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The Effectiveness of a Suggested Program Based on STEAM in Enhancing Eleventh Graders' Creative Thinking Skills

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Abstract:

This study examines the impact of a STEAM-based program on enhancing eleventh graders' creative thinking skills. A quasi-experimental design was used with two groups: one experimental (36 students) taught via STEAM, and one control (34 students) taught traditionally. The experiment lasted six weeks, and a creative thinking test was used. The results showed that the STEAM program significantly improved creative thinking skills, with notable differences favoring the experimental group. The researcher recommends training teachers to design STEAM-based programs to foster creative thinking.

Keywords: STEAM, creative thinking, skills**.**

فاعلية برنامج مقترح قائم على STEAM في تنمية مهارات التفكير الإبداعي لدى طالبات الصف الحادي عشر

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الملخص:

تهدف هذه الدراسة إلى التحقق من فاعلية برنامج مقترح قائم على منهجية STEAM في تعزيز مهارات التفكير الإبداعي لدى طلاب الصف الحادي عشر. تم استخدام تصميم شبه تجريبي مع مجموعتين: مجموعة تجريبية (36 طالبًا) تم تدريسهم باستخدام البرنامج المقترح القائم على STEAM، ومجموعة ضابطة (34 طالبًا) تم تدريسهم بالطريقة التقليدية. استمر التجربة لمدة ستة أسابيع، واستخدم اختبار التفكير الإبداعي كأداة قياس. أظهرت النتائج أن البرنامج القائم على STEAM أدى إلى تحسين مهارات التفكير الإبداعي بشكل كبير، مع وجود فروق ذات دلالة إحصائية لصالح المجموعة التجريبية. أوصت الباحثة بتدريب المعلمين على تصميم برامج قائمة على STEAM لتعزيز مهارات التفكير الإبداعي لدى الطلاب.

الكلمات المفتاحية: STEAM، التفكير الإبداعي، المهارات.

Introduction:

In the context of rapidly changing global economies and technological advancements, the need for innovative problem-solving has never been greater. The 21st century has brought with it unprecedented challenges, from complex environmental issues to rapid technological disruptions. In this environment, traditional educational approaches, which often focus on isolated disciplines, may no longer be sufficient to prepare students for the multifaceted problems they will encounter. As a result, educators have turned to interdisciplinary strategies, applying this process produces a final output that integrates knowledge and abilities from several topic areas. Implementing the knowledge and abilities learned in actual life is the result of using strategies that deal with the development of creative thinking. (Fuentes & González, 2017). Students are highly motivated and develop their thinking if they learn through various strategies that ensure interaction between the student and the teacher and involve their senses, attitudes, and perceptions.

To speak more creatively, students become more creative when they can generate ideas and are able to ask questions, verify hypotheses, conduct experiments, and master problem-solving skills (Kuo & Hwang, 2014; Zorana, 2016(.There are a lot of educational institutions that do not care much about developing creative thinking or thinking outside the box, while many studies have shown that schools that offer their students strategies interested in developing creative thinking show higher rates of creative thinking. (Rahardjanto & Fauzi 2019 ; Ritter, S & Biekens, P. 2023; Gajda, A & Beghetto, R 2017; Akpur, U. 2023 (.

Defining creative thinking is not easy. Imagination is the key to creativity. Accompanied by a person's desire to produce an original, unprecedented product or idea. The definition may include sensing problems, formulating hypotheses for them, testing them, and reaching innovative solutions (Bartscher, et al , 2001). The educational environment should be one that fosters creativity more than any place outside it. The school must adopt new and advanced methods and strategies away from tradition.

The development of knowledge these days, which focuses on employing knowledge practically in the context of life, is also reflected in the educational perspective. Researchers in the educational field began to seek knowledge integration, which led to the creation of the STEAM curriculum, which greatly affected the field of education.

Over the past few years, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) curriculum has incorporated the arts with STEM subjects to improve student engagement, creativity, inventiveness, problem-solving abilities, and other cognitive advantages (Liao, 2016). The term STEAM was introduced by the National Science Foundation (NSF) in the US during the 1990s. In current educational reforms, STEM is viewed as a collaborative approach that highlights a comprehensive approach to better equip students for STEM careers and to succeed in the worldwide economy (Thomasian, 2011).

