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Effect of Role-Play Teaching Method on Science Students' Interest in Teaching and Learning of Photosynthesis

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Abstract

The study used a quasi-experimental study design to evaluate the effect of a role-play teaching strategy on science students' interest in the teaching and learning of photosynthesis. The sample comprised third-year biology students of 3 intact classes totaling 157 at Ghana Senior High School, Koforidua. Sixty-three (63) of the students, 21 for each class, volunteered to participate in the role-play. The students answered a 5-point Likert scale questionnaire on whether the use of role-play for teaching and learning photosynthesis was an interesting experience. Chi-square in SPSS version 20 was used to analyze students' responses to a 5-point Likert scale questionnaire. Analysis of the association between the role-play teaching strategy and the students' interest indicated a significant association with a p-value of 0.00. To determine the strength of this association, a Phi and Cramer's V value of 0.422 was obtained, which indicates a moderate association between the role-play and interest.

Subject Areas

Educational Technology

Keywords

Role-Play, Teaching Method, Student Interest, Science Education, Science Learning, Photosynthesis

1. Introduction

1.1. Background

Science education is critical to a nation's growth, and, as a result, countries must prioritise education in their educational institutions [1]. Ref. [2] Ahmed (2008)

indicates that science, especially biology, is a prerequisite subject for many fields of learning that contribute immensely to the technological growth of a nation. The United Nations General Assembly's Agenda number 4 for Sustainable Development ensures inclusive and equitable quality education and promotes opportunities for lifelong learning [3]. The Ghana Education Service (GES) Senior High School Science Syllabus makes a conscious effort to equip students with relevant basic scientific knowledge and produce character-minded learners who can contribute to personal, national, and global development [4]. According to [5] Ansu-Kyeremeh, Casely-Hayford, Djambah, and Orivel (2002), since 1989, the government of Ghana and development partners such as the United States Agency for International Development (USAID), etc., have embarked on science and mathematics education initiatives and projects to improve the teaching of these subjects to improve student achievement. But after decades of reforms, there are still concerns that students' achievement in science and mathematics has not improved significantly to reflect the huge investment in basic education. Ref. [6]-[9] indicate that candidates performed woefully in topics including the process of photosynthesis. Other WASSCE Chief Examiners' Reports consistently comment on students' lack of understanding of basic concepts in science subjects. Ref. [10] [11] assert that students achieve poorly in biology. According to [12] and [13], factors contributing to low performance include the use of inappropriate teaching methods. Research findings show that most biology teachers are still struggling with how to effectively utilise some teaching methods and strategies identified as effective through research in biology education [14]. Ref. [13] indicates that the teacher is an important factor that generally influences students' achievement in science because teachers can use their occupational skills to manipulate all other factors and channel them toward enhancing students' participation, interest, and achievement in the subject. The majority of science teachers still adopt conventional teacher-centred methods in our senior high schools. Science taught in the classroom is detached from real-life situations, and therefore, students only obtain abstract concepts that do not motivate their interest. Research must be conducted to identify teaching strategies that will present content in a way that will enable students to conceptualise abstract science concepts more realistically. Evidence suggests superior student outcomes result from more experiential, rather than lecture-based, classes [15]. To trigger situational interest, much or less to maintain it toward an ultimate goal of individual interest, students must be in an environment that fosters and supports student interest [16]. A strong interest in science and technology influences students' involvement in scientific tasks [17] and studies, and consequently their engagement in developing a scientific and technological culture as well as pursuing career choices associated with these disciplines [18].

Over the past decades, societies have shown a growing need for individuals trained in science and technology, while the number of students attracted to it is stagnating and, in some cases, declining [19]. For example, the European Commission's report, "Does the EU need more STEM graduates" [20], estimates that

the need for high-qualification STEM jobs will generally increase throughout Europe by 2025. This gap, which many describe as students' loss of interest in Science and Technology (S&T), has been observed in many parts of the world, for example, in England [21], Germany [22], the United States [23], and in Canada [24]. Ref. [25] in a review on attitude toward S&T, noted that there is a greater need for research to identify those aspects of science teaching that make school science engaging for pupils. Other authors have also pointed out the need to develop research and tools that simultaneously consider a number of interest-related components [26]. In this context, developing students' interest in science, over and beyond the quality of learning, must be a priority for schools and academic research in education. The contribution of this study to the global need to develop science students' interest in the classroom and beyond is to investigate the effect of the role-play teaching method on science students' interest in the teaching and learning of photosynthesis in Ghana Senior High School, Koforidua, in the Eastern Region of Ghana.

