



TEACHING AND LEARNING OF PROTEIN SYNTHESIS THROUGH THE USE OF MULTIPLE-BLENDED INSTRUCTIONAL METHODS

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ABSTRACT

This study was an inquiry into the productivity of 'eclectic blend' of novel instructions with the default traditional biology instructional approach. The novel instructional approaches used were Computer-Assisted Instruction (CAI) and Concept Mapping Instruction. The topic, 'Protein Synthesis' was taught using the Multiple Blended Instructional Approach (MBIA). The objective was to find out whether the type and number of instructional approaches employed in the blend influence students' achievement. A quasi-experimental design involving four biology classes designated as A, B, C and D with a total sample size of 104 was employed. Class A was taught using only the traditional instructional approach. Class B was exposed to a blend of traditional instructions and concept mapping instruction only. Class C was also exposed to a blend of traditional instructions and CAI only. Class D on the other hand, was taught using all the three instructional approaches. Data gathered for the pre- and post-tests were statistically analyzed using SPSS Version 16.0, and that yielded Cronbach's Reliability Coefficient Values of 0.71 and 0.80 respectively. The effect size (ES) of the blend of traditional instruction and concept mapping instruction only was also found to be 0.95; that of traditional instructions and CAI only was 0.96, while the blend of all the three instructional approaches yielded an effect size of 1.43. These results implied that when more instructional approaches are blended in a teaching/learning process, students achieve better, and that the choice of constituent instructional approaches for the blending process also has some influence on achievement.

KEYWORDS: Multiple Blended Approach, Traditional Instructional Approach, Concept Mapping, Computer-Assisted Instruction

INTRODUCTION

Protein synthesis has been recognised as one of the most challenging topics in biology since the introduction of the Senior High School (SHS) programme in Ghana. Meyer and Powers (1994) also expressed similar sentiments, when they asserted that protein synthesis is one of the most abstract concepts for biology students to comprehend. According to Saraiya, North and Duca (2005) understanding biological processes such as protein-synthesis and photosynthesis demands complex visualisation and imagination, especially when one wants to facilitate the exploratory analysis of such complex pathways. Therefore, the use of multiple instructional strategies in the teaching and learning process is one of the approaches that many people have advocated for (Epstein & Mac Iver, 1992; Cawelti, 1995; Russell, 1997). Each young adolescent is unique, with a particular cultural, experiential and personal background and a distinctive array of learning styles, interests, talents and skills. In the case of science in particular, understanding the variety of learning styles that students bring to a science classroom will not only help some students learn more science, but also help more students to learn any science (Tanner & Allen, 2004). No single teaching method will work for every student; in fact, no single method will work for any one student every day. In the light of this, Tomlinson (1999) opined that teaching should enhance and accommodate diverse skills, interests, abilities and talents. Teachers should pay attention to learning styles (Dunn & Dunn, 1987) and build on multiple intelligences (Gardner, 1983; Gardner & Hatch, 1989; Armstrong, 1994).

Tomlinson (1999) explained that teachers who seek to adapt teaching to students, instead of trying to adapt students to teaching should consider attending to student differences (experiences, culture, gender, prior knowledge); modifying content, process and products because of students' varying points of readiness, interests and learning profiles for their continued growth; and balancing group and individual norms, helping each student to be the best he or she can possibly be. For the past three decades, there has been a classical debate in the field of learning styles: the debate over the so-called "matching hypothesis" (Zhang, Sternberg, Rayner, 2012). The adjustment of instructional strategies according to the students' learning styles enhances the academic achievement (Arthurs, 2007; Rogers, 2009; Tulbure, 2010). From all these ideas cited above, there seems to be great advocacy for the use of multiple instructional strategies. John Hattie of Auckland University synthesised many meta-analyses on all categories of educational researches, and discovered that varying teaching strategy greatly augment students' performance by a reasonable degree. After analysing the results of 5667 studies, he had an aggregate effect size of 0.6 for varying instructional strategy (Hattie, 2008). According to Cohen (1992), an effect size of 0.5 and above may be considered medium to large. This supports the call of Tomlinson (1999) that teaching should enhance and accommodate diverse skills, interests, abilities and talents. In accordance with this, Nelson and Cammarata (1996) suggest that, rather than adopting single strategy solutions in the teaching/learning situations, teachers need to search for tricky mixes of

instructional strategies that address the unique learning needs of students. Though Nelson was specifically referring to the teaching of disabled students, his idea is equally necessary for the regular learning situation also.

