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# The Effects of Digital Media Instruction on Senior High School Students' Performance in Organic Chemistry Nomenclature

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## ABSTRACT

The objectives of the study were to determine the effect of digital media instruction on students' academic performance in expressing organic chemistry nomenclature and to assess its effect on the male and female experimental groups of students' performance in expressing organic chemistry nomenclature. The study adopted the non-equivalent quasi-experimental research design using the pre-test and post-test design. The sample consisted of 103 students, with 48 from Potsin Senior High School forming the control group, and 55 from Winneba Senior High School forming the experimental group, including 31 males and 24 females. A pre-test was administered to all the participants to determine their academic performance. During the study, the experimental group (Winnesec) received treatment through digital media, while the control group (Postin) was taught using traditional teaching methods. These teaching approaches were implemented over four weeks. After the treatment, a post-test was administered to both groups. The tests (pre-test and post-test) were analyzed using Microsoft Excel 2019. The results revealed that digital media was found to be more effective than the traditional method of teaching. Furthermore, results revealed that there was no differential effect of digital media on male and female students' performance in organic chemistry nomenclature.

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## 1. INTRODUCTION

Chemistry is one of the science subjects offered in the secondary school curriculum in Ghana. An analysis of the secondary school chemistry syllabus shows that students are required to master introductory concepts related to inorganic chemistry, physical, analytical, and organic chemistry all of which are tested at semester examinations. According to the syllabus, Organic Chemistry requires that students master concepts related to nomenclature, nature, properties, and uses of organic substances grouped in different families as well as those of their products. According to Sirhan (2007), organic chemistry plays a crucial role in the development of new compounds and in improving existing ones which are increasingly important for meeting the needs of humanity. This subject area is very important, not only to those who are interested in science-related careers but also to every individual living today and to future generations.

Chemistry curricula mostly integrate many abstract concepts most of which, though essential to further learning in both chemistry and other sciences, most students find difficult to comprehend (Sirhan, 2007). One of the essential characteristics of Chemistry is the constant interplay between the macroscopic and microscopic levels of thought and it is this aspect of Chemistry learning that represents a significant challenge to novices (Sirhan, 2007). Teachers also have challenges with pedagogical approaches for instruction which result in students' poor concept formation and, subsequently, poor performance in the subject area. The abstract nature of organic Chemistry along with other content-related learning difficulties means approaches that equip students with high-level skill sets be adopted. Likewise, Jaji (1994) posited that learning Chemistry should be student-centered, participatory, and problem-solving in approach.

In an attempt to be in tune with the current prevailing computer literacy era, the World Bank suggested in its report that science curriculum has to be taught through modern systems such as digital media so that learning can be enhanced and more curiosity and enthusiasm created in the students. Other researchers through their observations and research studies have called for the adoption of experiential-based teaching methods such as digital media instruction (DMI) as a way of enhancing universally-connected academic societies. Digital media generally incorporates photographs, videos, audio clips, animations, software and learning management systems (LMS) to be utilized via mobile devices, tablets, or computers (Heo, 2009; Melton & Burdette, 2011; Ungerer, 2016). Digital media platforms can help students link abstract representations of scientific phenomena cognitively. Digital media instruction (DMI) improves concept formation exponentially with students learning as much as 45% quicker and possessing better retentive memory leading to more positive interest and performance than colleagues who were taught through conventional methods of instruction. Digital media instruction platforms also strengthen the teaching of Chemistry generally (Ezeudu & Ezinwanne, 2013).

Chemistry appears to be taught in Ghana's Senior High Schools through lectures, note-taking, chalkboard illustrations, demonstrations, and other teacher-centered techniques. However, these teaching methods have not yielded the expected results. Students have continued to yield poor results in Chemistry year in and year out. Learning Chemistry poses a challenge to a majority of students, particularly in its sub-disciplines which include inorganic chemistry, organic chemistry, and physical chemistry. Several researchers have acknowledged that many students find mastery of topics related to Organic Chemistry to be difficult (Ryles, 1990; Schmidt, 1992). For Ghanaian students, WASSCE results analysis for Paper II in Chemistry in the last five years shows that questions testing Organic Chemistry concepts were among some of the most challenging for candidates at the end of the subject examination.

