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EV3 Robot as a tool to help teachers in the classroom to increase the efficiency of the educational process in Mathematics

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Abstract

Subject like mathematics is hard to understand for many students so there is need for some communication channel which can make it easier to understand and this can be meet with EV3Robot. The purpose of this analysis endeavor is to increase the productivity of teaching –learning practice for the vast subject like mathematics. This study focuses on the Jordan where curriculum of mathematics is hard to apply and understand by the local students so technology like EV3 Robot can work as a volumetric role player. The level of understand of mathematical terms are still inferior and degraded as literature suggests. The present work is based on Design based intervention study and Mixed – method data collection and comprises in total five phases which actually helps to execute the aim successfully and two private schools of Jordan were selected for the study. To evaluate the performance and to increase efficiency a Lego Mindstorms™ EV3 robots was used to develop programming skills. The process of building, making mistakes and troubleshooting difficulties while building and programming the Lego Mindstorms™ EV3 robots will be able to stimulate the students to refining their understanding and explore different approaches in mathematics challenges. The proposed technology will help the students of Jordan to perceive the mathematics and interpret easily and will increase the teaching learning performance as well.

Keywords: Teaching-Learning practice, Robotic Technology, Mathematics, Learning productivity.

1.   Introduction

Development of 21st century skills among students involving significant thinking and trouble understanding are the crucial component for today's instruction specially in science, technology, maths, and engineering (STME) sectors. The current focus in technology and science Standard is on integrated teaching approach and emphasising the principles of Engineering such as models development which able to solve all of the real and perceived problems in current educational system. Currently, education of STEM is implemented throughout nationwide movement. Teachers are trying their level best to increase students' interest by mobilizing at both state and national levels and hence increase student's achievement in STEM fields. However, the definition of STEM education differs by policymakers, educators, and researchers; therefore, a common and consistently agreement or understand is needed to clarify the role of STEM education in 21st century learning. This is also an ideal initiative in the field of education especially for middle grade students (13 years old). This group of students have the ability to think creatively and concretely, along with inquiry and discovery teaching methods, are completely relevant and challenging (Khan, Francis & Davis, 2015).

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Fig. LEGO MINDSTORMS EV3 Kit

At all levels of education use of Educational robots is becoming very prevalent especially in teaching subjects related to science, technology and mathematics. Creativity, critical thinking , logical reasoning and teamwork are a few of the many skills that can be developed by ER and many studies have demonstrated it. ER makes different manners of pedagogy and understanding reasonable, and they can composure helps to teach pupils for a world of AI-enabled products with which they will have to interactions daily. Making use of concepts and principles of engineering, computing , mathematics, computer science and physics ,it is multidisciplinary approach.A LEGO MINDSTORMS EV3 gear is expected for this workout. Plus accumulation to standing entertainment for pupils to manipulate, it can also be employed to verify all the ideas mentioned in this training, as nicely as be used for multiple other classroom tasks and trainings.

Pupils' interest in STEM were greatly influenced by teachers (Duschl, Schweingruber, & Shouse, 2007). STEM curriculum has underlined in secondary academies as a framework for higher education (Murphy & Mancini-Samuelson, 2012). STEM education is lower in primary schools than in auxiliary schools (Hossain & Robinson, 2012) given the long-term effect of secondary school students ' learning experience and perceived ease of use as well as ease of use. (Archer et al., 2013; Maltese & Tai, 2010). To order to transfer knowledge to the students, secondary school teachers need to be trained with STEM subject knowledge. As only 30% of undergraduate programs allow pre-service teachers to take a science course (Greenberg, McKee, & Walsh, 2013). Graduate-level teaching programs do not do any better; 56% of these programs do not allow applicants to take an undergraduate science course (Greenberg et al., 2013). Science and mathematics are subjects that secondary school teachers will teach, but the extent to which they master these subjects and execute them interestingly is largely restricted by the access they have had to these content areas. Since many secondary teachers still teach what they know from science or calculation lessons, students have not been exposed to any of the recently established learning approaches in the classroom. (Nadelson et al., 2013).
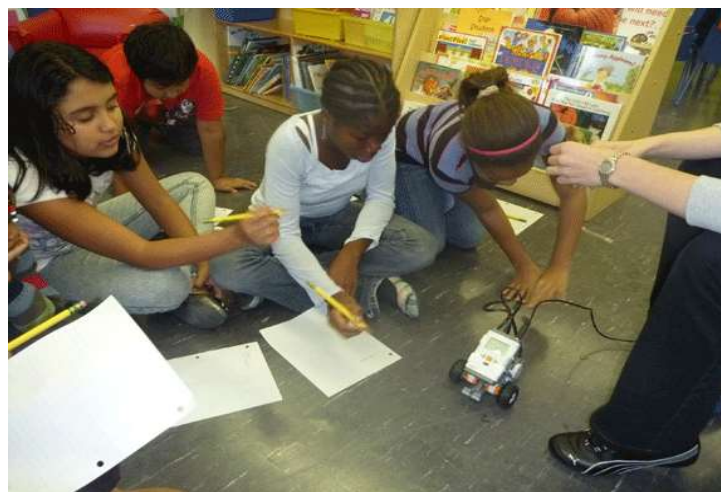