The nature of the topic, the learning environment, the skillfulness of the teacher, the level of the students, etc, are all factors which come into play when considering which instructional approach to use. Of course, assessing all these factors should definitely give the instructor a mixed feeling as to the logic in using any single instructional approach. In the case of the present educational situation in many African countries which is characterised by large heterogeneous (in term of student ability) classes, individual differences particularly frustrate the effectiveness of any single strategic instructional approach. Within a learning context, differences can be found in the areas of general skills, aptitudes, information processing and application of information to new situations (Johnson & Aragon, 2002). In addition, all learners differ in their ability to perform various education-based and real-world learning tasks. Consequently, the general abilities or preferences of the learner will affect his or her ability to accomplish different learning outcomes. Individual differences specific to learning and instruction can be found within intelligence, cognitive controls, cognitive styles, learning styles, personality types and prior knowledge (Jonassen & Grabowski, 1993). In reality therefore, as Rusbult (2012) declares, usually there are diminishing returns for each type of instructional approach. In order for most of the relevant influencing factors to be addressed, in the teaching/learning situation, it should be prudent mixing instructional approaches. Michigan Department of Education Office of School Improvement (2012) states that multiple instructional strategies are necessary because of the following reasons:

- i. Students learn differently, and different strategies speak to different learners.
- ii. Teachers teach differently, and finding what works for you is part of what makes any strategy work.
- iii. Learning is an active process, and requires teachers to make on-the-spot decisions from a rich repertoire of choices.
- iv. Transfer and retention are enhanced when multiple strategies are used in learning.
- v. Multiple thinking skills are promoted when strategies are varied.

As Lahey (2008) put it, the teacher has to teach each student in his or her classroom as well as engage each student in the classroom and help them learn to the best of their ability. Lahey also emphasised that, to do this the teacher will have to use different strategies in his/her classroom and that since each student will have different abilities, strengths and weaknesses, he/she will equally have to address the different abilities that students in the classroom have. She concluded by stating that all these can only be achieved by using different strategies.

From the above reasons, this investigation is necessitated to find out the use of Multiple- blended Instructional Approach in the teaching and learning of protein synthesis.

Research Question

The following research questions were used for the study:

1. “Does the use of multiple-instructional approaches influence students’ achievement in the topic ‘Protein Synthesis’ at the SHS level?”
2. “Is there any relationship between the number of instructional approaches blended in the teaching process, and the achievement of the students in the topic ‘Protein Synthesis’ at the SHS level?”

METHODOLOGY

The study employed the quasi-experimental research design, a type described by some authorities as a ‘compromised experimental design’ because of its’ lack of randomization (Kerlinger, 1970). The target population was all third-year SHS elective biology students in the Upper West Region. The accessible population, however, comprised the 2011/2012 third-year elective biology students in the Jirapa Districts. The schools for the study were St. Francis Girls’ Senior High School and Jirapa Senior High School. A pre-test was conducted and four classes were used for the study. The sample was made up of four classes from the two selected schools with a total of 104 students. The selected classes which were designated A, B, C, and D had two of these selected classes (classes A and B) were from St. Francis Girls’ Senior High School, while the other two (classes C and D) were from Jirapa Senior High School. Selection of the schools was based on non-probability sampling technique because the population was assumed to be homogenous in character. Therefore, a non-probability selection in such case would not make any much difference. The four third-year intact biology classes used for the study were designated Groups A, B, C and D. The classes were used to avoid distortions of the academic activities in the participating schools. It was therefore, obvious that substantial academic differences would exist between the classes. This could adversely affect the credibility of the findings. As Campbell and Stanley (1963) explained, it would become predictably certain that the groups’ post-test scores would differ independent of any experimental treatment effect. Therefore, classes of comparable standards were used, and their comparability was established by means of pre-test scores which assessed students’ knowledge in basic biological concepts.