Having explored the potential of digital media instruction as a useful method, this research sought to determine whether it would help improve the academic performance of Chemistry students in expressing Organic Chemistry nomenclature.

The objectives of the study were to determine: (i) The effect of digital media instruction on students' academic performance in expressing Organic Chemistry nomenclature; and (ii)The differential effect of digital media instruction on the male and female experimental group of students' performance in expressing Organic Chemistry nomenclature.

The following research questions were addressed in the study: (i) What is the effect of digital media on students' performance in expressing organic chemistry nomenclature?; and (ii) What are the differential effects of digital media on the experimental group of male and female students' performance in expressing organic chemistry nomenclature?

The following null hypotheses HO were tested for statistical significance: (i) $H_O$ 1: There is no statistically significant difference in the academic performance of the experimental and control group of students before the treatment; (ii) $H_O$ 2: There is no statistically significant difference in the academic performance of the experimental and control group of students after the treatment; and (iii) $H_O$ 3: There is no statistically significant difference in the mean performance of the male and female experimental group of students.

## 2. LITERATURE REVIEW

### 2.1. Theoretical Framework of the Study

This study is based on Kolb's learning cycle theory. Kolb's (1976) theory describes the sequential stages of learning as knowledge, experience, and skills acquisition. This mode of learning is called 'experiential learning' or learning by practice and this is in line with constructivist learning. The sequential stages are watching, thinking, practicing, and feeling and these stages are linked to one another as follows: (i) Watching (reflective observation); (ii) Thinking (abstract conceptualization); (iii) Doing (active experimentation); and (iv) Feeling (concrete experience).

In Kolb's learning cycle, four stages of learning are identified. Students are exposed to new experiences. Furthermore, students must make time and space to reflect on their new experiences from a different point of view (Reflective observation).

Students can form, reform, and process their ideas, take ownership of them, and integrate their new ideas into sound logical theories (abstract conceptualization). Students need comprehension to make decisions, solve problems, and test their knowledge in new situations (active experimentation). These pedagogical processes, approaches, and activities catalyze the learning processes to the next round. (Concrete experience).

Students tend to differ in their abilities, approaches, and preferences to learning due to personality, cognitive processes, and prior learning experiences. This theory is perfectly linked to the present study, in that, for every student to draw, name an organic aliphatic compound, and also know the properties of the compound, he or she has to watch the compound to be drawn critically and think about it before drawing and naming is made. A good drawing and naming of organic structures will lead to a concrete experience.

### 2.2. IUPAC Nomenclature of Organic Compounds

Other systematic nomenclature systems came before the IUPAC system and IUPAC names may not be the most commonly used ones. Common names can be searched for with a dictionary-based approach and directly mapped to the corresponding structure at the same time. But IUPAC and IUPAC-like names are identified concerning the structure of the organic compound (Kolarik *et al*., 1999).

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In using the IUPAC nomenclature system to name and write structural formulae of organic compounds, the functional group (which is an atom or group of atoms largely responsible for the chemical behavior of organic compounds) of a compound is taken into consideration (see in HTTP://www.cerlabs.com/ experiments/1053447599X.pdf). For instance, all alkanoic acids and alkanols contain the carboxyl (–COOH) group and hydroxyl (–OH) group respectively bonded to carbon atoms. According to Skonieczy (2006), preference should always be given to a functional group that has the highest precedence when the organic molecule in question contains more than one functional group. The principal functional group is usually named as the suffix and the others as the prefixes.

Students' ability to translate the IUPAC name of an organic compound into its structural formula is the most important and most flexible as compared to the ability of Chemistry students to give the IUPAC name of any given structural formula. In any Chemistry examination, if students find it difficult to write a structural formula of any named compound, then they will also find it difficult to understand what the examiner is looking for. Hence, the performance of such students is affected by such questions.Though almost every organic compound contains carbon and hydrogen atoms, the names of these two elements do not appear directly in the names of the respective compounds. The IUPAC names of organic compounds are influenced partly by the number of carbon atoms in the longest continuous carbon chain.

