Research Article

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The Impact of (STEAM) Approach on the Innovative Thinking and Academic Achievement of the Educational Robot Subject among Eighth Grade Students in Jordan

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Abstract

This study aimed to identify the effect of a STEAM-based learning approach in teaching the educational robot's subject on academic achievement and creative thinking among eighth-grade students in Jordan. A purposive sample was selected and divided into two groups. An experimental group (n=30) implements a STEAM-based learning approach, whereas the control group (n=32) studied in a traditional method. A pre-posttest was administered, and the data were analyzed using statistical methods to validate the study results, such as "t" tests and a one-way ANOVA test. The results showed statistically significant differences between the experimental and control groups in academic achievement and creative thinking. In conclusion, the STEAM-based learning approach significantly improved the students' academic achievement and creative thinking skills.

Keywords: *Innovative Thinking, STEAM Approach, Educational Robot, Eighth Grade Students*

1. Introduction

The states are keen to develop programs and scientific principles to support multi specialties skills for students, such as creativity, digital literacy, and critical thinking. Programs focus on Science, Technology, Engineering, Art, and Mathematics represented in the integrative access STEAM, especially in the primary stage, and forming them comprehensively to be qualified in technology in line with the technological development. It is expected that an increase in job opportunities in information technology and communication fields will continue (Kor & Zakaria, 2019) claimed that 75% of the new jobs would be available in these areas during the coming years. The interest in (STEAM) approach increased after the TIMMS result showed a regression in the 8th-grade students' performance in science and mathematics. The regression was gradually increased from 482 in 2003 to 449 in 2011, then

decreased to 426 in the last participation in 2015 (Ababneh, Altowesi, Abi Libda, 2016).

The study carried out by The Arab observatory for education follows Alsco overbalanced in (2014). The study explained the reason for regression in the performance level of the Arab students in science and mathematics, mainly with the 4th grad and the 8th-grade students were due to a set of reasons: Weakness of the academic and educational preparation and the non-commitment in the on-going vocational development, and weakness in asking and seeking the assistance of the information technology that can assist students in understanding the scientific concepts in a proper way as well as its applications in life contexts. The study recommended revising the educational curricula to develop the present math and science curricula to help students learn math and science goals. And that the revision is not limited only to re-reviewing the contents and nature of the curricula but exceeds to include creating actual opportunities for learning, and providing the necessary factors to the management of the teaching-learning process effectively, the use of aids and technological tools, providing the suitable conditions that will contribute in the development of creativity and innovation as well as upgrading the students' achievement level. A need for developing teaching curricula and its methods in information technology and communication appeared; therefore, The Ministry of Education in Jordan employed computers in education and curricula. The computer became an educational subject in different stages of 7th grade until the end of the secondary stage. It contains advanced lessons to introduce the computer's basic principles, such as the educational EV3 robot dedicated for ages 10-16 (Ministry of education, 2015). It is a program to learn the basic interactive electronics that focus on the essential combination of the small control parts, the simple sensor, and the movement from simple robots. Jordan attempts to offer instructional programs based on the STEAM integrative access between science, technology, engineering, art, and math (STEAM) and seeks to employ the new methods, applications, and scientific strategies in the teaching/learning fields. The instructional robot subject can play a vital role by providing design, building, and imagination contexts.

This study's researchers believe that teaching based on STEAM is considered the best way to teach instructional robots to students. By designing their creative projects that lead the learner to look at the subjects positively and comprehensively to develop the creative thinking, increase the achievement level and help him have an integrative connection among different study subjects and the integrative relationship between real life and the study subjects. Setting multiple concurrent goals in the study curricula sparks students' curiosity, motivates their imagination, and deepens their understanding. Kantrov & Hergert (2011) said that well-designed learning depends on asking students to design projects and defining them the performance evaluation methods will encourage them to develop the skills they need to improve the academic achievement in the primary subject, in addition to empowering them to transfer the acquired knowledge to solve the problem in actual life. The educational robot EV3 is distinguished with providing the learning opportunity by (Learning by doing) and is known by the experimental or practical learning. Figure (1) explains the experience cone (Edgar Dale's cone of experience).

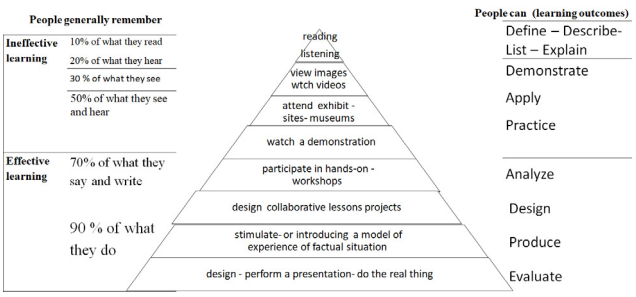

Figure 1: Edgar dale's cone of learning

Based on Edgar Dale's cone of learning, it is straightforward that there are many methods of forming the students' learning experience and making learning activities more interesting (Davis & Summers,2014). The results in acquiring high memory through designing activities, producing robots, and training them on concepts application to develop every aspect of scientific-practical skills (Jackson, 2016).

