motion, Speed, Acceleration
Obstacle avoidance robot activities.	Waves, Reflection and distance Calculation
Robotic arm rotational dynamics activities.	Geometry, Angles, Circular motion Rotation, Translation, Forces and Energy

The robotic activities were spread over three workshop days. In the first session the learners were taken through activities revolving around basic programming, robotic car and arm. The learners moved the car forward and backwards in linear motion at constant speed, acceleration or deceleration. The students learnt to programme various robot parts like the motor and sensors. The learners would move the robot car forward and backward in linear motion using the Arduino Uno programming environment.

In the 2nd session, the main focus was physics where the students were reminded on the basics of motion at constant speed and were asked to programme their robot to move forward and then backward at constant speed. They were instructed to assemble an ultrasonic sensor on their robot in order to detect the distance from a stable object. They also assembled and programmed infra-red sensors on the robotic car in order to detect a black path drawn on some wooden boards. In this session, the students were exposed to the concept of acceleration, deceleration, circumference and perimeter of particular shape.

In the 3rd session Physics activities related to the robot arm were also introduced. The activities included the process of assembling the robotic arm and the physics concepts connected to the arm assembly. The activities included; Forces, Circular motion, Rotation, Translation, calculation of speed and estimation of distance.

In order to establish the impact of the robotic activities to learners' interest in Physics, the learners filled a questionnaire with items assessing the impact of the activities in understanding, perception and interest. The questionnaires were administered before and after exposure to the robotic activities. Data obtained from both teachers and students was then analyzed.

4. RESULTS AND DISCUSSION

In order to assess the impact of the robotic activities on students' interest towards Physics, the researcher formed the basis of seeking opinion from students. The students were presented with questionnaire items that assessed the impact of the robotic activities. The items included were understanding of Physics and Mathematics, made learning of Physics and mathematics fun, enhanced creativity, interest in classroom participation and how the robotic activities made topics in Physics and Mathematics easier. The students were presented with these items prior and after exposure to the educational robot. The pretest responses findings are reported herein.

On a Likert scale of Strongly Disagree to Strongly Agree, the participants were presented with several statements regarding robotic activities and integration in Physics and Mathematics. The findings are as presented in Table 2.

From the findings, 40.6% (78) indicated that exposure to robotic car and robotic arm can give them a better understanding of Physics topics they learn in class to a moderate extent; 26.0% (50) to a great extent, 13.5% (26) to a lower extent, 12.0% (23) to no extent and 7.8% (15) to a very great extent. From the findings, 38.0% (73), 34.9% (67), 9.9% (19), 8.9% 917) and 8.3% (16) of the respondents were of the opinion that exposure to robotic car and robotic arm can raise interest of the students in participating in the classroom activities to a moderate extent, to a great extent, to a lower extent, to no extent and to a very great extent respectively. the findings also demonstrate that 57.8% (111) of the respondents indicate that exposure through robotic activities can change their interest in Physics to a moderate extent; 15.6% (30) indicated to a great extent, another 15.6% (30) indicated to a lower extent, 8.9% (17) to no extent and 2.1% (4) to a very great extent. According to 38.5% (74) and 21.4% (41) of the learners who agreed and strongly agreed, the use of robotic activities in learning of Physics improved their attitudes towards the subject; 21.4% (41) neither agreed nor disagreed, 11.4% (22) disagreed and 7.3% (14) strongly disagreed. From the responses, 27.6% (53) and 28.1% (54) of the learners agreed and strongly agreed respectively that the use of robotic activities should be introduced in the curriculum to improve students' attitudes in Physics.

Table 2: Pretest Findings on Impact of Integration of Activities

	To no extent	To a lower extent	To a moderate extent	To a great extent	To a very great extent
In your own opinion, would you say the exposure to robotic car and robotic arm can give you a better understanding of the Physics topics you learn in class	23 (12.0%)	26 (13.5%)	78 (40.6%)	50 (26.0%)	15 (7.8%)
In your own opinion, would you say the exposure to robotic activities can raise interest of the students in participating in the classroom activities	17 (8.9%)	19 (9.9%)	73 (38.0%)	67 (34.9%)	16 (8.3%)
In your own opinion, to what extent do you think the exposure through robotic activities can change interest in Physics?	17 (8.9%)	30 (15.6%)	111 (57.8%)	30 (15.6%)	4 (2.1%)
The use of the robotic activities in learning of Physics and Mathematics can change my attitude towards Physics.	14 (7.3%)	22 (11.4%)	41 (21.4%)	74 (38.5%)	41 (21.4%)
The use of the robotic activities if introduced in the curriculum can improve students interest in Physics	21 (10.9%)	23 (12.0%)	41 (21.4%)	53 (27.6%)	54 (28.1%)

After being exposed to the educational activities, and working with the robots on their own, the students were presented with the same questionnaire items. The Likert scale responses on robotic activities and integration are as presented in Table 3.

The posttest findings on the impact of robotic activities are as presented in Table 3.