### 2.3. Concept of Academic Performance

Academic performance is how students deal with their studies and the responsibilities given to them by their teachers. Louis (2012) indicated that academic performance is the ability of students to obtain high grades and standardized test scores in school subjects, especially subjects that are part of the core academic curriculum. Lavin gives an objective definition of the term academic performance as some method of stating or expressing a student's academic rank, generally, this is a grade for a particular subject area or an average for all subjects expressed on a 0-to-100 or another quantitative scale. The extent to which a worker or student contributes to achieving the goals of his or her institution. Academic performance as an expression used to present a student's scholastic standing and which is a function of various factors such as the method of teaching, teachers' qualifications, learner's home background, school environment, attitude, and interest among others.

The most current information on improving academic performance shows that there are three conditional influences linked to levels of academic performance among school pupils. These influences according to the information include high-quality parenting (the degree to which a young star is provided with an enriched, warm, and responsive learning and home environment), high-quality child-care environments (stimulating activity and nurturing as reflected in high-quality parenting), and high-quality first-grade classrooms (with a focus on literacy instruction, evaluative feedback, instructional conversation, and encouraging child responsibilities).

### 2.4. Digital Media

Digital media is a set of technological formats that can either be produced or consumed (Koc & Barut, 2016). Using digital media generally incorporates photographs, videos, audio clips, animations, software and learning management systems (LMS) to be utilized via mobile devices, tablets, or computers (Heo, 2009; Melton & Burdette, 2011; Ungerer, 2016). Digital media has been found to enhance stronger learner engagement (Reynolds, 2016). These technologies are encouraged to be used in educational settings by ISTE (2017), which remains

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the standard in technology-based teaching and learning best practices in the United States (Baek *et al*., 2018).

As generations grow up with digital media in both leisure and academic environments, competency skills and educational standards are increasingly affecting how teachers teach and students learn (Casey *et al*., 2017; Tiernan, 2015). Students are also expected to implement digital media in their learning experience through critical thinking and the use of contemporary technologies. It is important to acknowledge that both learners and teachers will continuously be digital natives (Bodsworth & Goodyear, 2017; Kretschmann, 2015).

However, more could be understood about digital media as a pedagogical tool used between students and teachers in physical science settings (Bodsworth & Goodyear, 2017; Casey *et al*., 2017; Stapleton *et al*., 2017). Digital media can be implemented in a combination of formats with a variety of uses. The major digital media formats that were found in the relevant literature and could be applied to Organic Chemistry included but were not limited to the use of video, audio, learning management system usage as well as social media and virtual worlds.

Audio has also been used to record lessons for students to listen to (Gross *et al*., 2017) and could be used to verbally share and create information. The audio could also be within videos which might require a planned script with intended content and outcomes (Weir & Connor, 2009).

The use of learning management systems could be a repository for video, audio, photographs, and text information used to communicate between teachers and learners. Learning management systems are consistently encouraged to be utilized by educators and students which could incorporate other digital media formats as accessibility remains increasingly popular and ever-evolving with personal devices (Cochrane *et al*., 2014; Melton *et al*., 2015; Reynolds, 2016; Stapleton *et al*., 2017; Melchor-Couto, 2019). Physical science subjects have increasingly taken advantage of LMS by incorporating online and hybrid courses for students (Goldstein *et al*., 2017; Stapleton *et al*., 2017). It was important to develop proficiency via training that could be completed either online or in person (Brock *et al*., 2018). Other digital media include social media, augmented reality, and virtual worlds such as chatrooms or video games (Guse *et al*., 2012; Melchor-Couto, 2019). The described digital media formats provide the foundational continuum of pedagogical practices that could be adopted within physical science.

However, it is important to recognize that implementing digital media is not a one-size-fits-all adoption plan, particularly among students (Loizzo *et al*., 2017). Although this study focused more on pedagogical practices, it was essential to highlight students learning aspects and foundations regarding digital media. Therefore, the remaining sections discuss digital media involvement in student learning and pedagogical practices. Considered to be digital natives, younger generations are immersed in a digitally-bound educational environment (Bodsworth & Goodyear, 2017). Using devices such as iPads or mobile phones and their respective apps, digital natives are highly accustomed to learning from digital devices (Bodsworth & Goodyear, 2017). Digital resources such as educational websites, tutorial videos, and mobile apps provide students with the opportunity to learn by constructing personal inquiries with social experiences (Reynolds, 2016).