The integrative (STEAM) approach reflects the formative learning point by focusing on creative and realistic learning and different disciplines based on problems and projects (Kim &Park,2012). The initial form of it was STEM, then art was added to the original STEM learning later, which means that science and human and sciences contents are merged in STEM, which provides creative resources to practice science and engineering (Perignat & Buonincontro, 2019).

The integrative access learning –STEAM is based on Gain Piaget's constructivism theory three decades ago of knowledge science. A learning theory adopted the transformation in learning goals and stressed higher thinking skills and evaluation based on performance. Constructivism enhanced creative thinking and created enthusiastic and dependent learners who can merge experience, knowledge, sensation, and logic (Melvin,1999). In constructive study classes, students find a suitable place for learning and will be able to think in knowledge rather than memorize facts and train on planning for practical projects to apply them to real situations.

Melvin (1999) stated that innovation can be learned and taught and could upgrade the individual's creative level by providing a suitable environment, such as home and school. The global interest in teaching thinking through study subjects, in general, has increased. Thus, it encouraged educators to modernize curricula and design teaching items. It aims to teach thinking and its skills in general who provided the impetus to educators to update new educational items aiming at teaching thinking and its skills to adapt to life's requirements based on technological development and the information revolution.

MacKinnon (2005) identified three different kinds of creativity used as a basis for evaluating personal research in California. The first one is technical creativity that reflects internal individual needs, images, and motives. The second one is scientific and technological creativity, which tackles environmental problems and leads to new solutions. It appears slightly in the personality of the inventor. The third is hybrid creativity, found in architectural engineering fields that present a new problem and show the innovator's character. Davis (1996) states that creativity differs from creative thinking. The invention is related to the outcomes. The creative thinking in operations or the creative process's mental skills that the individual employs produces a more significant number of characterized ideas with variety and difference when solving the problem or situation.

Gordon (1995) believes that creativity means the individual ability of production. Torrance described the invention as a process in which the individual is sensitive to problems. In Torrance's perspective, creativity is a particular type of problem-solving and believes that the solution may be considered creative when some conditions are met, such as: When the outcome of thinking is new and is valuable. It requires excellent provocation of thought and lasts for a long time. It should be flexible and accepts multiple solutions. Torrance's theory is based on the Traits Theory and basically on reason. It stresses the trait that distinguishes the individual and could be measured by the graded level to identify individuals' differences. It clarifies that creativity is a recognition process of the changes and imbalances of information and the loss of some elements unrelated to the situation. Thus, the learner does not find a solution to it, so he resorts to searching signs and influences on that situation. Therefore, he formulates a hypothesis based on information, tests hypotheses, connects outcomes, and then explains them (Saif Aldeen, 2017).

Torrance emphasized in his tests that he and his assistants designed to measure creative abilities: fluency, flexibility, originality, and identifying elaboration. Lately, he added some capabilities such as synthesis and the ability of abstraction. They are also represented in producing distinguished captions for built drawings, merging two forms or more in an integrative image and closure, which is expressed in postponing the completion of a particular mission for a specific period that allows meditation to reach the production of distinguished original ideas. He preferred to call his

tests as activities to exclude fear and anxiety of the test situation (Allam,2000).

Further research showed that using technology in study classes increases achievement, creativity, and innovation and improves communication. For example, Clements & Sarama (2000) mentioned that technological development enhances creativity without teachers doing anything; either it was used for reading, writing, or the study of science, math, and other areas.

Promoting students' achievement levels and developing creative thinking ability is essential at all learning levels. However, it needs the provision of the appropriate learning environment. Therefore, this study aimed at exploring the effect of the (STEAM) approach in teaching the educational robot in study achievement and creative thinking among 8th-grade students in Jordan.

Some studies were carried out using the integrative access approach (STEAM) among science, technology, engineering, and math on students' achievement in the electronics discipline and their creative thinking. Examples of these studies: The study of Ayob, Hussain, Mustaffa, & Abdul Majid (2012), when evaluating the creative level among Electric and Electronic students participating in a national competition for mechanical design, the study showed that the average of standard points among 67% of students was more than 100 through the indicator's values of the creative indicator which are considered as a comprehensive indicator for the innovative capabilities. The study recommended that teachers plan in a better way of evaluating curricula outcomes. It explained the importance of using a teaching method for students that designs and manufactures the robots to achieve the nation's ambition, leading it to creativity. Olivares (2012) carried out a study exploring the effect of a STEM-based program in developing the study achievement in math and math among 8th-grade students in South Texas. The researcher used the comparative causative approach. The sample study was composed of 73 students who were subjected to the STEM program. Then they were compared with 103 students who were taught by typical methods. The study results showed the group's supremacy that was studied according to the STEM approach in the study results over the comparative group. DuMont (2013) study explored whether the new merged technology could provide the high school students new methods in using computation and encourage participation in debugging where students designed interactive pets like some well-known games that are available commercially. Pets were virtual and were available on well-known screens and physically perceptible. Students reused and modified the programming code. The study increased the participation and interaction of the students and success in dealing with links and programming mistakes, improving the design and implementation to repeat it in the future. The study recommended an improvement in activities and technologies to include a broad group of students' interests and focusing efforts in taking care of designers' society. Alshuhaimstudents'5) carried out a study to identify the STEM approach's effect in developing creative thinking and science among 3rd-grade students. The approach used the quasi-experimental method and Torrance scale for formal creative thinking. The study results showed the group's supremacy studied through the STEAM approach in creative thinking and science achievement. Slattsveen, Steinert & Aasland (2016) study described a project that aims at training students on a design by trying to build a robot to help students in developing creative trust or self-creative efficiency, aiming at increasing the students trust in the theoretical elements of the discipline and their abilities in finding appropriate solutions for problems. The study increased motivation to learn mechatronics by 88.4% and growing trust in translating the theoretical course into the practical experience (79.1%), and high individual satisfaction in the project (82.9%).