The treatments and exposures administered to the groups (classes) are described as:

Group A: Traditional Science Teaching Approach

Group ‘A’ had the fundamental control group treatment type. Only the traditional/ prevailing science instructional approaches were followed in the teaching of this group. This approach which some authorities often refer to as ‘the chalk and talk’ approach, employed chalkboard illustrative sketches of the models, and verbal descriptions of the processes.

Group B: A blend of Traditional Science Teaching Approach and Concept Mapping Instructional Approach

This group was also taught using concept mapping approach in addition to the traditional science teaching approach. This concept mapping also involved the use of some graphic organisers in which concepts (located in

nodes) are linked by lines which denote propositions or specify relationship between the concepts. The diagram below gives a simple illustration of concept mapping. The linkage arrows as illustrated in the diagram, point towards

the direction in which the linkage relation should be read. For instance, the relation enveloped by the ellipse labelled E, is read as “Nucleotides come together to form RNA”.

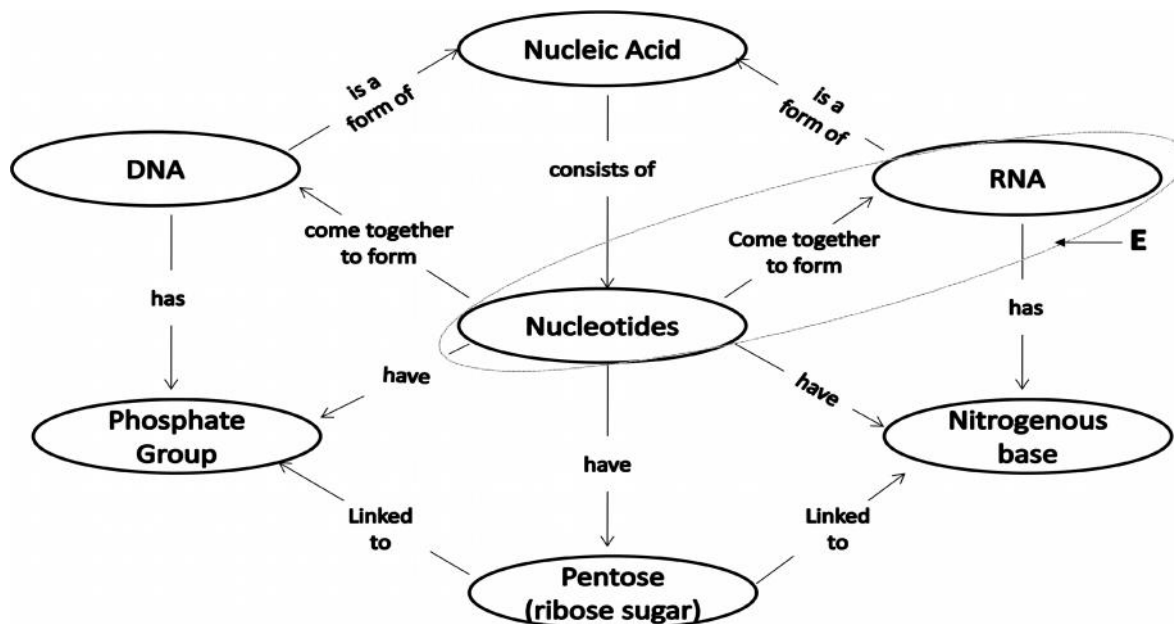


FIGURE 3: Teaching ‘Protein Synthesis’ Using Concept Map

Many of such “a diagram worth thousand words”, were blended with the traditional science teaching approach in teaching the topic ‘Protein Synthesis’ to this particular group.