The purpose of the study was to investigate how the use of role-play affects students' interest in the teaching and learning of photosynthesis at Ghana Senior High School, Koforidua.

1.2. Objective

To determine the influence role play on science students' interest in teaching and learning of photosynthesis.

1.3. Significance of the Study

The findings of the study may present role-play as an effective instructional method, and refine the teaching and learning of science to offer a better classroom experience for both teachers and students in Ghana Senior High School, Koforidua. The findings may provide relevant information to stakeholders in the formation of science education policies.

1.4. Delimitation

The study focused on third-year science students in Ghana Senior High School in the New Juaben North Municipality. and on photosynthesis as a topic. The study determined students' interest with the use of role-play in teaching and learning of photosynthesis.

1.5. Limitation

According [27], the application of role-playing is mostly challenged by the lack of availability of ample class time with students and limited access to resources. The study was limited by material constraints, inexperienced student role-players and fixed school settings. An intact class was used for the study and the role-play was designed to fit into the period allocated by the school for the lesson to avoid disruption of the schools' settings. The role players were given scripts for their role

to facilitate the smooth flow of the role playing.

2. Literature Review

2.1. Theoretical Framework

The study is based on Piaget's cognitive constructivism and Vygotsky's sociocultural constructivism. Constructivism has dominated and generated further investigations in the process of human learning. Piaget's cognitive constructivism and Vygotsky's socio-cultural constructivism are the most eminent among the many pioneer theorists studying constructivism. Both theorists acknowledged the active role of humans in the construction of knowledge but had different views on the process of knowledge construction. Piaget believes that knowledge is constructed in the learner's mind by the mental organisation of their experiences, while Vygotsky believes that knowledge is constructed through social and cultural interactions. Both theories emphasise active participation in the lesson through physical activities and mental engagement. The key assumption that differentiates constructivism from other theories of learning is that knowledge does not exist independently of the learner but is constructed.

According to [28], psychologists recognise multiple educational frameworks, such as Self-Determination Theory (SDT) and Social Cognitive Theory (SCT), in explaining interest. SDT describes how one is motivated to engage in a task based on three fundamental innate psychological needs: autonomy, competence, and relatedness [29]. These needs can influence how one develops values and sets goals. If a student has control over his/her learning experience (autonomy), he feels capable of completing a task (competence) and feels as though they are a part of their learning community (relatedness). SCT is based on the construct that what motivates individuals is more than just their internal drives but also how these internal drives interact with peers and the environment [30]. An SCT approach to interest provides more power to the instructor. There are opportunities for the instructor to design an environment that provides conditions favourable for fostering positive motivation through this feedback process, which can lead to developing and deepening interest. These interest frameworks usually acknowledge two different types of interest, namely situational and individual interest. These two types differ from each other in how much they affect knowledge and value, as well as the time duration of interest. Situational interest is viewed to be more affect-based and temporarily fleeting, whereas individual interest is considered to connect more with the individual's values and acquired knowledge on the subject and be more stable over time [31] [32]. Both of these forms of interest can be viewed as representing different analytical levels, where situational interest refers to the actual and ongoing process of engaging in activity, and individual interest is the relatively stable tendency to invest time and effort in the topic of interest [33]. According to [28], triggered situational interest differs from curiosity; triggered situational interest leads to a desire to know more, whereas curiosity, once satisfied, does not. They also asserted that as interest becomes more individually developed,

emotional reactions may not be as frequent but are still triggered occasionally to continue the desire to pursue and engage [28]. Interest is a blend of both affective and cognitive components that drives motivation and involves some form of interaction between the individual and the environment [34].