Kawar's study (2018) aimed at identifying the effect of using the STEAM approach in developing conceptual thinking in math among 9th-grade students. The sample was 65 students of boys and girls—the quasi-experimental method was based on designing two groups and carrying out a pre and posttest. The study resulted in favor of the experimental group in areas of conceptual understanding and creative thinking. Revilla, Maria Greca & Bravo (2018) developed the STEAM approach program on electricity issues and applied it to elementary-stage students. The study found that students achieved high grades in using the program in terms of the scientific efficiency in physics and the appropriateness of the STEAM approach for teaching science. Finally, Sarican & Akgunduz (2018) aimed to evaluate the effect of the STEM approach on study achievement, meditation thinking skills

towards problem-solving, and learning impact in teaching science. The study used the quasi-experimental approach with 44 students from the 6th grade. The investigation resulted that the STEM teaching approach has a positive effect on study achievement, and it has no tangible impact on meditation thinking skills towards problem-solving and the existence of teaching effect.

Abu-Mosa's (2019) study aimed to reveal the efficiency of a science unit designed according to the STEM approach in developing scientific practice using the quasi-experimental method. The study was applied to 40 students in 9th grade in Palestine. According to the STEM approach, the study results showed a significant effect in developing the scientific practices among female students. Alshara (2019) aimed to identify the integrative model- STEM- in achieving math and math links skills among the first intermediate class in Iraq. It used the quasi-experimental approach and was applied to 62 students. The study tools were represented in an achievement test in math and a test for math link skills. It resulted in the supremacy of the experimental group. In Gale, Koval, Ryan, Usselman, & Wind (2019) study in implementing science teaching approach and integrating the design, engineering, and robotics which integrates the basic ideas for engineering and physics as a significant challenge in the engineering design in which they apply their understanding for energy, motion, and power for designing automated brake system of a truck. The results of interviews for students' design and the written design recommendations, the engineering notebooks, the previous and post evaluations, and teachers' interviews student's efficiency in identifying and distinguishing the problem and developing solutions. Many groups of students made models and creative brake solutions that imply the creative use of items.

Samarni & Kadarwati (2020) study tackled the effect of implementing teaching based on the Ethno-STEM project on high school students and investigated its impact on critical and creative skills. The study included 230 students from seven secondary schools in mid-Java- Indonesia. Data were collected through a group of tools to explore the critical and creative skills among the students. Results showed that learning based on Ethno-STEM was able to improve critical and creative skills among students.

Previous studies discussed the effect of the integrative approach (STEAM) in study achievement. The results were positive such as the study of Sumarni & Kadarwati (2020), Gale & et al. (2019) and Alshara (2019), Abu-Mosa (2019), Sarican & Akgunduz (2018), Revilla, Maria Greca & Bravo (2018), Kawar (2017), Slattsveen & et al. (2016), DuMont (2013), Olivares (2012). Nevertheless, one study did not find any difference in the students' achievement, such as Bowen & Peterson's (2019) study. However, the study found a positive effect on the strategy in terms of visualizing math concepts.

Some of the studies that dealt with its approach's microcontrollers were Slattsveen et al. (2016), which aimed to enhance the teaching of automated control. Some studies tackled creative thinking, such as Sumarni & Kadarwati (2020), Gale & et al. (2019), Kawar (2017), Slattsveen et al. (2016), and Ayoob & et al. (2016), and Alshuhaimyya (2015). The previous studies used different measurement tools designed by researchers except for the Alshuhaimyya (2015) study, which used the Torrance Test of Creative Thinking (Form B) used in this study. The present study agrees with the previous studies in using the quasi-experimental approach, but the current study shall deal with the effect of the STEAM approach on achievement and creative thinking and the use of the Torrance scale for the formal creative thinking (B) in studying the impact of using learning which is based on projects in teaching electronic.

1.1 The Study Problem

Unified International TIMSS results showed regression in the students' academic achievement in Science and Math in 8th-grade class in Jordan. Some of the recommendations of the Arab observatory for education which belongs to ALESCO (2014), where the necessity of revising teaching curricula to develop math and science curricula to help students to learn the skills to achieve teaching science and math goals and creating real learning opportunities, provide the necessary elements to manage

the teaching-learning process effectively. Using all methods and technological tools provides appropriate conditions that contribute to developing creativity, innovation, and upgrading students' achievement levels.

