

EFFECT OF CROSSWORD GAMES IN STEM SUBJECTS ON STUDENTS'
ACADEMIC PERFORMANCE OF SELECTED SECONDARY SCHOOLS
IN OSUN STATE, NIGERIA
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Abstract

The Study developed a crossword puzzle and compared the effect of both traditional classroom teaching and the crossword game on Students' academic performance in STEM subjects. The research entailed the building of a cutting-edge Natural Language Processing environment for the creation of a web-based crossword puzzle game. The study adopted the quasi-experimental research design. The study's population included one thousand seven hundred and forty (1440) Senior Secondary One (SS1) scientific subject students from all 16 public secondary schools in the study area. The sample size consisted of 156 SS1 Science students selected from two co-educational secondary schools and at each of the selected schools, a simple random sample procedure was applied. The instrument utilised for data collection was the STEM Science Achievement Test (SSAT), which was validated by specialists in STEM fields. A reliability coefficient of 0.72 for the Kuder- Richardson Formula 20 (KR) was created. To address research questions, data were analyzed using mean

and standard deviation, and hypotheses were tested using Analysis of Covariance at the .05 level of significance. Students taught the notion of Biology, Chemistry, and Physics using crossword puzzle teaching approach outperformed those taught using traditional classroom teaching strategy with a mean gain performance score (8.7) to (5.6). The Study concluded that, the crossword puzzle teaching technique improves students' understanding and, as a result, greater academic performance on the notion of STEM subject as well as students' (gamers') comprehension skills in STEM-related themes. It is suggested, among other things, that STEM-based topic teachers use a crossword puzzle teaching technique.

Keywords: STEM Education, Digital Games, Crossword games, Academic Performance

Introduction

STEM, also known as Science, Technology, Engineering, and Mathematics, has grown to dominate educational activities. The creation of mobile game-based learning has become a new area of research and technological growth in the domains of educational technology, (STEM) education, and game design .

Global recognition of the expanding significance of STEM education is widespread, but there are various interpretations of what that means . All STEM subjects, including science, mathematics, technology, engineering, and cross-disciplinary combinations of the various STEM fields, might be included in a comprehensive definition of STEM education. The STEM disciplines of science, mathematics, technology, and engineering are expressly referred to as STEM subjects in the context of our current study. The complexity, abstraction, and multidimensionality of the subject, however, has been thought to make mastering these subjects tough and challenging .

The use of digital games to support learning has become more popular in recent years, and game-based learning is quickly expanding on both a European and international level . Digital gaming is undoubtedly a rapidly expanding industry, as it is one of the most widely used technologies among young people for entertainment. Digital games' educational potential is linked to factors like motivation, amusement, and interest, all of which are thought to be consistent with effective learning outcomes . Computer games can affect the dynamics of digital learning since they provide a quick and engaging learning speed in comparison to conventional teaching approaches. This is backed up by pertinent studies .

Because to the enormous amount of digital data that is generated every single minute, Natural Language Processing research which is actually a subset of Artificial Intelligence is currently attracting a lot of interest. In today's information world, the capacity to analyze information and transform it into knowledge is tremendously valuable . Natural Language Processing is a branch of artificial intelligence that focuses on processing data using language, rules, and grammar . It ties the fields of computer programming and interpersonal communication together. It helps the computer understand human data and carry out the necessary transformation.

This paper explores the idea of crossword games in the classroom and its efficiency as a way to fulfil and satisfy students' evolving demands for more dynamic and interesting STEM learning experiences in Nigerian Secondary Schools.

Statement of the Problem

Because STEM subjects are complicated, abstract, and multi-dimensional, learning them is generally perceived as being difficult and challenging. In light of this fact, using educational games as a motivational tool for students to engage with difficult concepts (Boyle et al., 2016). Using game-based learning, instructors can give students a graphical interface for interaction that strengthens scientific ideas in a fun setting. Over the years, crossword puzzle games have been utilized for game-based learning (Anwar & Efransyah, 2018). Crossword puzzles can be solved by humans using a straightforward logical iterative procedure, but this is insufficient.