Fig. Students calculate distance travelled by robots

2. Literature Review

A. Mathematics performance of Jordan students

The performance of Jordan 15- year- old students in Mathematics was lower than the *Organization for Economic Cooperation and Development* (OECD) average of 76% hitting at least level 2 Mathematics skills in 2018. According to the OECD (2019), 41 percent of Jordanian students reached level 2 or higher in Mathematics. The students at this level should perceive and acknowledge the situation which can be interpreted mathematically without direct guidance. The cases, for example, were comparing the overall distance between two alternate routes or translating rates into a foreign currency.

B. Problem solving skills in key mathematical concepts

According to Altun (1995), problem solving refers to resolving a problem by using the appropriate operations and information involving process of cognition (reasoning). Cognitive, affective, and experiential factors affect the success of the students in problem solving (Haylock & Cockburn, 2014; van de Walle, Karp & Bay-Williams, 2014). Challenges faced when solving problems are generally associated to trouble reading (Reikerås, 2006). The students who faced the problems have trouble reading. On the other hand, theses students learn mathematics and always described as no understanding towards symbols, having behavioural difficulties, unable to communicate about the memory and problem (Grauberg, 1998). Furthermore, according to Dowker (2005) as challenges in reading significantly impact learning, they can contribute to problems while teaching problem solving or math terminology. In fact, it is justified that the diverse reading rates of students will influence their success in problem solving.

C. Programming Mathematical Critical Thinking

A study by Khan, Francis and Davis (2015) among students aged 9 and 10 years old of First Nations school in northern Alberta had implemented Lego Mindstorms™ EV3 robots in various mathematics challenges by developing building and programing skills. The pupils were needed to program their robotic to outline shape of polygon. When programming loop was used to complete the task, they could represent the repetition of shapes by using multiplication.

D. Educational Robotics

Robotics is the area which can have a major effect on the essence of science and engineering education at all levels, from one class to finish schools (Matari'c, 2004). Beyond occurring a content itself, it can also be used as a teaching resource in a wide mixture of topics varying from earlier childhood (Bers *et al.*, 2002), primary (Bell, 2008), middle school (Norton *et al.*, 2006), secondary education (Moundridou and Kalinoglou, 2008), computer science (McNally *et al.*, 2006), engineering (Ringwood and Monaghan, 2005), computer programming (Lawhead *et al.*, 2002), to artificial intelligence (Parsons and Sklar, 2004) and psychology (Miglino *et al.*, 1999).

3. Methodology

The research design fundamentally aides the research procedure, specifically in the gathering and investigation of information (Brymen & Bell, 2014). Chosen research design must fall inside the paradigms and the technique secures the quality and legitimacy of the research. This would be a design-based intervention study involving mixed-method data collection. Design based study has capacity to produce knowledge that significantly applicable in educational practice as well as enhanced theoretical implication of teaching and learning. Design-based intervention study is "progressive, formative and iterative in nature". This design comprised of an emergent and open-ended framework requires numerous sources of data and analyses to obtain a better understanding (Ryu, 2020).

A. Research Questions

The analysis questions recommended in this research goal to analyze knowledge about programming settings and educational practices in EV3 Robotics classes. The study topics (RQ) are:

RQ1 : Is the usage of EV3 robots in mathematics classroom reshape the getting knowledges in terms of experience learning, constructivist learning and optimistic learning among students?