Group C: A Blend of Traditional Science Teaching Approach and Computer-Assisted Instructional approach

This experimental group was instructed using both traditional science-teaching approach and CAI approach only. The instructional resources for this group included computers projectors, amplifiers and instructional software of various kinds as well as those mentioned above under the traditional science teaching approach. The exposures included the following:

- Verbal descriptions and explanations and chalkboard illustrations.
- Use of Microsoft power point (both customised and non-customised) to facilitate text presentation.
- Use of Microsoft power point presentation (both customised and non-customised) to present structural diagrams and models of the nucleotides, nitrogenous bases, DNA and RNA molecules, etc.
- The use of computer animations of diverse kinds along with narrations to show the processes of replication of DNA, transcription of RNA, translation (polypeptide chain formation), etc.
- The use of computer-based jingles, songs and dances to impress upon students understanding and memory of replications of DNA, transcription of RNA, translation, etc.

Validity of Instruments

Validity of both the pre-test and the post-test was assured by comparing the demands of the questions to the

demands of the biology syllabus. Also the items were given to some senior biology teachers in some SHS to examine them and to help correct any validity problem; be it content, construct, face validity, etc. The instruments were also pilot-tested and the items whose scores suggested validity problem were consequently reviewed before they were used for the actual data collection.

Reliability of Instruments

The internal consistencies of both the pre- and post-tests were also determined through the pilot-testing. Twenty (20) students of ‘Queen of Peace Senior High School’ were used in both cases. This school was chosen because it was outside the accessible population. Besides, there was homogeneity in characteristics between the accessible and the pilot school populations.

The reliabilities (internal consistencies) of the two tests were determined and the reliability co-efficients (Cronbach’s Alpha) were calculated using SPSS Version 16.0. The pre-test yielded an Alpha value of 0.71 while the post-test had 0.80. According to George and Mallery (2003) categorisation, the above values were good estimates.

Data Collecting Instruments

The instruments used for data collection were ‘tests’. Two tests, namely pre-test and post-test, were used.

i.Pre-test: This test was tagged ‘Students’ Knowledge in Basic Biological Concepts Test’ (SKBBCT). After the administration of the pre-test to all the biology classes in the selected schools, the mean scores of the classes were calculated. The classes with the closest mean scores were identified for use as the subjects for the study.

ii.Post-test: The post-test was also tagged ‘Students’ Achievement in Protein Synthesis Test’ (SAPST). Data

collected from the post-test were analysed to provide answers to the research questions and hypotheses.

Data Analysis

Data collected from the pre-test were analysed by simply comparing the mean scores of all the classes that took part and identifying the classes that had the closest mean scores. The four selected classes were assigned to the various treatments and exposures as already discussed under above.

The post-test data were processed using the 'Statistical Package for Social Sciences' (SPSS) software. By virtue of the fact that as many as four sets of performances were being compared, one-way ANOVA was employed in determining whether significant differences existed between the mean scores of the four classes. The outcome of this analysis was used to support inferences drawn from

the study. Effect sizes of the three treatment groups were also calculated as against the control group and presented accordingly.

RESULTS

Inferential statistical evidences needed for drawing conclusions have been provided. Again, tested hypotheses, interpreted results, as well as evidence-based answers to the research question have also been presented.

Pre-test of marks obtained by the students

The pre-test mean scores of the four classes obtained before introducing the interventions were compared. These were 'class A', 'class B', 'class C' and 'class D'. One-way analysis of variance (ANOVA) was used in the comparison process. The outcome of the analysis is displayed in Table 1.

TABLE 1: Analysis of Variance of Groups' (Classes') Pre-test Scores

Sources of Variation (Mark of the student)	Sum of Squares	Degree of Freedom	Mean Square	F-Ratio	Significance of F
Between Groups	39.808	3	13.269	0.264	0.851
Within Groups	5028.154	100	50.282		
Total	5067.962	103			

The value indicated in the Table 1 [$F(3,100) = 0.264, p < 0.851$] implies that there is no significant difference between the pre-test mean scores of the four classes.

Research Question One

"Does the use of multiple-instructional approaches influence students' achievement in the topic 'Protein Synthesis' at the SHS level?"