"The acronym STEM was created early in the twenty-first century to describe professions or academic programs that focus on the fields of science, technology, engineering, and mathematics (STEM)", which are the fastest-growing sectors of the American economy. The tendency to integrate STEM into educational frameworks started to acquire significant popularity (Become, 2021). Integrated STEAM education has evolved from STEM by incorporating the arts, aiming to create a more holistic learning experience. Research highlights that adding arts fosters creativity, critical thinking, and interdisciplinary learning. For example, Aguilera and Ortiz-Revilla (2021) found that STEAM-based interventions promote creativity through multidisciplinary collaboration, though implementation varies in practice. Similarly, Sanz-Camarero, Ortiz-Revilla, and Greca (2023) reviewed STEAM's impact on arts education, noting that while integration shows promise, arts content is sometimes overshadowed by technical disciplines. They argue for a more balanced approach that values artistic and scientific competencies equally for meaningful STEAM education development.

STEAM combines the skills of science, technology, engineering, arts and mathematics (STEAM) through a set of standards related to integrated activities that focus on STEAM to achieve a number of goals. These goals include the development of creative thinking among students. STEAM includes real-world problems in addition to the integration of a large number of disciplines into one project or activity (Quigley et al, 2017).

In addition, STEAM is flexible for application, as it can be applied at different educational stages. STEAM has recently become popular for its efficacy in promoting creative thinking, problem solving, and motivation for learning. The emphasis on creativity within the STEAM framework is particularly important as it nurtures students' ability to approach problems from multiple perspectives, fostering innovation and novel solutions (Sousa & Pilecki, 2018). Studies have shown that students engaged in STEAM activities demonstrate improved problem-solving abilities, enhanced creativity, and greater collaboration skills (Larmer & Mergendoller, 2015).

To form integrated STEAM activities, the researcher held lengthy sessions with the teachers of the different subjects in the school, such as science, technology, and mathematics, in order to build the program. They helped the researcher identify the STEAM crossings between all these courses and the English language curriculum in general and units 7 and 8 in particular. The actual experiment coincides with the teaching of the seventh unit. The researcher divided the students in the experimental sample into groups in order to carry out projects based on teamwork. The researcher allowed the students to choose projects that are compatible with their preferences. In the feedback stage, the students had to express and discuss what they had done in English, either directly or through technological tools such as presentations. The students exchanged feedback and had discussions in groups. Later, the researcher asked the groups to express how they would modify or develop the project in the future. The researcher believes that the program has helped students develop their problem-solving abilities, unleash their creative thinking, and connect what they have learned to their everyday lives.

After carefully evaluating each of these STEAM definitions, the researcher derived her theoretical definition of STEAM approach as science, technology, engineering, art, and math projects and activities that create an inclusive learning environment that encourages all students to participate and contribute through engaging in the projects.

Statement of the Problem

Based on the researcher's experience who works as a teacher of English Language to the secondary female students and a supervisor for English trainee teachers, she noticed that COVID-19 affected the students' creative thinking badly

Moreover, the researcher reviewed literature and previous studies related to this study; many of which have been conducted recently and aimed to promote the students creative thinking through STEAM Harris, Anne; de Bruin, & Leon (2018) Ozkan, Gulbin; Umdu Topsakal, & Unsal(2021), Hope,W. et al (2021); Emma,S & Latifah (2021); Rahmawati et al 2019; Deák & Kumar, B. (2024) ; Bati, T, & Sun, Y. (2022) and Santos, M & Souza, R (2023) .

Research Questions

The study problem is formulated in the following major question:

What is the effectiveness of the suggested program based on STEAM in enhancing 11th graders' creative thinking skills?

The following sub-questions merged from the above major question:

1. What is the framework of the suggested program that is based on STEAM to enhance eleventh graders' creative thinking skills?
2. Are there statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of the experimental group and control group post application of creative thinking skills test?

Study Hypothesis

The study hypothesis is stated as follows:

There are no statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of the experimental group and control group post application of creative thinking skills test.

Purpose of the Study

The recent study aims to:

1. Construct an instructional program based on STEAM to enhance creative thinking skills of the 11th grade students.
2. Identify the creative thinking skills that should be improved for 11th graders.
3. Find out the effectiveness of the suggested program based on STEAM developing creative thinking skills among eleventh graders.

1.6 Significance of the Study

The significance of the study is determined in:

1. It would be beneficial for syllabus designers to direct their interests toward activating STEAM in all curricula by providing it with activities that enhance creative thinking skills.
2. It may encourage educational supervisors to hold training courses for teachers to train them in developing students' creative thinking skills through STEAM projects.

1.7 Delimitations of the Study

This study was applied with the following limitations:

1. The population of the study was literary stream (grade 11) female students from Beit Hanoun Secondary School for Girls.
2. The study covered units 7 and 8 of English for Palestine grade 11.
3. The study was limited to employing the suggested program based on STEAM to enhance creative thinking skills.