RQ2 : How do students perceive the suitability and solace of practice of the of EV3 robots in mathematics classroom?

RQ3 : Is usage of EV3 robots in mathematics classroom positively influence the level of problem-solving skills in key math concepts among students?

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RQ4 : Do usage of EV3 robots in mathematics classroom enhance students' performance in mathematics?

Both quantitative and qualitative data will be collected for this study. Bryman (2016) said that quantitative research deals with numbers, but qualitative study describes the experiences and meanings termed with words. Queirós, Faria and Almeida (2017) expanded on this point, noting that the main difference between the two methods is the conciliation between depth and width, because quantitative analysis comprised a wide scope, while qualitative analysis allow intended research applying a statistical method form to calculate the data obtained numerically. The quantitative data will be collected during assessment of students' understanding in mathematical concepts, students' perception towards their experiential learning, constructivist learning and joyful learning, students' perception towards perceive the usefulness and ease of use of the of EV3 as well as their performance in Mathematics. The qualitative data will assess the students' reflection towards the usage of EV3 robots in mathematics classroom, teachers' interview and classroom observation towards practice of problem solving and collaboration among the students.

There will be five phases in this study namely (i) Phase I: Baseline, (ii) Phase II: Tool Development, (iii) Phase II: Pilot study, (iv) Phase IV: Experimental and (v) Phase IV: Evaluation

B. Study subjects and location

The study will be conducted in two private secondary schools in Jordan. During baseline analysis two private secondary schools in Jordan will be randomly selected from the list of private schools available in Jordan. Pilot study will be conducted in one school which was selected randomly from the list to improve the flow of formal experimental study. One (1) school will be selected as experimental school while another one (1) school will be selected as control schools randomly. Students aged 13 years old will be recruited in this study with ratio 1:1 between experiment and control groups. The experiment groups will be arranged to learn mathematics with the EV3 robots, while the control groups will be arranged to learn mathematics using blackboard.

According to Westland (2010), sample size need for this study was determined based on the an equation of $n \geq 50r2 - 450r + 1,100$, where n is sample size and r is the ratio of indicators to latent variables. In this study there are four (4) latent variables under each constructs. Therefore the calculation was as follows:

$n \geq$ $50 (4)^2 - 450 (4) + 1100$

$n \geq$ 100

The total samples need for this study must be ≥ 100 respondents. Therefore, it is proposed that 50 students will be recruited for experimental group and 50 students will be recruited for control group.

C. Modelling of robots and their systems

A Lego Mindstorms™ EV3 robots will be used to develop building and programing skills. The process of building, making mistakes and troubleshooting difficulties while building and programming the Lego Mindstorms™ EV3 robots will be able to stimulate the students to refining their understanding and explore different approaches in mathematics challenges. Programming such as sequence repetition and movement completion will be incorporated to explain mathematic concepts such as multiplication and repeated addition (Skluzacek 2017). The effect of Lego Mindstorms™ EV3 robots implementation will be assessed in term of experiential learning, constructivist learning and joyful learning respectively to answer the research questions.

In this study EV3 robot will be used as a support tool, which able to assist the educators explain, interact and review the answers with students.

D. Plan

In this intervention development, several aspects will be considered such topics selection for EV3 robot planning support for different mathematical operation. The most important aspects to take into consideration will be the frequency of visits, measurement instruments, assessments, students' reflection and teachers' interviews.

The first visit to school will be an introductory session, where once the EV3 robot been introduced to the students, it will create a first excitement for them. The secondary school will be visited four times for 60 minutes full class session for each visit. In each class period, the teacher will be using the EBV robot for 15 minutes as planned in design of session. Assessment will be conducted in both intervention and control group. Classes chosen as intervention group will be carried out with the intervention while the classes in control will not undergo any form of intervention. The purpose was to compare and assess the effectiveness of the EBV robot on the students. Study instruments will be applied for both groups before and after the intervention session

concurrently in both groups. Then the interview will be carried out with the teachers of classes from both groups.

E. Study instruments

The observation method, questionnaires, and interviews will be adopted for data collection in this research.

4.   Questionnaire

A self-administrative pre-tested questionnaire will be used to collect quantitative data. The questionnaire comprised of five sections.