Digital media is just one example of a learning-by-doing approach. A learning-by-doing approach could include students actively researching information, communicating through discussions among peers and stakeholders, and most importantly, the use of whatever sort of digital media is implemented. However, creating environments that promote critical thinking and effective learning depends on the teacher and their administrative practices.

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Applying digital media technologies in an educational environment is becoming more affordable for pre-tertiaries and tertiaries (Stapleton *et al*., 2017). With teachers integrating a variety of multimedia (e.g., videos, podcasts), mobile apps, or the use of LMS, digital media is considered an essential practice among secondary schools (Lim *et al*., 2009; Melton *et al*., 2015). Institutions that utilize LMS in subjects allow both the teacher and the students to cross-reference work and promote improved teaching and learning experiences that might not have been communicated otherwise (Melton *et al*., 2015; Reynolds, 2016; Stapleton *et al*., 2017).

The possibility of incorporating an LMS as a backup resource or a primary resource gives teachers and students open possibilities to utilize digital media technologies (Campbell & Cox, 2018). Pedagogical practices will only continue to grow as digital natives embrace digital media (Tiernan, 2015). The implementation of digital media as a pedagogical practice promotes the transition from a teacher-centered approach to a student-centered learning environment. This approach is considered the best practice for enhancing student performance and developing cognitive skills in a particular subject area. (ISTE, 2017; Kretschmann, 2015; Stapleton *et al*., 2017).

Furthermore, discussions about digital media instruction in Organic Chemistry are growing in both empirical and practical literature. Existing literature showed an increase in additional digital media formats in a variety of chemistry-related fields. Digital media implementation also continues to be examined and discussed within the academic community (Goldstein *et al*., 2017; Lim *et al*., 2009; Melton *et al*., 2015) Recent research explored the use of online and mobile software within the academic community (Goldstein *et al*., 2017; Melton *et al*., 2015). For example, Melton *et al*. (2015) evaluated the effectiveness of using educational software to increase student motivation, social support, self-efficacy, and enjoyment in classroom learning. Quantitatively, the study found a significant difference between the treatment and control groups resulting in software-based teaching and learning with higher self-efficacy and peer support. Qualitative findings showed that students valued the learning process as it gave them control of their performance and feedback.

## 3. METHODS

The study adopted a quantitative research approach and a non-equivalent pre-test post-test quasi-experimental research design. The population of the study was all senior high schools in the Central Region. However, the target population was all Elective Chemistry students in senior high schools in the Central Region. The accessible population where Elective Chemistry students of Potsin Senior High School and Winneba Secondary School because these schools were closer to the researchers. Forty-eight (48) Form 3 science students of Potsin Senior High School and fifty-five (55), comprising 31 males and 24 female Form 3 Science students of Winneba Senior High School were selected on purpose as the sample for the study. Form three students were considered for this study because having had a longer period of exposure to secondary school life, hence, they were better placed to provide more concrete information required for this study. More importantly, the topic selected for this study is offered in Form Three having had the introduction to organic compounds in Form Two.

The research instruments that were used in the study for data collection were an Organic Chemistry Achievement Test (OCAT) pre-test and an OCAT post-test. The two tests consisted of twenty multiple choice and ten short structured questions of the Chemistry Paper II type each. Both tests were collected and marked after administration and scored out of 100 marks. A trial test was conducted in a mixed secondary school (Uncle Rich SHS) which was

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purposively selected because it provided the researchers with the categories of the targeted population in one sitting (has both boys' and girls' students).

The collection of data for this study took place between March and May 2022. These dates correspond with the first and second term of the school year which was chosen because the topic used in the study is usually taught during those dates. The researchers administered the DMI lessons using Chemistry class teachers. Therefore, during this initial period, the researchers met teachers and held discussions with them on DMI and how such lessons could be planned and executed. The researchers, together with the teachers then prepared the DMI lessons. At the same time, the researchers with the help of the respective school's IT technician inspected and installed the DMI-supported lesson programs in the desktops and laptops for use later in schools sampled for DMI lessons. Phase two involved the administration of the pre-test instrument to the students which took place in the first week of April 2022. The sampled students were pre-tested on several topics including organic compounds, hydrocarbons, functional groups as well as IUPAC nomenclature. Phase three involved teaching the experimental group with DMI and the control group with the conventional method. The researchers ensured that both control and experimental groups covered the topic within the stipulated time by providing the teachers with a common time plan (four weeks). Finally, the last phase found the researchers administering the post-test OCAT instrument to the students and this took place at the end of the four weeks treatment duration.