1.8 Operational Definitions of Terms

The researcher defines the following terms operationally for the purpose of the current study:

- **Effectiveness**: The change in the learners' creative thinking due to STEAM projects
- **STEAM program:** a program based on science, technology, engineering, arts, and math (STEAM) projects and activities that encourages students to participate and contribute by getting them involved in activities that boost creative thinking skills.
- **Creative thinking**: the ability of the study sample to express ideas and thoughts in fluent, flexible, and original way where the students express themselves and present their perspectives freely through and after the program. It includes the students' ability to solve problems from a singular perspective and think outside the box. It was measured by a test prepared by the researcher.

Eleventh graders: are the female pupils from the literary stream who are enrolled in the 11th grade at the secondary schools in the Gaza Strip and West Bank. They are between 16 and 17 Research Design

The researcher adopted descriptive approach which examines the core and analytical processes (content analysis). In order to analyze the content of the seventh unit, "Food on the Table," and the eighth unit, "Amazing Animals," from the eleventh grade secondary textbook, second semester, the researcher employed the descriptive approach to analyze steam components, as well as creative thinking skills.

The study used an experimental methodology with quasi experimental design. Participants in the study were divided into two groups: the experimental group, which included 36 students, and the control group, which included 35 students. Table (3.1) illustrates the distribution of the study groups:

3.3 Study Variables

1. The independent variable: suggested program based on STEAM and the traditional method.
2. The dependent variables: creative thinking skills.

The experimental group was taught using the suggested program based on STEAM, while the control group was taught by the traditional method. The experiment lasted for 6 weeks under the supervision and observation of the researcher.

Two eleventh grade classes in the literary stream from Beit Hanoun Secondary School for girls were randomly selected among five classes as the study sample. The experimental group was one class with 36 students, and the control group was the other one with 34 students. The students in both groups had comparable levels of academic, and age (17-year-old pupils). A STEAM program was used by the researcher herself.

3.5 Pilot Study

Using the random sample technique, a group of students in the twelfth grade was selected. 35 female students were chosen as a pilot sample to verify the instrument validity and reliability.

Study Instruments

Based on the researcher's analysis of numerous related prior studies and consultation with experts and specialists, the researcher developed the study tool, which was:

1. creative thinking test

Creative Thinking Skills test

The test description :

After the researcher had reviewed many related studies, she designed the test which consisted of 12 questions each question contain 3 demands (the total is 12 items for fluency skill , 12 items for flexibility skill, 12 item for originality skill) 36 items. The duration of the exam was 60 minutes, and the student was required to answer the questions freely and in their simple English. The format of the exam included images and specific problems, and the student had to find solutions to these problems or comment on some pictures . The type of questions in the exam were open-ended essay questions.

Validity:

1. Referee validity: The researcher consulted pedagogical experts to assess the validity of the work. Their suggested modifications were incorporated into the final draft.
2. Pilot Study: the researcher administered the test to a sample of 12th-grade students to evaluate its validity and reliability.
3. Internal consistency validity: The researcher employed the Pearson Correlation Coefficient to determine the internal consistency. Table 1 presents the Pearson Correlation Coefficient values for each item and the overall test.

Table (1): Pearson Correlation coefficient of each item and the whole test

No. of questions	Pearson Correlation	Sig	No. of questions	Pearson Correlation	Sig
1.	0.629**	0.001	**19**	0.473**	0.001
2.	0.813**	0.001	**20**	0.866**	0.001
3.	0.697**	0.001	**21**	0.666**	0.001
4.	0.508**	0.001	**22**	0.583**	0.001
5.	0.646**	0.001	**23**	0.707*	0.01
6.	0.675**	0.001	**24**	0.627**	0.001
7.	0.888**	0.001	**25**	0.622**	0.001
8.	0.848**	0.001	**26**	0.878**	0.001
9	0.818**	0.001	**27**	0.743**	0.001
10	0.818**	0.001	**28**	0.835**	0.001
11	0.842**	0.001	**29**	0.848**	0.01
12	0.861**	0.001	**30**	0.753**	0.001
13	0.693**	0.001	**31**	0.451**	0.001

14	0.716**	0.001	**32**	0.762**	0.001
15	0.740**	0.001	**33**	0.607**	0.001
16	0.594**	0.001	**34**	0.498**	0.001
17	0.768**	0.001	**35**	0.828**	0.001
18	0.695**	0.001	**36**	0.624**	0.001

***r table value df (35) and sig(0.05)=0.304**
****r table value df (35) and sig(0.01) =0.393**

Table (1) indicates that the correlation coefficient for each item within its respective level is statistically significant at the (0.01) level. This suggests that the instrument demonstrates a high degree of consistency and validity for the purposes of this study.