- **Section A: Students characteristics**
- **Section B: Experiential learning**

Table 3.1 the number of items for each construct of experiential learning

Construct	No of items
Environment	6
Active Learning	8
Relevance	9
Utility	8

- **Section C: Constructivist learning**

Table 3.2 the number of items for each construct of constructive learning

Construct	No of items
Knowledge construction	5
In-depth learning	4
Authenticity	5
Multiple perspectives	4
Prior knowledge	4
Teacher- student interaction	5
Social interaction	3
Cooperative dialogue	3

- **Section D: Joyful learning**

Table 3.2 the number of items for each construct of joyful learning

Construct	No of items
Active	5
Creative	5
Effective	5
Enjoyable	5
Meaningful situation	5

- **Section E: Perceive the usefulness and ease of use**

Table 3.2 the number of items for usefulness and ease of use of EV3 robot

Construct	No of items
Perceived usefulness	2
Perceived ease of use	5

- **Section F: Students performance**

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A. Student Reflections

Students will be asked to respond to several writing prompts exclusively to capture students' impressions and reflections on the project while building and programming EV3 robots. The questions that are included during the reflection writing are as follows:

1. What are the challenges you and your group faced while using EV3 robot?

2. What are the aspects that you like or love most while using EV3 robot?

3. What are the aspects that make you proud while using EV3 robot?

4. What are the mathematical concepts that you have learned while using EV3 robot?

5. What you have realised about yourself during out robotic session?

The reflection writing will be collected and analysed using textual and sentiment analysis methods in terms of problem solving and collaboration.

The text then further analysed for sentiment analysis. Sentiment analysis identifies the "mood" of the student based on the frequencies of particular terms while replying the writing prompts. Basic sentiment analysis breaks each write up into separate components such as parts of speech tokens, phrases and sentences. Then each sentiment-bearing phrase and respective component will be identified. Each sentiment phrase and component will be assigned with a sentiment score (-1 to +1). Finally, the scores will be combined for multi-layered sentiment analysis (Lexalytics, 2021).

B. Teacher Interviews

Formal and informal interview will be conducted among teachers during each phase of the study: baseline, tool development, experimental evaluation. Teachers' perception towards student's problem solving and collaboration in mathematic classroom, the usage of EV3 robots in classroom and lesson planning will be assessed and recorded as well as analysed. The collection of question

C. Classroom Observations

Classroom observations will be conducted during experimental phase both in experiment group and control group. During these observations, student-student and student-teacher interactions, students' cooperation and collaboration will be taken note. Observation towards students' reaction while managing their materials and task will be recorded.

D. Pre-test

Pre-testing allows for the detection of incorrect terms or phrases in question wording, an inaccurate flow, inaccuracies in questionnaire layout and instructions, as well as issues caused by respondents' inability or failure to address some questions (Babonea & Voicu, 2011). Therefore, this study had used a pre-test evaluation for validating the instruments to get the final version of the questionnaire. As all the questions were adapted from previous studies, a minor amendment had been done to suit the Jordanian context. Furthermore, the questions will be translated into the Arabic language to suit the understanding and interpretation of the Jordanian students. The edited questionnaire (in both version – English and Arabic) acquire input of two language experts from academia to warrant content validity. Groves et al. (2004) recommend a sample size of 5 to 15 participants for pre-test questionnaires in order to detect misinterpretations, inconsistencies, or other difficulties. On the other hand, Beatty and Willis (2007) mentioned that the sample participant of 8 to 15 is enough for pre-testing questionnaire. Therefore, this study had followed Beatty and Willis's recommendation and the questionnaire shall be pre-tested on a group consisting of 15 selected students randomly chosen from public secondary school in Jordan

E. Pilot Study

A pilot study is used to assess the questionnaire's feasibility (Thabane et al., 2010). According to Lancaster, Dodd, and Williamson (2004), a pilot study sample size of 10 to 30 questionnaires is sufficient. Lancaster et al's suggestion will be adopted in this study, which will be piloted on 30 respondents from a Jordanian public secondary school. In addition, the respondents chosen for the pilot study would not be included in the final analysis.