Educational seminars and conferences held in Jordan and the Arab world recommended encouraging thinking and creativity and increasing teaching technology achievement. Examples of these conferences are: "The international conference of education was held in July 2019, "The third Arab conference for thinking, creativity, and innovation" was organized by Debono center for teaching thinking in Mach 2019, "transfer teaching in the Arab World from teaching to learning for creativity purpose was held by The Arab League in Cairo in 2019, and " International Conference on E-Learning STEM Education in Knowledge Society. The conference theme focuses on STEM education strategies, practices, and implementation, which the Egyptian university held for electronic teaching, 2018. This led to increasing responsibilities for the educational institutions' role in changing its approach to upgrade the achievement level and instill creativity and creative thinking skills in its curricula. The Ministry of Education in Jordan inserted teaching programs to teach an educational robot. Based on lack of interest in Jordan in identifying the effect of these programs on academic achievement and creative thinking skills, this study attempts to answer the following question: What is the impact of the integrative approach in teaching the educational robot on academic achievement and the creative thinking among 8th-grade students in Jordan?

1.2 The Study Questions

1. What is the effect of the integrative STEAM approach on teaching the educational robot subject among 8th-grade students in Jordan?
2. What is the effect of the integrative STEAM approach on creative thinking among 8th-grade students in Jordan?

1.3 The importance of the study

- The study's importance emanates from educational robot importance that helps students on creativity and imagines things to discover building things. The use affects creative motivation and acquires programming skills to prepare them for the functional future, develop their future talents in the technological society, increase their study achievement, promote logical thinking in reading, writing programming codes that build their knowledge and analytical skills and gain them with positive behaviors such as commitment and accuracy.
- The study's importance appears through the dearth of previous studies that tackled the effect of teaching the educational robot on study achievement and the promotion of creative thinking among primary school students. According to researchers, no study has been carried out about this field in Jordan.
- It may avail researchers and interested persons in the implementation of the integrative approach on different study aspects.
- It is availing from study outcomes that provide officials of the Ministry of Education in developing curricula and teaching strategies to upgrade the study achievement level and develop creative thinking.

1.4 The Purpose of the study

The current study aims to identify the effect of existing teaching on the STEAM approach on teaching the educational robot subject on study achievement and creative thinking among 8th-grade students in Jordan.

1.5 The Limits of the study

1.5.1 Temporal limits

Time of the second semester (2018-2019) from 2nd October to 18th April.

1.5.2 Spatial limits

Khadija Um Al-Mumineen first school- Zarqa governorate Jordan, and what facilities and support tools it can provide

1.5.3 Human limits

The 8th-grade students at Khadija Um Al-Mumineen first school, aged 13-14.

1.5.4 Subjective limits

- Applications of the educational robot while applying the integrative approach represent what happens in the lab and does not represent reality.
- The study tools' generalization of the study outcomes is determined by psychometric characteristics (validity and reliability).

1.6 The Study Terminology

1.6.1 Educational EV3

The "evolution3" of the Mindstorms product line. Its function is based on the smart building unit, which is adaptable to programming that controls engines and sensors, in addition to its ability to communicate wirelessly and provide opportunities to choose machines and sensors the student likes to use in building the robot according to the design the student makes (Menshi,2015).

1.6.2 STEAM Approach

It is an approach for teaching that uses science, technology, engineering, art, and math to focus on education and creative learning, which is multidiscipline, realistic. It is based on problems or projects (Kim & Park, 2012). It is defined procedurally as a learning method based on the idea of role-playing, where students in a comparative collective work prepare and design the electronic interactive projects by using educational EV3 under the teacher's supervision.

1.6.3 Academic Achievement

The outcomes of a group of knowledge in teaching the essential skills for the educational robot course. It is procedurally defined as comparing the student's achievement level in the first and second semester in the educational robot.

1.6.4 Creative thinking

It is a process in which the mental processes are activated to assist the learner in problem-solving he encounters and provide new valuable responses and require strong thinking provocation that lasts for a long time. It is also flexible and accepts multiple solutions (Jarwan,2002). procedurally defined as follows: it is the degree the learner gets on the Torrance Test of Creative Thinking (Form B)

2. The Study Methodology

This study is considered a quasi-experimental study (designing inequivalent groups in the pre and post-sale). It used to design two groups: learning based on the integrative approach and traditional education with the Torrance Test of Creative Thinking (Form B). After the completion of teaching the two groups, the Torrance Test of Creative Thinking (Form B) was applied

2.1 The Study population

The study population consists of primary stage students- 8th-grade students at Khadeeja Um Al-Mumineen first basic school- Zarqa governorate in Jordan in the second academic semester (2018/2019). They were selected purposefully due to the cooperation of the school administration and teachers with researchers and the availability of internet and computer labs. They were distributed randomly into two groups: The experimental group of 30 students and a controlling group of 32 students.