2.2. The Conceptual Framework

Figure 1 presents a student-centred classroom where learners are actively involved in the construction of knowledge rather than being passive listeners [35]. Such an environment, according to [36], creates a democratic classroom and prepares students for success in class, in the workplace, and in a globalised world. An activity-based classroom allows for student participation and interaction, and such a classroom environment motivates students' interest in learning.

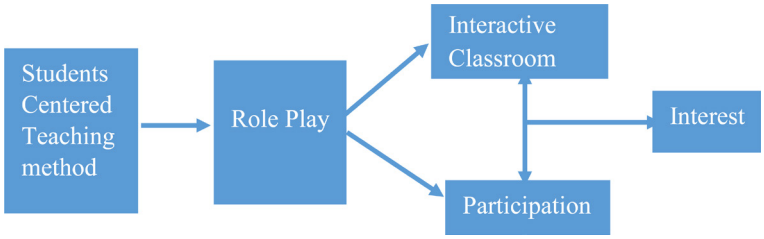

Figure 1. Conceptual framework of students-centered teaching.

2.3. Teaching Method

A teaching method comprises the principles and methods used for instruction. The choice of teaching method(s) depends largely on the information or skill that is being taught, and it may also be influenced by the aptitude and enthusiasm of the students [37]. Teaching objectives should reflect cognitive objectives, operational skill objectives, and socio-emotional objectives. The selection of teaching content and teaching methods should be appropriate for the teaching objectives and should be in line with students' ability to absorb and understand the material. The teacher should concentrate on the needs of each student and closely observe their reactions and expressions to adjust the plan in real-time if need be [38].

2.4. Lecture Method

The lecture method has been a primary pedagogical form throughout history [39]. Though often maligned, it remains a dominant method of teaching, both to younger and university-level students [40]. Over the past 50 years, many alternative learning activities have been developed, including active, experiential, and problem-based learning [41]. Evidence suggests superior student outcomes result from more experiential, rather than lecture-based, classes [15]. Student-centered teaching strategies focus on learning activities where students are actively involved in the process of learning. Research into student-centered instructional strategies will contribute significantly to improving teaching and learning.

2.5. Role-Play

Role-play is a group activity involving more than one person who assumes different roles in a given situation [42], to acquire learning experiences [43]. Role-playing as an active learning technique that involves a high level of participation from students [44]. Learning in role-playing is facilitated by observing as well as acting out the series of events happening in the respective situation. Role-play is an example of learning by doing [45].

Research on role-play's effectiveness and best practices exists as far back as the 1970s; recently, however, role-play has been touted as a tool better suited for the needs of today's college students than more traditional teaching methods [46]. Role-play is a pedagogy that has been used in a wide variety of contexts and content areas [42]. Though role-play has traditionally been used in educational settings with an emphasis on the social dynamic of learning and fostering collaboration among students, researchers have found role-play useful in getting students to better grasp practical cognitive skills as well [47]. Not only does it increase student engagement, but it also increases knowledge retention [44]. According to [48], role-play pedagogy is effective in reaching learning outcomes in three major learning domains: affective, cognitive, and behavioral [42]. Ref. [44] indicates that when students take the skills, they have learned in theory and put them into practice, this creates a deeper cognitive link to the material, making it easier for students to learn. Ref. [49] argues role-play's main contribution is to involve learners in a fun environment avoiding rivalry and competition among learners. One of the main challenges in the application of role-playing includes the lack of availability of ample class time with students and limited access to resources [27]. Ref. [50] suggests the following phases of role-play: 1) Setting the scene, 2) Acting out the role-playing, 3) Reflection and feedback and 4) Integration of new learning.

Several teaching strategies and instructional materials are used to meet the learning styles and needs of students. There is no ideal strategy that generates success in all learning situations, therefore, teachers should use appropriate strategies that satisfy student learning [51]. According to [52], role play is effective but may lose its effectiveness if used too often. The key to being an effective teacher is to use a variety of teaching methods.