Although several variables have been implicated in the observed low academic performance of students in the subject, the extent to which they fail in STEM courses raises many questions about the teaching-learning process in these topics. Umanah (2017) cites one of the causes as students' perceptions of science courses as abstract and challenging. Word games have also been demonstrated to be helpful in expanding comprehension, although the effectiveness of their use will depend on a number of variables that may be anticipated by current cognitive theory (Mueller & Veinott, 2018).

Here, we make an effort to develop a crossword-solving assistant utilising NLP principles. The purpose of this game is to help pupils with their STEM topic vocabulary. Creating a web application that would give people access to a crossword puzzle generator is the project's main goal. Furthermore, the effectiveness of learning through the created crossword games will be contrasted with conventional classroom instruction.

Purpose of the Study

The purpose of this study was to examine the effect of Crossword Games in STEM Subjects on Students' Academic Performance of Selected Secondary Schools in Osun State, Nigeria. Determining the variation in mean performance scores of scientific students who were taught the concepts of chemistry, biology, and physics using crossword puzzles and conventional teaching methodologies is the specific objectives. These would involve the use of Natural Language Processing techniques in the development of a web-based Crossword games for STEM subjects.

Research Question

What variations exists between the mean performance scores of scientific students who were introduced to the idea of STEM subjects through crossword puzzles and conventional teaching methods?

Methods

Crossword Game Development

The object of the game is to solve clues that lead to the solutions in order to place letters in the white squares to create words or phrases. The project's objective is to use the Python programming language to develop a crossword puzzle generator that can be accessed as a web application. The generator shouldn't rely on a vocabulary that the user or the outside world provides. Instead, it should use Natural Language Processing technologies to extract words and hints from the open data sources.

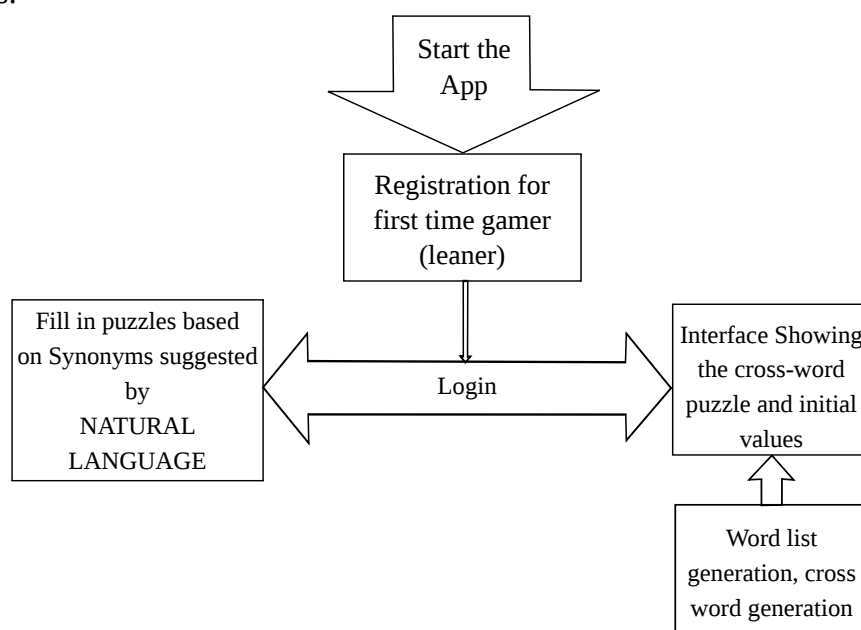


Figure 1: Creation of Word List

Web Application

The suggested system is an online application that was created and put into use utilizing flask and Python to create a user interface as shown in figure 2. The user interface enables users to request crosswords and get crosswords that have been created in response as shown in figure 3.