This question was answered using the findings from the statistical analysis of research hypothesis one (H_0 1), as well as computing the effect sizes of the various treatments. The hypothesis is stated below:

H_0 1: There is no significant difference between the mean scores of third-year SHS students who were taught the topic 'Protein Synthesis' using:

i. Traditional teaching approach only,

ii. Both traditional teaching approach and concept mapping approach only,

iii. Both traditional teaching approach and CAI only, and

iv. Traditional teaching approach, Concept mapping and CAI.

Analysis of Groups' Variance and Multiple Comparison Test

The post-test mean scores of the four classes obtained after the experimental teaching were compared. These were 'class A' (control group), 'class B', 'class C' and 'class D'. One-way analysis of variance (ANOVA) was used in the comparison process. The outcome of the analysis is displayed in Table 2.

TABLE 2: Analysis of Variance of Groups' (Classes') Post-test Scores

Sources of Variation (Mark of the student)	Sum of Squares	Degree of Freedom	Mean Square	F-Ratio	Significance of p
Between Groups	3689.413	3	1229.804	11.644	.000
Within Groups	10561.423	100	105.614		
Total	14250.837	103			

Table 2 revealed that significant difference exists in at least one of the mean scores of the third-year SHS students who were exposed to the four different levels of multiple-instructions on the topic 'Protein Synthesis', $F(3,100) = 11.644, p < 0.001$. This did not support the null (H_0 1), hence the null hypothesis was rejected.

A Tukey post-hoc test results as well as relevant descriptive statistics which were concurrently processed by the SPSS software along with the ANOVA revealed that the mean score of the students who were exposed to both traditional and concept mapping instructions was significantly higher, that of those exposed to both traditional and CAI only was also significantly higher, and

those exposed to traditional instructions, concept mapping instructions and CAI even had highest mean score, when compared to those exposed to traditional instruction only. On the other hand, the pre-test yielded mean scores of 57.7%; 58.4%; 56.8% and 57.1%, and post-test also yielded mean scores of 61.3%, 70.3%, 72.2% and 77.85% for classes A, B, C, and D respectively. However, there was no significant difference between students exposed to traditional and concept mapping only, and those exposed to traditional and computer-assisted instructions only, ($p = 0.916$). Neither was there any significant difference between mean scores of students that were exposed to traditional instruction and CAI only, and those exposed to

traditional instructions, concept mapping instructions and CAI, ($p = 0.196$). Table 3 & 4, and Figure 1 present the

summary of these findings.

TABLE 3: Tukey HSD Post Hoc Multiple Comparison of Significance of Groups' Mean Scores

Comparisons		Mean Difference	Std. Error	Sig.	95% Confidence Interval		Remark
					Lower Bound	Upper Bound	
Traditional Instruction Only	& Traditional Instruction and Concept Mapping Only	-9.0385*	2.8503	.011	-16.486	-1.591	H ₀ Rejected
Traditional Instruction Only	& Traditional Instruction and CAI Only	-10.8846*	2.8503	.001	-18.332	-3.437	H ₀ Rejected
Traditional Instruction Only	& Traditional Instruction, Concept Mapping, and CAI	-16.5769*	2.8503	.000	-24.024	-9.130	H ₀ Rejected
Traditional Instruction and Concept Mapping Only	& Traditional Instruction and CAI Only	-1.8462	2.8503	.916	-9.293	5.601	H ₀ Failed to be Rejected
Traditional Instruction and Concept Mapping Only	& Traditional Instruction, Concept Mapping, and CAI	-7.5385*	2.8503	.046	-14.986	-.091	H ₀ Rejected
Traditional Instruction and CAI Only	& Traditional Instruction, Concept Mapping, and CAI	-5.6923	2.8503	.196	-13.139	1.755	H ₀ Failed to be Rejected

*. The mean difference is significant at the 0.05 level.