2.6. Student Interest in Science Education

Ref. [53] and [54], both indicate that students' interests in science typically have little to do with what is typically taught within the classroom also known as school science; as a result, their interest in science tends to decline as they reach the ages of middle school and high school, where the science curriculum becomes much more restrictive with less exposure to content that supports interest. If student learning does not include content that supports development in interest, then it will not lead to continued interest. [55], indicates students' interest in learning science, technology, engineering, and mathematics (STEM) varies at different ages. Ref. [33], states the change in learners' interest mostly occurs during the

transition from elementary to secondary school. During that period, some students seem to start losing interest in investing effort into STEM learning. This decline in interest threatens the ability of nations to tackle science-related problems in the future. For example, the European Commission's report "Does the EU need more STEM graduates". Ref. [20] estimates that the need for high qualification STEM jobs will generally increase throughout Europe by 2025. This is expected to coincide with a diminishing number of low-qualification jobs due to increased digitalization and robotics. Interest in science is very important because according to [56], early interest in STEM careers has been found to predict student persistence in science and the choice of a science-related major in college. According to [57] interest is most commonly sustained when it is developed early, before middle school. Interest in science can be found to be stable in children as young as four [58]. According to [59]). Early experiences in the outdoors and informal learning experiences and field experiences can be powerful in developing students' interest and shaping their learning experiences.

2.7. Effect of Students' Interest on Learning

Positive relationships have been reported between interest and a wide range of learning indicators [60]. When allowed to pursue their interests, students participate more, stay involved for longer periods, and exhibit creative practices in science [61]. Interest has been found to facilitate and mediate effects on learning outcomes, and have a positive connection with other motivational factors such as mastery of goals [62], utility value [63], and self-efficacy [64]. Ref. [62], assert that pedagogical approaches have been developed to increase learners' interest in the studied topic, on the basis that making learning more engaging and enjoyable for the student, will increase their interest, and leads to better learning outcomes. However, the recent research literature has highlighted the fact that there exists an incongruence between the direct effects of interest in learning, and that the empirical findings are not as self-evident as previously suggested [65]. Despite a significant amount of empirical research existing on interest-enhancing practices in educational settings, a considerable portion of the studies reports only partial improvements. The lack of research on the directionality of the interest-learning relationship had already surfaced some years earlier. Ref. [33] indicates that individual interest may help students to remain situationally interested during learning situations, and according to the four-phase model, individual interest is more knowledge-based and less reliant on affective fluctuations. Contrary, [31] [32] found that the number of knowledge students had at the beginning of the experiment seemed to influence their interest in the topic, and the interest and knowledge acquisition did not affect each other reciprocally. Ref. [66] found that interest is significantly correlated with concentration but learning styles have no significant effect on both concentration and achievement; learning styles and interest do not yield interaction effects on the learning concentration of students, but interest alone significantly affects concentration and learning styles; and interest and con-

centration do not yield interaction effects on the academic achievement of students. To support student interest through pedagogical interventions, the learning environment may impact the development of interest as much as what the students bring into the classroom. To trigger situational interest, much or less to maintain it toward an ultimate goal of individual interest, students must be in an environment that fosters and supports student interest [16]. The key concept of works on student interest is to facilitate student learning in an engaging way that helps them to make connections between the content and their own goals [56], provides opportunities for students to be engaged with one another, and provides content that appropriately challenges them [34]. Knowing how to appropriately achieve a classroom with these components is where the expertise of the instructor plays a role. When engaging students in active-learning environments that are most conducive to facilitating situational interest, the teacher's role is critical in fostering interest through expertise in facilitating student learning through the use of scaffolding and appropriate support structures [16]. The greatest restriction on this development is that students enter the classroom with many prior experiences and goals, which can influence what they may find interesting. For example, there is strong evidence to support that there is a distinct difference between interest in science (content that is not necessarily structured within a specific curriculum, e.g., exploration of the outdoors or Science Olympiad type events) and an interest in school science [54]. So, the prior knowledge of a topic and personal values and experiences can influence interest development [28]. Cultural values may also impact what drives interest based on how a topic is valued [57], one's interpretation of the drivers of interest, affect, and cognition, is likely to change with age and context [56].