5.   Analysis

A. Validity Analysis

The term "validity" refers to whether the results of a study are linked to existing educational practises. To put it another way if the tests are assessing what they appear to be measuring. According to Nkwake (2015), the validity of the face or the validity of the content entails a subjective assessment of the accuracy of answers to predetermined questions through logical evaluation. To ensure the validity of the content, experts from the academic world must contribute to the items in the questionnaire (Sekaran and Bougie, 2016).

Two academics who obtained a doctorate in XXX (what is your faculty or department) and two face-to-face discussions with mathematic teachers will be conducted to obtain constructive suggestions towards achieving the aims of this study. Both, academic and mathematic teachers whose opinions sought are expected to have more than ten years of working experience at their respective institution. These comments are valuable because they increase the relevance and consistency of the measures by representing the concept under consideration (Sekaran, 2003). In this scenario, the initial assessments on the measurement elements minimize the discrepancies between the questionnaire and the measured concept.

B. Reliability Analysis

"**Reliability** is a test of how consistently a measuring instrument measures whatever concept it is measuring". In other words, a measure's reliability is an indicator of the instrument's stability and accuracy in measuring a concept, and it aids in evaluating a measure's "goodness" (Kyle, 2020). Subsequently, a reliability analysis conducted to demonstrate that these measures produce consistent results on several occasions. As indicated by Zikmund (1991), repeatability and inside consistency are two aspects that characterize the idea of unwavering quality. Cronbach's alpha is the most usually used measure to assess the dependability of dimensions with a general standard that suggests that Cronbach's alpha value must exceed 0.70 and higher values indicate greater reliability (Nunnally, 1978). Therefore, this study will be using Cronbach's alpha to measure internal consistency based on the mean correlation between elements.

C. Data Analysis Methods

The preselection of data will be conducted during the collection of primary data. At the time of collecting each questionnaire response, it will be checked to make sure there are no incomplete questions. Statistical Package for Social Sciences (SPSS) version 25 will be used in coding all the questions with numerical values for primary data analysis. Accordingly, data analysis method involves having an idea of the data collected, prove the goodness of the data and test hypotheses for the study (Sekaran & Bougie, 2016). The following sections illustrate all the analysis method that will be used to examine the hypotheses.

D. Descriptive Analysis

According to Sekaran and Bougie (2016), the descriptive analysis is used for clarification purposes, as well as to decide the connections between the factors of the study. The descriptive analysis describes "the transformation of raw data into a form that would provide information to describe a series of factors in a situation that will make them easy to understand and interpret" (Zikmund, Carr & Griffin, 2012). Therefore, this study will analyse the demographic data by using descriptive analysis methods with percentage distribution of the variables and the distribution of the data is estimated.

E. Partial Least Squares Analysis (PLS)

This study will adopt the Structural Equation Model (SEM) for data analysis. SEM able to test previous theoretical hypotheses with respect to empirical data. SEM evaluates the scale's properties used to evaluate the theoretical constructions and estimate the hypothetical association between these constructions (Westland, 2007). While there are other SEM tools, the choice to use PLS has been determined by several factors. PLS has been established to manage both formative and reflexive variables, while other SEM methods do not allow it. This capability allows the type of relationship that the researcher believes exists between the independent variables and dependent variables (Hair et al., 2018).

F. Ethical Considerations

The ethical problems that arose throughout the research process are supported by two fundamental principles: "honesty and respect for the rights of the individual" (Creswell, 2013). The individual in this framework refers to the investigator and the research participants. The investigator must respect ethical codes of conduct, how to obtain informed consent, protect respondents from risks and allow them free choice. In

addition, an individual must be supervised, with their confidentiality and anonymity protected (Bryman & Bell, 2014)

6.   Conclusion

The study yielded results on performance of students of Jordon in the subject of mathematics. The study was conducted and key findings were the difficulties students faced while learning mathematical concepts, programming mathematical thinking, problem solving ability. The study also reviewed the previous studies in the same field and research gaps were found out. The EV3 robots which are used in teaching purposed are studied and efforts were concentrated on increasing the efficiency of these robots in the field of education. The students in Jordon who were chosen for research were aged 11 to 13. The questionnaires provided quantitative data on the variables under study. The ethical consideration which would influence the responses from the respondents were discussed in addition to quantitative. The statistical tools such as mean, frequency, standard deviation, reliability analysis descriptive analysis, the partial minimum applied in the process of interpretation and analysis of the primary data..

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