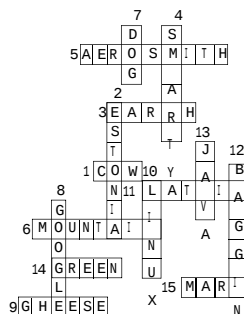


Figure 2: Crossword Demonstration

A comparator that can accept a single sentence proposal and the initial letter of the word that has to be changed in the problem is developed from Figure 2. As seen in figure 3, the term that most closely resembles the definition will then be returned, enabling the player's response to be confirmed. The next step is to compare each word definition in the alphabet with the clue.

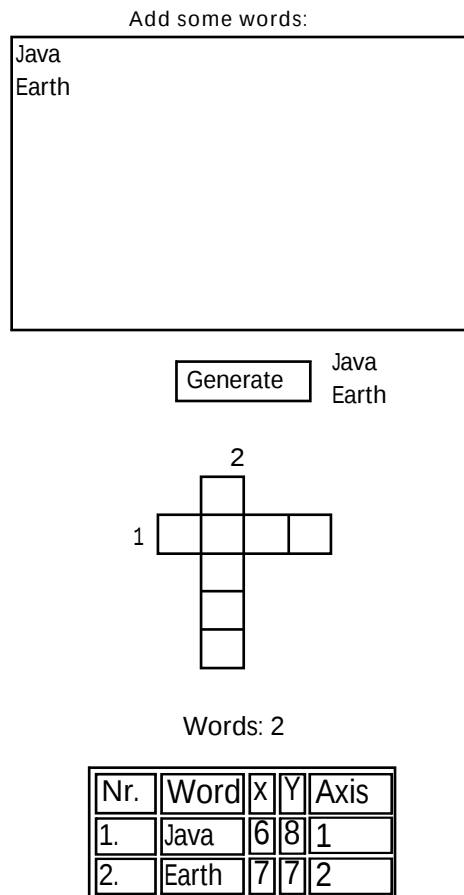


Figure 3: Generating Crossword from Provided Words

Research Design

The pretest-posttest design was used in this investigation. In the framework of this design, two experimental groups were used: experimental group 1 and experimental group 2. Where the groups are further subdivided as follows:

- i. Pretest for experimental group 1,
- ii. Posttest for experimental group 1;
- iii. Pretest for experimental group 2,
- iv. Posttest for experimental group 2.
- v. Treatment for experimental group 1;
- vi. Treatment for experimental group 2.

This research was conducted in the Iwo Local Government Area of Osun State, Nigeria. The study's population included 1440 Senior Secondary School One (SS1) students from the sixteen public secondary schools in Iwo Local Government Area. The study included 156 scientific students from two public high schools. The two (2) secondary schools were chosen using a simple random sampling procedure from among the 14 public secondary schools in the study area. In each of the selected schools, one intact class was assigned to experimental group 1 and the other intact class was assigned to experimental group 2.

The instrument utilized for data collection was the STEM Science Achievement Test (SSAT), which was validated by specialists in STEM fields. A reliability coefficient of 0.72 for the Kuder- Richardson Formula 20 (KR) was created. This study gathered both quantitative and qualitative data. Before beginning, demographic information about the students was acquired. They would have to complete a pre- and post-test before and after the lesson to assess their progress in learning STEM subjects. The lecturer would lead the students through the game activity in small groups. On the observation form, each subgroup was allocated a trained research assistant who would keep track of how the players interacted with the game. Participants were also given a questionnaire with a five-point Likert scale (from 5 to 1: strongly agree, agree, neutral, disagree, strongly disagree) to answer questions about their attitudes towards learning in relation to scales for gauging students' endurance, engagement, and expectations.

While the lesson package for the experimental group II was based on traditional classroom teaching approach, the lesson plan for the experimental group I was created utilizing a crossword puzzle teaching strategy. Before treatment began, pretests were given to the two groups of students. While students in experimental group II were taught using a traditional teaching method, students in experimental group I were taught using a crossword puzzle teaching strategy for the concepts of biology, science, and physics. Students in the two groups received questionnaires as a post-test following the two-week therapy period. The two groups' Pretest and Posttest scripts were gathered, graded, and used for data analysis. The relevant descriptive statistics would be calculated using the SPSS 12.0 statistical package, and the pre-test, post-test, and questionnaire scores would be evaluated. An ANOVA was carried out to look for differences between the variables that were significant. The questionnaires would gather data on the respondents' perceptions of how the game would assist them in learning technical terms for various STEM fields. The mean and standard deviation were used to respond to the study questions, and the analysis of covariance (ANCOVA) was used to evaluate the hypotheses at the .05 level of significance.