3. Methodology

The study adopted a quasi-experimental study. Ref. [67] indicates that, a quasi-experiment includes the non-random assignment of participants to the group because the experimenter cannot artificially create the group. In a school setting, non-random sampling is appropriate to avoid the disruption of a normal class lesson. Purposive sampling was used to select three intact general science classes made up of 157 students. According to [67] and [68], purposive sampling allows the researcher to choose participants because they possess characteristics required for the research study.

Within three weeks, the participants were subjected to teaching of photosynthesis using role-play according to a lesson plan (Appendix B). A pre-treatment conference was held to explain the objectives of the lesson to participants. According to [69], role-play activities should be tied to the learning objectives of the course to be aligned with the demands of the curriculum. The role play had 21 characters representing concepts in photosynthesis. A section of the participants in each class who volunteered to act as role-players (63 students; 21 for each class) were given role-play scripts. Each role-player represented a particular concept in

photosynthesis. The role-players were briefed on their roles as outlined in the script. They acted out the content of the lessons, guided by the role-play script, in front of the class (Appendix C). Five-point Likert scale questionnaire was given to the students immediately to solicit whether the use of role play in the teaching and learning of photosynthesis was an interesting experience (Appendix A). Students responded to the items by ticking Strongly Agree (SA), Agree (A), Uncertain (UN), Disagree (DA), or Strongly Disagree (SD). The researchers observed students during the lessons to determine their level of interest.

3.1. Validity and Reliability

Draft of the role-play script was triangulated and given to senior researchers for expert review to ensure content validity and face validity. Appropriate sampling techniques and data collection instruments and analyses were used for the study. According to [70], data validity might be improved through careful sampling, appropriate instrumentation, and appropriate statistical treatments of the data. The research objective was analysed using Chi-square in SPSS.

3.2. Results

In Table 1, those who participated, the expected counts were 49 strongly agree, 12.8 agree, 0.8 uncertain, and 0.4 disagree. The observed counts were 62 strongly agree, 0 agree, 1 uncertain, and 0 disagree. For those who did not participate, the expected counts were 73 strongly agree, 19.2 agree, 1.2 uncertain, and 0.6 disagree. The observed counts were 60 strongly agree, 32 agree, 1 uncertain, and 1 disagree.

In Table 2, A chi-square test was used to see if there was a significant link between role play and student interest. The results showed a p-value of 0.00, which is less than the 0.05 confidence level. Therefore, there is an association between the role-play teaching strategy and students' interest.

Table 1. Did you participate in the role play * It is interesting to us role-play in teaching and learning.

			It is interesting to us role-play in teaching and learning				Total
			Disagree	Uncertain	Agree	Strongly agree	
Did you participate in the role play	Yes	Count	0	1	0	62	63
		Expected count	0.4	0.8	12.8	49.0	63.0
		% within did you participate in the role-play	0.0%	1.6%	0.0%	98.4%	100.0%
	No	Count	1	1	32	60	94
		Expected count	0.6	1.2	19.2	73.0	94.0
		% within did you participate in the role-play	1.1%	1.1%	34.0%	63.8%	100.0%
Total		Count	1	2	32	122	157
		Expected count	1.0	2.0	32.0	122.0	157.0
		% within did you participate in the role-play	0.6%	1.3%	20.4%	77.7%	100.0%

Table 2. Chi-square tests.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-square	28.004[a]	3	0.000
Likelihood ratio	39.619	3	0.000
Linear-by-linear association	19.601	1	0.000
N of valid cases	157		

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is 0.40.

Analysis in Table 3 describes the degree of association between participation in role play and interest. The Phi and Cramer's V values of 0.422 indicate a moderate association between the role-play and student interest.

Table 3. Symmetric measures.

		Value	Approx. Sig.
Nominal by nominal	Phi	0.422	0.000
	Cramer's V	0.422	0.000
N of valid cases		157	

a. Not assuming the null hypothesis. b. Using the asymptotic standard error assuming the null hypothesis.