Table 3: Posttest Findings on Impact of integration of Robotic Activities

	To no extent	To a lower extent	To a moderate extent	To a great extent	To a very great extent
Did the exposure to the robotic car and robotic arm give you a better understanding of Physics topics you learn in class	6 (3.1%)	5 (2.6%)	21 (10.9%)	58 (30.2%)	102 (53.1%)
In your own opinion, would you say the exposure to robotic activities raised interest of the students in participating in the classroom activities	5 (2.6%)	4 (2.1%)	17 (8.9%)	48 (25.0%)	118 (61.5%)
In your own opinion, to what extent has the exposure through robotic activities changed your interest in Physics as a subject	3 (1.6%)	7 (3.6%)	17 (8.9%)	47 (24.5%)	118 (61.5%)
The use of robotic activities in learning of Physics and Mathematics improved my attitude towards Physics	2 (1.0%)	3 (1.6%)	8 (4.2%)	79 (41.1%)	100 (52.1%)
The use of robotic activities should be introduced in the curriculum to changed students attitudes towards Physics	2 (1.0%)	5 (2.6%)	1 (0.5%)	62 (32.3%)	122 (63.5%)

The post exposure opinion on whether exposure to the robotic car and robotic arm gave the respondents a better understanding of the Physics topics learnt in class had 53.1% (102) of the respondents indicate to a very great extent, 30.2% (58) to a great extent, 10.9% (21) to a moderate extent, 3.1% (6) to no extent and 2.6% (5) to a lower extent. It is also clear that 61.5% (118), 25.0% (48), 8.9% (17), 2.6% (5) and 2.1% (4) of the participants indicated that exposure to the robotic car and robotic arm raised interest of the students in participating in the classroom activities to a very great extent, to a great extent, to a moderate extent, to no extent and to a lower extent respectively. The opinion of 61.5% (118), 24.5% (47), 8.9% (17), 3.6% (7) and 1.6% (3) of the respondents was that exposure through robotic activities changed their interest in Physics to a very great extent, to a great extent, to a moderate extent, to a lower extent and to no extent respectively.

Majority of the respondents, a total of 93.2% (179) were of the opinion that the use of robotic activities in learning of Physics changed their attitude towards the subjects to a great extent and to a very great extent; 4.2% (8), 1.6% (3) and 1.0% (2) indicated that use of robotic activities improved their attitude towards Physics to a moderate extent, to a lower extent and to no extent respectively. According to 95.8% (184) of the respondents, the use of robotic activities should be introduced in the curriculum to improve students' attitude in Physics to a great extent and to a very great extent.

General observation of the pretest and posttest results reveal differences in responses on questionnaire items regarding the use of robotic activities. Through a paired sample t-test, the difference in the responses was assessed. Paired samples t-test involves a comparison of the means between two groups that are related on the same dependent variable that is continuous. It can be used to test differences in the means of paired measurements such as those taken at two times that are different, for instance a pre-test and a post-test score where an intervention has been administered between the two points in time.

In this study, a paired samples t-test was applied for the categorical sub-variables with the same scale of measurement and measured one major aspect of the study; as a result, the sub-variables would be aggregated into one variable using a measure of central tendency.

From the descriptive statistics, it is evident that there are differences in opinions of the respondents on the five items between the pretest and posttest responses. Prior to running the paired sample t-test, the pretest responses were aggregated into one variable, the pre-impact, while the post responses were aggregated into one variable, the post impact through the use of the mean. The paired sample t-test was then conducted. From the summary presented in Table 4, it is evident that the overall pretest impact had a mean of 3.0486 (approximately to a moderate extent) while the posttest impact had a mean of 4.3628 (approximately to a great extent).

Table 4: Pre-Impact and Post-Test Impact Means

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-impact	3.0486	192	.75732	.05466
	Post-impact	4.3628	192	.69130	.04989

The difference between the overall impact in the pretest responses and posttest responses is significant. The fact that that the posttest overall mean is higher than the pretest overall mean is a clear indication that the educational robotic activities had an impact in their understanding of Physics topics you learn in class, raised interest of the students in participating in the classroom activities, changed their interest in Physics as a subject and also improved their attitude towards Physics as shown in Table 5.

Table 5: Paired Sample t-test on Impact

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-impact – post-impact	-1.31424	.77945	.05625	-1.42519	-1.20328	-23.363	191	.000

In this study, robotic activities were integrated in various Physics topics. The activities equally elicited a lot of interest in learning of the selected topics and promoted the learners' participation in the learning process. The learners would also handle the activities individually and as a team. The integration of such activities in to the secondary school syllabus would improve learners' interest and most importantly attitude of the Science subjects and thereby improving performance and learners' perception towards these subjects.

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

From the research finding it can be concluded that:

i. The exposure to the robotic activities gave the learners a better understanding of Physics topics they learn in class thereby making the subject fun.

ii. The exposure to robotic activities raised interest of the students in classroom participation hence making the learning environment very interactive and making the learners more creative in the learning of physics which agrees with the findings of Afari, E., & Khine, M. S [21].

iii. The exposure through robotic activities changed learners interest in Physics as a subject and learners expressed their interest in choosing Physics in preparation of future STEM career. This agrees with finding of Ben-Bassat & Ben-Ari [22].

iv. The use of robotic activities in learning of Physics improved learners' attitude towards Physics

v. The use of robotic activities should be introduced in the curriculum to improve students' attitudes towards Physics

5.2 RECOMMENDATIONS

Robotic activities should be integrated in Physics to promote teaching and learning of the topics. This will require the government of any given country to facilitate the integration of the activities in the current curriculum. Through policy makers in education, the curriculum should be reviewed so as to adopt educational robotic activities to be utilized in the teaching and learning process.

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