2.2 Group equivalency

To ensure the equivalence of the two study groups_ the experimental and control groups, scores of the first semester were used in the educational robot course; the two researchers calculated the arithmetic mean and the standard deviation for the students' scores in both study groups. A test was used where it was clear that the difference between these averages was not of statistical significance at significance (0,05= α) which is clear from data of Table (1)

Table 1: The arithmetic Means, Standard Deviation, and values of (t) test for student's achievement in the first semester for the experimental and control groups

Groups	N	Mean	STD	Std Error Mean	Mean Difference	df	T	Sig.
experimental	30	80.100	7.88429	1.43947	2.91250	60	1.304	.545
Control	32	77.1875	9.56282	1.69048				

Table (1) shows that the test value for students' scores means equal to the experimental and control groups for first-semester (1.304). This is of no statistical significance, meaning there is no difference between the two groups- the experimental and control groups. Thus, they are equivalent. Therefore, the Torrance Test of Creative Thinking (Form B) was applied to ensure equivalence in creative thinking.

Due to the difficulties of controlling some experimental factors such as economic and status, the IQ that affects the research outcomes results in statistical control. Therefore, the two researchers used one-way ANOVA to calculate the difference between the two groups' scores- the experimental and control groups to ensure that no distinction has statistical significance among the two groups in the pre-application. The statistical results are as follows in Table (2)

Table 2: Results of the ANOVA variance of students' scores in the experimental and control group based on creative thinking

		Sum of Squares	df	Mean Square	F	Sig.
Fluency	Between Groups	49.704	1	49.704	1.372	.246
	Within Groups	2174.167	60	36.236		
	Total	2223.871	61			
Flexibility	Between Groups	61.549	1	61.549	1.681	.200
	Within Groups	2196.919	60	36.615		
	Total	2258.468	61			
Elaboration	Between Groups	112.008	1	112.008	2.372	.129
	Within Groups	2833.685	60	47.228		
	Total	2945.694	61			

		Sum of Squares	df	Mean Square	F	Sig.
Originality	Between Groups	46.074	1	46.074	2.383	.128
	Within Groups	1160.200	60	19.337		
	Total	1206.274	61			
Other skills	Between Groups	43.767	1	43.767	1.382	.244
	Within Groups	1899.669	60	31.661		
	Total	1943.435	61			
Total	Between Groups	1511.831	1	1511.831	2.060	.156
	Within Groups	44038.169	60	733.969		
	Total	45550.000	61			

Results of Table (2) show the variance level in the performance of the two groups on the creative thinking scale has no statistical significance at the significance level of (0.05), and that the total scale value among the means of the two group scores (2.060) between the experimental and control group in the pre-application, of difference, equals. This means there is no vital difference between the two groups; thus, they are equivalent.

2.3 The Study Variables

First: The independent variable: It is represented in:

- The STEAM approach strategy
- The traditional learning strategy

Second: Dependent variables

They are represented in the students' results in the first and second semesters. And results of the mental ability scale using the Torrance Test of Creative Thinking (Form B)

Table 3: Study design; it is as follows

Experimental group	Pre-application (10)	Practical application (x)	Post application (20)
Control group	Pre-application (10)	Typical application (-)	Post application (20)

Whereas: (01) pre-application results of students in the first semester, and Torrance Test of Creative Thinking (Form B). The (x) is the experimental implementation (the application of the integrative approach of learning). As for (O2), it is the post-application of students in the second semester, and Torrance Test of Creative Thinking (Form B), and (-) is the traditional application (without the integrative approach learning).

2.4 The Study Tools

Torrance Test of Creative Thinking (Form B). This study shall use the Torrance Test of Creative Thinking (Form B), which Sulaiman & Abu Hatab (1973) (codified) and modified for the Arab environment. It consists of three activities: Forming an image, lines, and circles completion. Four abilities will be measured (fluency, flexibility, originality, elaboration, and other skills). Torrance Test of Creative Thinking (Form B) was selected due to its appropriateness to the environment and computer course, and the age of the sample study aims to explore the students of creative thinking and improve the appropriate educational conditions. It is considered one of the best methods to measure creative thinking, and it is suitable for all stages from kindergarten to mature persons. According to (Kim, 2011), it was translated into more than 35 languages, and it has a high predictive ability. It was used over 40 years in longitudinal studies by Torrance, used in several studies in the Arab world, such as Egypt (Abdullah Sulaiman & Fuad AbuHatab,1973), Sumayyah Abdul Warmth (1996). Ibrahim Al ha (1981) is in Sudan and Jordan: Rashid Alshanti (1983). In UAE: Shaker Qandeel

(1997), and in KSA: Huda Saifaddin (2017).

Abdullah Sulaiman and Fuad Abu Hatab (1973) modified the formal image (B) on a sample of Egyptian children aged (12-15), and validity was made accompanied by teacher assessments. In addition to terminal comparisons. They were all at function (0.01). To calculate reliability, they used correction reliability among (6) different correctors and achieved high correlations. Ibrahim Abdelhadi (1981) investigated the psychometric characteristics and calculated reliability by re-doing the procedure where fluency reliability reached (0.975), flexibility (0.618), originality (0.944), and elaboration (0.949). Concurrent validity was conducted using the teachers' assessment by choosing (3) teachers who know the students well. They classified the students into two categories: The most creative and less creative, then measured their differences in the Torrance scale. The resulting function was in favor of the most creative group.