Results

Research Question: How do the mean performance scores of science students who were taught the idea of STEM subjects through the developed crossword puzzles and classroom teaching methodologies differ?

Table 1: Mean and standard deviation of students' pretest post-test performance scores based on teaching strategies (N=156).

Teaching Strategies	N	Pretest Mean	SD	Pottest Mean	SD	Mean Gain Sources
Crossword Puzzle	79	6.6	3.6	15.3	3.0	8.7
Classroom Teaching	77	6.5	3.2	12.1	3.4	5.6

Table 1 showed that students taught the idea of vocabulary in science using crossword puzzle teaching strategy had mean gain performance scores (8.7) that were higher than the mean gain performance scores (5.6) of those taught using classroom teaching strategy. This suggests that students who were taught using the crossword puzzle teaching technique outperformed those who were taught using the classroom teaching strategy, ranking highly in their mean gain. As a result, using crossword puzzles as a teaching approach has been found to improve student performance on the idea of vocabulary in science disciplines.

Null Hypothesis: The mean performance ratings of students who learned STEM concepts using crossword puzzles and classroom teaching methods did not differ significantly.

Table 2: ANCOVA result on students' academic performance in STEM based on strategies of teaching (N = 156)

Source	Types III Sum of Squares	df	Mean Square	F	Sig.
Pretest	4300.346	1	4700.643	432.597	.000
Intercept	25.569	1	25.569	2.629	.108
Teaching Strategy	251.068	1	251.068	26.103	.000 ^s
Error	1075.743	99	10.866		
Total	20607.000	156			
Corrected Total	1354.837	103			

S = Significant @ $p < .05$

When comparing the mean performance scores of students taught the concept of vocabulary in the Science subject using crossword puzzle teaching strategy and those taught using classroom teaching strategy, the results of the covariance test analysis in Table 2 showed a significant difference in the performance null of the crossword puzzle teaching strategy; $F(1,103)=26.103$, $p0.05$. Therefore, the null hypothesis is

not accepted. This suggests that, when compared to students who were taught using classroom teaching approach, students' performance in the notion of vocabulary was greatly improved by the crossword puzzle teaching strategy. As a result, at the .05 level of significance, the mean difference that was previously detected is statistically significant.

Discussion of Findings

This study looked at how students' academic performance on the vocabulary in STEM subjects was affected by crossword puzzles and classroom teaching tactics. The results of this study showed a significant difference between students who were taught the notion of STEM subjects using the developed crossword puzzle and those who were taught utilizing classroom teaching methodologies to address research questions, data were analyzed using mean and standard deviation, and hypotheses were tested using Analysis of Covariance at the .05 level of significance. Students taught the notion of Biology, Chemistry, and Physics using crossword puzzle teaching approach outperformed those taught using traditional classroom teaching strategy with a mean gain performance score (5.6) to (8.7). Additionally, this study concentrated on three STEM subjects namely: Physics, Chemistry and Biology while involving several topics as against the work of , with an improvement in mean score.

Conclusion

As a result of the study's findings, it can be concluded that using crossword puzzles as a teaching tool has helped students perform better in class when learning STEM concepts. Given the benefits of this game and the significance of a larger scientific terms, STEM teachers may want to consider implementing this game in their language classes, especially as an extracurricular activity.

Recommendations

The following recommendations were made in light of the findings:

1. In order to improve STEM subject learning and boost students' performance in scientific classes, STEM subject teachers could employ crossword puzzles as a teaching approach.
2. STEM Teachers can help and motivate students to utilize crossword puzzles frequently to help them learn topics, especially those that are deemed abstract and challenging.

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