Table (2): Pearson Correlation coefficient of every domain and the whole test

Domain	Pearson Correlation	Sig
Fluency	0.914**	0.001
Flexibility	0.949**	0.001
Originality	0.965**	0.001

***r table value df (35) and sig(0.05)=0.304**
****r table value df (35) and sig(0.01) =0.393**

Table (2) shows that all the domains of the test have statistically significant correlations with the total test, which indicates a high internal consistency that reinforces the validity.

Reliability:

Reliability means that a test should give the same results if it is administered twice to the same group of students. The researcher used the following ways to confirm the reliability of the test:

(i) Split half method

This method depends on finding the Pearson correlation coefficient between the odd and even items in the creative thinking skills test and correcting the correlation coefficient using the Spearman brown formula:

The correlation coefficient between the odd and even questions equals (0.913). The Spearman-Brown Coefficient equals (0.954) and value of this correlation coefficient indicates good reliability of the test. See table (3).

Table(3): Pearson correlation coefficient between the odd and even items

Domain	N	Correlation coefficient	Modified correlation coefficient
Fluency	**12**	0.630	0.773
Flexibility	**12**	0.819	0.9
Originality	**12**	0.75	0.857
Total	**36**	0.913	0.954

Controlling the creative thinking skills test

The researcher looked at both groups' results on the test to make sure that both groups' results on the creative thinking abilities test were identical. The differences between the control and experimental groups on the test of creative thinking are shown in Table 4 using a t-test.

Table (4): t-test for the differences between the control and experimental groups in the creative thinking skills test

Variable	Group	N	Mean	Std. deviation	T	Sig	Sig. level

Fluency	**Experimental**	36	5,69	**1.16**	1.163	0.249	**Not sig**
	Control	34	6	**0.42**			
Flexibility	**Experimental**	36	5.36	2.2	0.265	0.792	**Not sig**
	Control	34	5.52	3.05			
Originality	**Experimental**	36	1.5	1.38	0.923	0.359	**Not sig**
	Control	34	1.82	1.54			
The creative thinking skills test	**Experimental**	36	12.5	2.8	0.851	0.398	**Not sig**
	Control	34	13.27	3.9			

***t table at df (68) sig. level at (0.05) = 2.000 **t table at df (68) sig. level at (0.01) = 2.660**

Table (4) results show that significant value is more than (0.01), and T calculated less than t table. So there were no statistical differences at (0.01) between the experimental and the control groups concerning the -test for the differences between the control and experimental groups in the creative thinking skills test, it indicated that there are no statistical differences between the control and experimental groups in pre application of the test in their creative thinking .

The researcher tried to control various variables. The control and experimental groups were taught by the same teacher. Both groups received a six-week education. The experimental group was taught using the suggested program based on STEAM, while the control group was taught traditionally.

Data analysis, Results and Discussion:

Answer of question 1:

What is the framework of the suggested program based on STEAM to enhance eleventh Graders' creative thinking skills?

To find the scientific procedures for designing the program, the educational literature was surveyed. The proposal implementation, its supervision and design went through a number of stages, including creating the program introduction, formulating the general program objectives, defining the educational objectives, defining the teaching strategies used in teaching the two units, defining the teaching and learning resources, defining the educational activities, and defining the evaluation methods in light of the approach's philosophical underpinnings STEAM integration and project planning.

After analyzing the relevant literature, the researcher built and presented the overall program based on STEAM and suggested a teacher guide that depends on STEAM.

4.2.4 Answer of question 2

Are there statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of the experimental group and control group post application of creative thinking skills test?

The researcher used a T-test to examine the forth null hypothesis in order to respond to the forth research question , There are no statistically significant differences at ($\alpha \leq 0.05$) in the mean scores of the experimental group and the control group post application of creative thinking skills test. Table 5 displays the outcomes of the variations in creative thinking abilities

Table (5): t-test results of the differences between the experimental and control groups in the creative thinking skills posttest.