Moreover, he performed hypothetical formative validity between scale dimensions and the total scale; thus, the correlation coefficient for the total scale (0.88-0.47). Finally, researcher Huda Saif Addeen (2017) studied the psychometric characteristics of the creative thinking scale on high school and university students. The outcome confirmed that the scale enjoys validity and reliability; therefore, its reliability coefficient was (0.85).

2.4.1 Reliability of the study tool

Torrance Test of Creative Thinking (Form B). To ensure the study tool's reliability, the researchers investigated the test method and re-testing (test-retest) by applying the scale and applying it again after two weeks on a group of 20 students from outside in Zarka governorate. Pearson correlation coefficient was calculated between their scores in the two cases and was (.76).

2.4.2 Construct Validity

Torrance Test of Creative Thinking (Form B) was applied to the exploratory sample of 20 8th-grade students in Zarqa governorate outside the study sample. The construct validity was calculated by calculating the correlation coefficient of the full score of the skill by the total score of the scale by using (Pearson correlation)

Table 4: Construct validity of the Torrance Test of Creative Thinking (Form B)

Dimensions	Correlation coefficient	Function
Fluency	0.77	**0.00
Flexibility	0.76	**0.00
Elaboration	0.70	**0.00
Originality	0.71	**0.00
Other skills	0.72	**0.00
Full score	0.73	**0.00

Table (1) shows a correlation relation of high statistical significance between the full paragraphs of each dimension and the tool's dimensions, which indicates the construct validity for each dimension and the terms(phrases) included in it.

The scale consists of three nonverbal activities: Forming an image, incomplete forms, and repeated forms. Ten minutes would be allocated for each activity.

The first activity: The examinee must form images from an oval shape (like a bean). It is placed on a white sheet; then, some additions are added to create an image of a story from it if it is exciting and unfamiliar. He puts in the picture whatever details he finds suitable, and then he must write a

caption(title) for it and be expressive and unfamiliar. This activity aims to provoke responses of originality and identify the elaboration.

The second activity: Incomplete shapes, They contain ten unfinished figures, and the examinee is required to add some lines so that pictures are formed or interesting, expressive, original, and unfamiliar shapes with the addition of details and provide a title for each picture. This activity aims at provoking originality responses and identifying elaboration, flexibility, and fluency.

The third activity consists of 36 circles, and examinees are required to draw shapes of pictures in which the circles are bases for each picture. The examinee draws excellent numbers of pictures or subjects and finds out within 10 minutes the most significant amount of ideas and that each picture should have an expressive, real story, then writes a title under each subject or picture. This activity aims at provoking originality responses, identifying elaboration, flexibility, and fluency.

Test Time: Abdul Aziz (2006, p 102) mentioned that the allocated time to do the Torrance Test of Creative Thinking (Form B) is 30 minutes.

Course subject: the educational robot school textbook, including experiences (Scientific material, skills, tools, activities, and a project by the students at the end of the academic period).

Aim of the subject: Designing the robot through learning programming, connecting different sensors, display screens, and various pieces of the EV3 that teach him programming and how other electric parts work and applications in robots and smart homes.

Method: Using the integrative approach for learning, starts the class with a fundamental question, makes timetables, then design projects, and monitor students and evaluate the experiments, in addition to presenting the projects and assessing the results.

- At the beginning of the first semester, the educational robot aims are well defined, the missions are planned, and the final assessments encourage students to produce ideas and solutions for problems. Conditions of final assessment evaluation should be the use of higher thinking skills among students.
- The teacher presents the educational robot subject material to the students, explains the components and aims of the learning material, the evaluation method, and shows an example for a robot model.
- Students are divided into five groups, with six students in each group. They are required to design a robot cooperatively.
- The group starts applying the natural Learning Cycle (Responsive classroom, 2017), which is clarified in the following shape:

Figure 2: Natural learning Cycle

First phase: Generating ideas and goals

In this phase, a plan is made that includes rules and instructions applied and selecting the supporting activities to make a robot. Timetables are set cooperatively between the teacher and the

students. This phase included many activities such as drawing schedules to complete the robot, setting the final deadline to achieve the robot, inviting the students to suggest new possible technology, and giving guidance when the recommended technology is not related to the robot. Students are required to provide explanations (reasons) for choosing the technology. The teacher helps the students set meaningful goals, where she works with each group to set goals for the project through students looking through the educational robot course, its goals, and the missions they are assigned to.