Microsoft Excel (version 2019) was utilized to analyze the data collected. Z-tests were employed to validate whether or not there was a significant difference between students' scores on the pre and post-treatment tests. Where necessary measures of central tendency (i.e., mean, mode, and median) were used to analyze the data.

## 4. RESULTS AND DISCUSSION

The analyzed data used to answer the formulated research questions are now presented in the same order as the research questions.

### 4.1 Research question 1: What is the effect of digital media on students' academic performance in expressing Organic Chemistry nomenclature?

The null hypothesis associated with this research question is tested in **Table 1**. Table 1 shows the results of the pre-test scores from the experimental and control group.

**Table 1**. Difference in the academic performance of the experimental and control groups of students before the treatment.

| Groups | Number of students | Mean (Max =100) | Mean Diff. | P-Value | Remarks |
|---|---|---|---|---|---|
| Experimental | 55 | 37.93 | | | |
| Control | 48 | 38.02 | 0.09 | 0.483 | Not significant |

P > 0.05 = Not Significant, P< 0.05 = Significant

**Table 1** shows the results of the pre-test scores from the experimental and control group. The mean values of 37.93 and 38.02 of the experimental and control group respectively indicated that a lot of students' scores centered around 38.00 and this confirms that students' academic performance in Organic Chemistry nomenclature is very low. A mean difference of 0.09 was obtained. Generally, the poor performance in the subject has been attributed to, among other factors, students' attitude towards Chemistry, teachers' attitude towards

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students' abilities in Chemistry inadequate teaching and learning resources, and poor pedagogical practices (Sirhan, 2007).

To determine if there is a statistically significant difference between the pretest scores of the experimental and control group of students, a Z-test was used and the results are presented in **Table 1**. From **Table 1**, there is no statistically significant difference between the pre-test scores of the control and experimental group as a p-value of 0.483 was obtained which is greater than the significant alpha value (0.05). This means that the academic performance levels of the control and experimental groups of students are of the same level, therefore, hypothesis Ho1 cannot be rejected but should be accepted.

**Table 2** shows the results of the post-test scores from the experimental and control group.

**Table 2**. Difference in the academic performance of the experimental and control group of students after the treatment.

| Groups | Number of students | Mean (Max =100) | Mean Difference | Standard deviation | P-Value | Effect size | Remarks |
|---|---|---|---|---|---|---|---|
| Experimental | 55 | 52.86 | 7.78 | 12.91 | 0.00035 | 0.67 | Significant |
| Control | 48 | 45.08 | | 10.34 | | | |

P > 0.05 = Not Significant, P< 0.05 = Significant

The experimental group obtained a mean score of 52.86 while the control group obtained a mean score of 45.08. The mean scores of both groups increased, especially the experimental group after the treatment. The mean difference between the two groups was 7.78. The standard deviation of the experimental group is 12.91 and the control was 10.34. The Z test was used to determine the statistically significant difference between the post-test scores of the experimental and control group and a p-value of 0.00035 which is lower than the significance level alpha (0.05) was obtained.

With this result, one should reject the null hypothesis Ho2. From Table 2, an effect size of 0.67 was obtained indicating that digital media has a medium effect on students' academic performance in Organic Chemistry nomenclature. Hence, digital media has proven to have a positive effect on students' academic performance in Organic Chemistry nomenclature and improved their level of understanding as well.

This is in line with the findings of ImpaCT2 (2001) which revealed that teachers in schools where students were taught English using digital media platforms obtained higher mean scores for their students which was attributed to the fact that the use of digital media platforms in teaching and learning has a positive effect on attitude, interest, interaction and problem-solving skills that enable students to learn more independently.