4. Discussion

According to [52], role play is effective but may lose its effectiveness if used too often. The key to being an effective teacher is to use a variety of teaching methods. There is no ideal strategy that generates success in all learning situations; therefore, teachers should use appropriate strategies that satisfy student learning [51]. Recent research has highlighted the fact that there exists incongruence between the direct effects of interest in learning and that the empirical findings are not as self-evident as previously suggested [65]. There is a distinct difference between interest in science and interest in school science [54]. Students interest in science tends to decline as they reach the ages of middle school and high school, where the science curriculum becomes much more restrictive. [53] and [54]. Students' prior experiences [28] and cultural values [57], drive interest based on how a topic is valued. These may underlie students' agreement, disagreement, or uncertainty about the influence of role play on student interest in this study.

Sixty-two out of the 63 students who participated agreed that role-play in teaching and learning is an interesting experience; however, 92 out of 94 students who watched but did not participate in the role-play also agreed that the use of role-play in teaching and learning was an interesting appearance. Ref. [49] asserts that role-play involves learners in a fun environment. The role-play in this study provided a fun and interactive classroom environment different from the traditional classroom environment. Ref. [71] asserts that if student learning does not include

content that supports the development of interest, then it will not lead to continued interest. Ref. [72] indicates that role-play increases students' motivation, stimulates students' eagerness to learn, and motivates students to be active in the learning process. Role-play is an active learning technique that conducts massive participation from students [44] [73].

Analysis of the association between the role-play activity and science students' interest indicated a significant association with a p-value of 0.00. To determine the strength of this association between role play and students' interest, a Phi and Cramer's V value of 0.422 was obtained, which indicates a moderate association between the role-play and interest. Role-play in this study provided a student-centred and activity-based learning experience, which put students in charge of their learning with the teacher serving as a scaffold. In such classrooms students have the opportunity to generate their learning.

4.1. Conclusions

There is a significant association between role play and student interest. The findings of this study indicated that role-play as a teaching strategy provides a viable experiential learning opportunity that considerably influences students interest in the teaching and learning of photosynthesis. Role play strategy allows students to take charge of the classroom activity in a fun environment. Thus, role play potentially provides a supportive learning environment that will enable the science student to develop 21st-century learning skills such as critical thinking, collaborative learning, creativity, and communication skills. The use of role-play will put teachers in a better position as agents and students as objects of global socioeconomic and technological transformation. The use of role-play will eventually bridge the gap between theory and practice and prepare students for lifelong learning.

4.2. Recommendations

Teachers support student interest by adopting interactive teaching strategies such as role play to promote comprehensive conceptual understanding in Ghana Senior High School. Stakeholders in science education should organise training programs for biology teachers on the effective use of role-play for teaching and learning. The Ministry of Education, Ghana Education Service (GES), National Council for Curriculum and Assessment (NaCCA), and other stakeholders associated with science education should introduce the use of role-play in the curriculum for teaching and learning science in Senior High Schools.

Conflicts of Interest

The authors declare no conflicts of interest.

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Appendices

Appendix A. Students' Perception of the Use of Role-Play in Teaching Photosynthesis at Ghana Senior High School Post-Treatment Questionnaire

This study is purposely meant for academic research work. Please, kindly answer the questions objectively. You are strongly assured of the confidentiality and anonymity of the information you provide. Thank you for your anticipated cooperation. Read each statement carefully and respond by ticking [√] the answer that most accurately represents your opinion.

Variable	Question	SD	D	U	A	SA
Student Interest	Using role-playing in teaching and learning of photosynthesis is an interesting experience.					

SA—strongly Agree, A—Agree, U—Undecided, D—Disagree, SD—Strongly disagree

Appendix B: Lesson Plan

Week 1	Topic: Photosynthesis	
	Sub-topic	**Content**
Day 1	**Lesson 1** Introduction to Photosynthesis	1. Definition of photosynthesis 2. Raw materials and products of photosynthesis, 3. Equation for photosynthesis 4. Importance of photosynthesis
Day 2	**Lesson 2** The biochemical nature of photosynthesis	1. Light-dependent stage • Formation of ADP • Formation of $NADPH_2$
Day 3	**Lesson 3** The biochemical nature of photosynthesis	1. Light-independent stage 2. CO_2 fixation/Carboxylation 3. Reduction 4. Regeneration

Appendix C: Photographs of Role-Play

Students acting in role play

Role play actors in group photograph