Second phase: Active exploration, experimentation, and problem-solving:

During this stage, the teacher can provide graded support and help students on connecting their daily work with their initial ideas and learning goals to implement the robot as follows:

- Attending to and studying the educational robot content and the school course about a robot (Science).
- Using EV3 programming technology (EV3 construct unit- EV3 engines- EV3 sensors: "circulation, touch, ultrasound, light rays waves and temperature." – connecting sensors and machines- connecting EV3 construct unit with a computer) in addition to ideas, and the technological practices that are related to the robot (technology).
- Working on designing a tangible prototype (engineering)
- We consider beauty in shape, size, and color coordination harmony in designing the robot(art).
- The teacher process Data by using variables, tables, and charts (math).

The teacher monitors students and their progress in implementing the robot. The monitor process is achieved by using an evaluation format to register all essential activities. Finally, the result is evaluated to help the teacher measure the student's achievement level and understand its understanding.

The third phase: Reflecting on learning experience:

It is more than just looking at the robot's production- what the students did in the second stage of the learning stage. The issue is related to returning to the first phase and thinking of the degree of goals achievement. The thinking process is done individually and collectively. Students must express their feelings and experiences while completing the robot, present the robot design, and represent their expertise (experiments).

3. The Study results and its Discussion

The researchers displayed the products that are achieved by answering the two study questions: **The results related to the first question:** What is the effect of learning based on the integrative approach in teaching the educational robot in academic achievement among 8th-grade students in Jordan?

To answer the first question, arithmetic, mean, and the standard deviation were calculated to find differences in second-semester results in the academic achievement among the sample study (the experimental & control), which is apparent in the output of the following Table (5).

Table 5: The experimental & control

	group	N	means	Std. Deviation	Std. Error
Prior	Experimental	30	80.1000	7.88429	1.43947
	control	32	77.1875	9.56282	1.69048
Post	Experimental	30	83.2000	7.34096	1.34027
	control	32	77.5313	9.20023	1.62639

It is clear from Table (5) that there are apparent differences between the means of the two groups' scores in academic achievement. To know the significance of these differences between the means statistically, a (t) test was done. This is clear in the data of the following Table (6):

Table 6: Values of (t-test) between the two groups in the achievement

Groups	N	Mean	STD	Mean Difference	Std. Error	df	(t)	Sig.	Partial Eta Squared
Experimental	30	83.20	7.3409	5.66875	2.1228	60	2.67	.010	.965
Control	32	77.53	9.2002						

It is clear from table (4) data that there is a statistical difference in academic achievement. The value of-test value was (2.670), and this is statistically significant in favor of the experimental group (integrative approach–based learning), where it is mean higher than the mean of the control group (traditional learning). Furthermore, the effect size was eta square (η.2) on the academic achievement results (0.965). Thus, we can say that the is variance (contrast) in academic achievement among students of the two groups using learning through the integrative approach and traditional learning, and this confirms the efficiency of using the integrative approach in academic achievement.

Outcomes of the present study agree with the results of the studies about the importance of applying the construct theory principles of the integrative approach based- learning by teaching the individuals through practical experiences that are related to reality and the exposure to real problems in their life, and increasing their interest in it through interaction while applying the robot design. This leads to developing higher thinking skills which result in achievement increase. Furthermore, the role of the teacher is positive in the acquisition of knowledge. Thus, it develops abilities to acquire information, understand and analyze it, imagine the information and investigate it, dealing with facts, concepts, and generalizations. This increases knowledge acquisition and skills and develops various abilities compared with the traditional method by having access to rote learning.

This study's results agree with Gale& et al.'s (2019) study in implementing a science learning curriculum and merging design, engineering, and robots and applying the learners of energy, circulation, motion, and power. Alshare (2019) study, Abu-Mosa (2019), Saarican & Akgunduz (2018), Kawar (2017) study, Slattsveen & et al. (2016), Alshuhaimyya (2015) study, DuMont study (2013), and Olivares study (2012). They disagree with Bowen & Peterson's (2019) study, which did not find variance in students' achievement due to the integrative approach. –based learning.

Results related to the second question: What is the effect of learning based on the integrative approach in teaching the educational robot in creative thinking among 8th-grade students in Jordan?

The means and standard deviations were calculated to identify the learning effectiveness of the integrative approach in teaching for students' scores of the sample study (experimental and control) on the dimensions of the Torrance scale of the creative thinking and on the scale as a whole which is apparent in data of Table (7) as follows:

Table 7: Arithmetic means of the two groups of study's performances on creative thinking

Groups		Fluency	Flexibility	Elaboration	Originality	Other Skills	Total
Experimental	Mean	15.533	17.133	14.366	11.533	11.667	70.2333
	N	30	30	30	30	30	30
	Std. Deviation	6.6523	6.4352	4.240	4.240	27.6376	27.6376
	Error- Std. Deviation	1.2146	1.2907	1.1749	.77420	.99693	5.04592
Control	Mean	11.500	12.281	9.7188	7.9375	7.5625	49.0000
	N	32	32	32	32	32	32
	Std. Deviation	5.4358	5.7430	5.7766	4.1962	4.8322	24.3535
	Error- Std. Deviation	.96093	1.0152	1.0211	.74181	.85423	4.30515
Total	Mean	13.451	14.629	11.967	9.6774	9.5484	59.2742
	N	62	62	62	62	62	62
	Std. Deviation	6.3392	6.81905	6.49077	4.55845	5.50611	27.91038
	Error- Std. Deviation	.80509	.86602	.82433	.57892	.69928	3.54462

It is clear from Table (5) that the total mean of the experimental group students who studied by using the integrative approach – based learning on the most creative thinking scale (70.2333) with a deviation of (27.63766) and was higher than the average of the students of the control group (49.0000) with standard deviation.