The results also agree with the findings of Emron and Dhindsa (2010), which showed that the integration of interactive whiteboard technology significantly enhanced secondary school science instruction. Yusuf and Afolabi (2010) in a study on the effect of digital media instruction (DMI) on secondary school students' performance in Biology confirmed that the performance of students exposed to digital media instruction either individually or collectively was better than their colleagues exposed to the conventional classroom teaching and learning approaches. Siddiqui and Khatoon (2013) maintain that digital media instruction and its various modes can support new inquiry-based approaches to science instruction and field learning experiences. Digital media instruction platforms allow students to visualize and explore scientific phenomena. Digital media instruction platforms also strengthen the teaching of Chemistry generally (Ezeudu & Ezinwanne, 2013).

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Henriques (2002) maintains that the use of digital media improves learning of the subject and creates an interactive learning atmosphere resulting in students' improved performance, a proposition buttressed by Akcay *et al*. (2006) as well as Ezeudu and Ezinwanne (2013). Other benefits include increased attendance, motivation, interest, and cooperation among students. Bhukuvhani *et al*. (2011) citing Funkhouser (1993) reported significantly higher test scores for students who used digital media-related instructional platforms than students who did not mean that the learning platforms or tools also affected their problem-solving skills or abilities.

### 4.2 Research question 2: What are the differential effects of digital media on male and female experimental group students' academic performance in expressing Organic Chemistry nomenclature?

**Table 3** presents results on the male and female experimental groups of student's academic performance in Organic Chemistry nomenclature.

**Table 3** shows the results of the post-test scores of the male and female students of the experimental group. The male students obtained a mean score of 52.81 while the female students obtained a mean score of 52.92. The mean difference between the two groups is 0.11. The standard deviation of the male group is 14.22 and the female is 11.30. Z-test was used to determine the statistically significant difference between the post-test scores of the male and female students of the experimental group and a p-value of 0.487 which is greater than the significance level alpha (0.05) was obtained so one should accept the null hypothesis Ho3, as there is no statistically significant difference between the mean post-test scores of the male and female experimental group of students. Again, a negligible effect size of value 0.0086 was obtained which is too small, reaffirming that there is no significant difference between the two groups. From the result of Table 3, there is no differential effect of digital media on male and female students' academic performance in Organic Chemistry nomenclature.

The findings in **Table 3**, which indicated that students' academic performance is unaffected by their gender, regardless of whether they are male or female, and also there was no statistically significant gender difference in the academic performance of students in Chemistry. On the other hand, female students performed better than their male counterparts in the experimental group (that is when they were both taught with DMI). Females achieve better than males.

**Table 3.** Differential effects of digital media on the male and female students' academic performance in expressing Organic Chemistry nomenclature.

| Experimental Group | Number of students | Mean (Max= 100) | Mean Difference | Standard deviation | P-Value | Effect size | Remarks |
|---|---|---|---|---|---|---|---|
| Male | 31 | 52.81 | 0.11 | 14.22 | 0.487 | 0.0086 | Not significant |
| Female | 24 | 52.92 | | 11.30 | | | |

P > 0.05 = Not Significant, P< 0.05 = Significant

## 5. CONCLUSION

Based on the findings of this study, digital media has a positive effect on students' conceptual understanding, improves their academic performance, encourages their

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participation, and increases creativity during teaching and learning. Also, digital media is not gender biased according to the findings from the study and students have a positive view of this form of instruction. Based on the findings from this study, the following recommendations were made: (i) Chemistry teachers in Ghana should place students at the center of the teaching and learning process to enable them to be actively involved in the lessons; (ii) Science teachers, especially, Chemistry teachers in Ghana should adopt the DMI approach instead of the conventional teaching approach in teaching Chemistry concepts.; (iii) All science teachers in Ghana should be given special training in the effective utilization of computers and other technologies in teaching learning Chemistry concepts; (iv) Regular in-service training should be organized for Chemistry teachers in Ghana to update their knowledge on the importance of varying their instructional methodologies to produce positive results; and (v) Schools in Ghana should take the initiative to provide ICT tools and devices needed to implement the Digital media instructional approaches.

Prompt feedback should also as much as possible be given to science students in Ghana after every work done to enable them to know their strengths and weaknesses and work on them appropriately.

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## 7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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