Variable	Group	N	Mean	Std. deviation	T	Sig	Sig. level
Fluency	Experimental	36	9.75	2.87	4.181	0.001	Sig.
	Control	34	7.205	2.14			

Flexibility	Experimental	36	9.36	2.30	3.659	0.001	Sig.
	Control	34	6.9	3.18			
Originality	Experimental	36	9.2	3.02	2.67	0.009	Sig.
	Control	34	7	3.8			
The creative thinking skills test	Experimental	36	28.33	4.47	6.332	0.001	Sig.
	Control	34	21.17	4.98			

t-table at df (68) sig. level at (0.05) = 2.000
t-table at df (68) sig. level at (0.01) = 2.660

According to Table (5), the experimental group's mean score on the T-test for creative thinking skills is (28.33) which is higher than the mean score of the control group's T-test (21.17). This means that there are differences between the experimental group and the control group in favor of the experimental group.

(T) Calculated value serves as further evidence for this which is for experimental group (7.189) is larger than the (T) table value (2.660). Hence, the null hypothesis is rejected and the alternative hypothesis is accepted. As a result, the STEAM-based program had a positive impact on the experimental group's ability to think creatively. The researcher utilized eta square (η^2) to calculate the effect size to ensure that the differences were due to the influence of the program based on STEAM in strengthening the study sample's creative thinking skills.

Table (6): T value, and eta square η^2 **.**

Scope	t value	eta square η^2	Effect level
Fluency	4.181	0.244	Large
Flexibility	3.659	0.186	Large
Originality	2.67	0.108	Medium
Total	6.332	0.539	Large

It is clear from table (6) that eta square η^2 value is (0.539). Hence, the effect level is large and the t test results and the differences between experimental group and control group due to the suggested program based on STEAM. These findings are consistent with those of several studies that used STEAM .Some recent studies have investigated the positive effects of STEAM to enhance creative thinking skills such as –Rahmawati et al (2019), Emma and Latifah (2021), Hope and Wilson et al (2021) , Ozkan and Unsal (2021).

These results can be attributed to the following points:

1. The STEAM program puts an emphasis on practical skills that foster creativity and the expression of solutions in clear English.

2. The STEAM program and project learning techniques helped the students make reports, create videos, and improve their creative thinking skills as they carried out various educational activities.
3. STEAM program incorporates interactive activities, enhances the subject matter with research, interaction, and design skills, and enhances student participation and performance.
4. Project learning in STEAM emphasizes progressive project implementation, planning, and tool accumulation, as well as interaction through collaborative work.
5. The STEAM program connects the application process with the students' knowledge and backgrounds.
6. Combining the STEAM activities with speaking and creative thinking skills boosted the students' willingness to study English in a balanced way.
7. From the researcher's experience in teaching students in the secondary stage, particularly those in the literary stream, need to change the classroom atmosphere and adopt new learning styles and strategies since they were very interactive with the program.
8. The range of evaluation processes, including observation and project evaluation, also gave the students more psychological support to work on and produce Steam projects.
9. STEAM activities within teams raised the spirit of competition among the students.
10. STEAM program allows the students to express themselves freely, make arguments, present, and engage in discussion.
11. STEAM activities Provide technological support and guidance as the students learned about numerous technology applications during the application process motivated the students to complete projects and improved their enthusiasm to learn.

5.3 Conclusion:

The suggested program based on STEAM has improved the students creative thinking skills according to the study results. STEAM gave the students the opportunity to advance their creative thinking skills individually and collectively .Given, the positive results of the program's application might be a way to make learning English as a foreign language easier. All student, whether low, middle, or high achievers benefited from STEAM. Students were able to speak freely, ask questions, and exchange ideas in this method's welcoming setting without fear of making mistakes or stumbling. The researcher believes that STEAM enables students to communicate in situations where the language is actually used and what they have learned can be put to use. Students were able to express themselves and share ideas in a comfortable and pleasant environment. They received inspiration and support. The STEAM approach enhances the proportion of engaged students by fostering a community among them that values cooperation and teamwork. Students felt at ease while working on creative projects, and they support one another. They acquired a variety of technological skills that improve their perception of the English language.

5.5 Recommendations:

Following are some recommendations formulated in light of the study findings:

- Making use of the current program in particular for English teachers at higher levels.
- Paying attention to and looking for new ways to help students enhance their creative thinking abilities.
- Designing teaching in integrated disciplines across various educational stages using a STEAM approach.
- Educating teachers to use an integrative approach within the specialties of the STEAM approach.
- Extending research into the integrated STEAM approach's effects on connecting theory and practice, as well as its application to higher grades.
- Including STEAM, not just in science, technology, and math but in all educational materials at all levels of study.

- Giving pupils the flexibility they need in class to participate actively and understand the subject at hand more effectively.
- Determining the materials based on the students' needs, interests, and degree of competency. Complex and sophisticated instructional materials are tiresome to use and distract pupils from their work

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