To know if there are significant statistical variations at the function level (0.05≥α) in the mean of sample study performance on the marginal dimensions of the scale and the total score, the ANOVA was used, which results are shown in table (8) as follows:

Table 8: Results of ANOVA post-analysis for scores of the two groups: The experimental and control on the creative thinking scale

Abilities		Sum of Squares	df	Mean Square	F	Sig.
Fluency	Between groups	251.888	1	251.888	6.871	.011
	Within groups	2199.467	60	36.658		
	Total	2451.355	61			
Flexibility	Between groups	364.532	1	364.532	8.848	.004
	Within groups	2401.935	60	41.199		
	total	2836.468	61			
Elaboration	Between groups	334.500	1	334.500	8.978	.004
	Within groups	2235.435	60	37.257		
	total	2569.935	61			
Originality	Between groups	200.207	1	200.207	11.255	.001
	Within groups	1067.342	60	17.789		
	total	1267.548	61			
Other Skills	Between groups	260.813	1	260.813	9.851	.003
	Within groups	1588.542	60	26.476		
	total	1849.355	61			
Total	Between groups	6980.972	1	6980.972	10.333	.002
	Within groups	4057.367	60	675.623		
	total	47518.339	61			

Table (8) showed the post results of the ANOVA for scores of the two groups: The experimental and the control group on the creative thinking scale

It is clear from the results of Table (8) that there is an effect of statistical significance attributed to the variance of the effectiveness of using the integrative approach based- learning. The (F) function was (10.333), which means a variance between the students' mean of the experimental group's performance over that of the control group on the Torrance creative thinking scale. Results were in favor of the experimental group. This question's results showed a positive effect for the integrative approach-based learning in developing the students' performance in creative thinking skills represented in fluency, flexibility, originality, elaboration, and other skills. The total score on the Torrance scale for critical thinking shows the importance of this strategy and its appropriation to the study subject (The educational robot course) for the practical technological projects that increased the strategy's effectiveness.

The result agrees with reference and literary studies such as Kilpatrick called prompted that learners be positive participants. They are provided with activities similar to real problems naturally through a social environment similar to the actual work environment. They discuss it with colleagues and accept others' different points of view to encourage them to exercise thinking and expression thinking freedom democratically. Moreover, cognitive psychologists such as Melvin,1999) pointed out the most critical influences on creative behavior. They are learning and education factors. This is done by providing the appropriate environment for the individual at his home and school. It can teach and develop creativity through training and practice. The results of this study agree with the results of (the study carried out by Clements & Sarama,2020), who focused on the importance of

technological development in enhancing creativity, and the study of (Sumarni & Kadarwati,2020), and the study of (Gale&Atmel.2019) in implementing science learning approach and merging design, engineering, and robot which encouraged students on samples and patterns and creative solutions. Morover, Bowen& Peterson (2019) study that increased the students' ability to visualize, in addition to Kawar (2017) study, and Slattsveen & et al. (2016), which results during experimenting building a robed that is based on Arduino pointed to the development of the creative trust among students, it agrees with Alshuhaimiyya (2015) and the study of Ayyoub & et al., (2012). Based on the results of this study, we could point out that learning based on the STEAM approach plays a vital role in increasing academic achievement, developing creative thinking, and obtaining more creative and distinguished ideas that help in social progress and development.

4. Conclusion

The study explores by designing creative projects that lead learners to look at the subjects positively and comprehensively to develop creative thinking. The essential elements of creative thinking skills have been stimulated in the study by exploring knowledge cognition in the science area, creating and applying in the technology area, designing and building in the engineering area, using paper for drawing and coloring in the art area, using formula and symbol in the mathematic area. The study determined that the STEAM approach on teaching the educational robot subject increased students' achievement and creative thinking skills. STEAM may grant a promising approach to boosting both students' motivation and willingness to perform. Creativity in education promises to develop Arab students in science and mathematics that meet the modern notions of learning and success. This study recommends that the STEAM approach improves individuals' skills and supports career development by addressing different disciplines and skills.

5. Recommendations and Suggestions

- Applying learning based on the integrative approach, and introducing it in the school plans, equip schools with teaching halls furnished with all requirements for practical application.
- There is a necessity to adopt appropriate teaching strategies and methods to upgrade students' mental abilities and creative thinking levels.
- Employing the construct theory principles in building the applied teaching courses is essential in activating the learning-teaching process.
- We are reconsidering science learning curricula and courses, especially computer learning, merging design, engineering, and robots, to develop various scientific skills and mental abilities.
- They carry out experimental studies showing the effect of different learning and teaching strategies in developing achievement and different thinking abilities among students at all school stages.

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