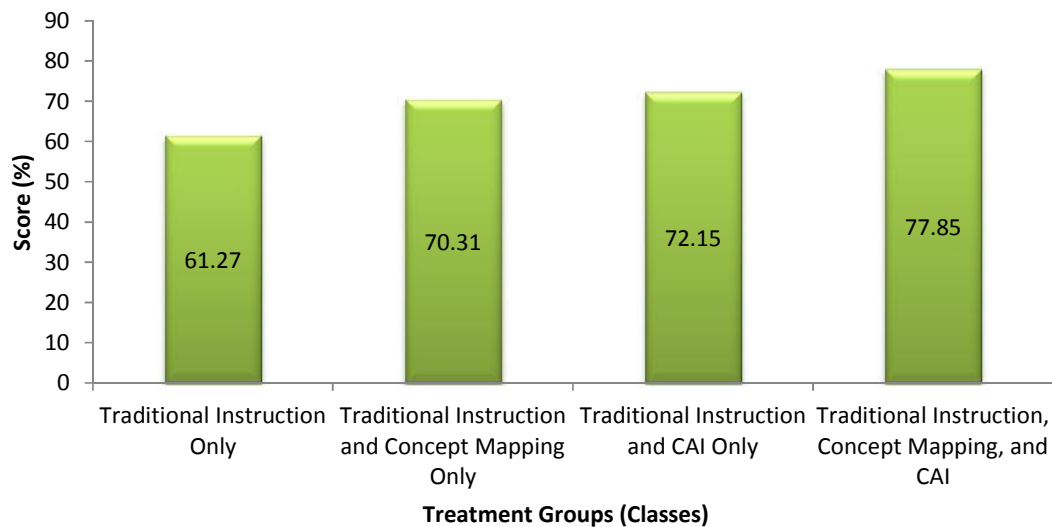


FIGURE 1: Mean Scores of the treatment groups

In the study, the group that was exposed to only the traditional instructional approach was the control group. Different ways of calculating effect sizes (ES) exist but one of the well known ES measure is the Standardised Mean Difference which is also called the Cohen's d or Cohen's g .

In essence, Cohen's g effect size is the difference between two means (e.g., treatment minus control) divided by the standard deviation of the two conditions. Cohen (1992) suggested that effect sizes around 0.20 are small, those around 0.50 are medium, and those around 0.80 and above are large. Such classification enables researchers to compare an experiment's effect-size results to known

benchmarks. Several formulae could be used depending on the statistical figures available. In the case of this study, the ES was calculated using the formula proposed by Hedges and Olkin (1985). From the calculation, it was realized that the ' g ' value for combining both traditional and concept mapping approaches only in the teaching process was 0.96 while the ' d ' value was 0.95; the ' g ' value for combining traditional instructions and CAI only was 0.97 while its corresponding d value was 0.95. The combination of traditional instruction, concept mapping and CAI also produced a ' g ' and a ' d ' value of 1.45 and 1.43 respectively. Table 4 gives these details.

TABLE 4: Effect Sizes of Treatment Groups

Treatment	Effect Size	
	G	D
1. Traditional Instruction and Concept Mapping Only	0.96	0.95
2. Traditional Instruction and CAI Only	0.97	0.96
3. Traditional Instruction, Concept Mapping and CAI	1.45	1.43

Research Question Two

“Is there any relationship between the number of instructional approaches blended in the teaching process, and the achievement of the students in the topic ‘Protein Synthesis’ at the SHS level?”

This question had corresponding null hypothesis (H_0 2) which stated thus:

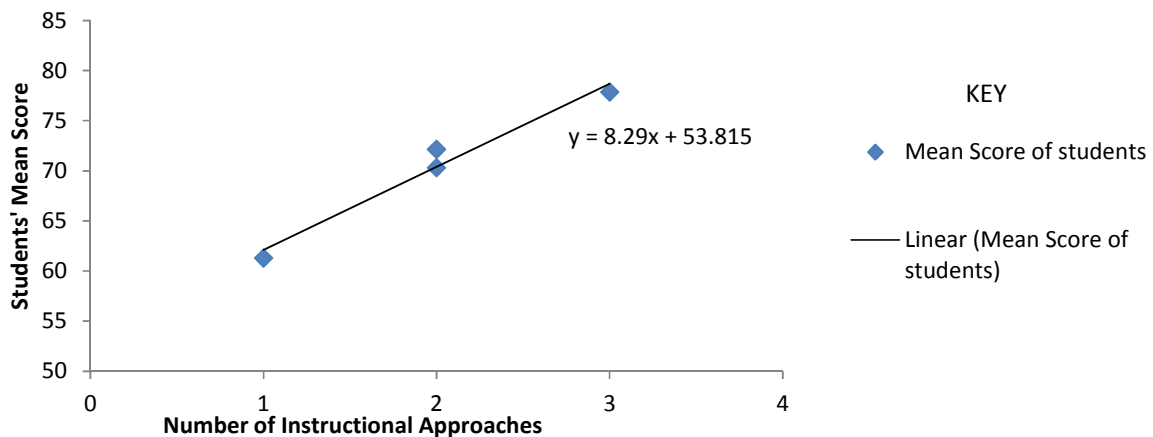
H_0 2: There is no significant correlation between the number of instructional approaches blended in the teaching process and the mean scores of students who were taught the topic ‘Protein Synthesis’ at the SHS level.

To test H_0 2, Pearson product-moment correlation coefficient (PPMCC) which is sometimes referred to as the Pearson Correlation Coefficient (PCC) or Pearson's r , was computed using the SPSS. The correlation test revealed a highly significant positive correlation between the number of instructional approaches used in the teaching process (Table 5). This rejected the null hypothesis (H_0 2) which claimed that there was no significant correlation between the number of instructional approaches blended and the achievement of the students (Fig. 2). The Table 4 and Fig. 2 presents the SPSS values of the PPMCC test and the graph respectively.

TABLE 5: Correlation between the Number of Instructional Approaches and the Achievement of the Students

		Number of Instructional Approaches Combined	Mean Score of Group
Number of Instructional Approaches Combined	Pearson Correlation	1	.984*
	Sig. (2-tailed)		.016
	N	4	4
Mean Score of Group	Pearson Correlation	.984*	1
	Sig. (2-tailed)	.016	
	N	4	4

*. Correlation is significant at the 0.05 level (2-tailed).

**FIGURE 2:** Number of Instructional Approaches and their Effect on Students' Mean Scores**DISCUSSION**

Findings of the study show that combining traditional instructional approach with concept mapping or CAI or both, has the capacity to augment students' achievement far more effectively than the use of any single one of such instructions. The mean score for the traditional instruction alone was 61.27; that of concept mapping and traditional instructions only was 70.31. Also, the mean score for

traditional instructions and CAI only was 72.15, while that for traditional instruction, concept mapping and CAI was 77.85. The last three approaches showed remarkable improvement over the mean score for the traditional instruction only, and this automatically gives a vivid picture of the positive effect of combining traditional instructions and other relevant instructional approaches. Interestingly however, not only did the means show this

overwhelming effectiveness of the integration process, but also the hypothesis test equally indicated real significance. Notwithstanding, the real evidence for contention is the unique 'hybrid vigour' demonstrated by the magnitudes of the effect sizes. What could be the reason?

From synthesis of meta-analysis, the effect size for CAI is 0.37 (Hattie, 2008), but by virtue of cross-fertilising the traditional instruction with the CAI the resultant effect size more than doubled (i.e. 0.96). That of concept mapping which is meta-analytically pegged at 0.57 also rose to 0.95. Integrating the three even gave an exceptional effective size value of 1.43. This is a phenomenon worth noting. The above discoveries justify the advocacy by Nelson and Cammarata (1996), Tomlinson (1999), Tanner and Allen (2004), and Rusbult (2012) that multiple instructional strategies should be used to enhance higher performance in heterogeneous classroom settings. This result also support the discovery articulated by Cotton (1997) that a blend of CAI and traditional instruction produces even better result than the use of CAI only.

Findings from the first research question indicates that blending or combining concept map instructions and/or CAI with traditional instruction enables students to perform exceptionally in such difficult subject areas as protein synthesis in biology. Findings also suggest that combining novel instructional approaches with traditional instruction has better chance of augmenting learning in students than the use of only the novel instructional approaches. By implication therefore, researchers should focus more on blending traditional instruction with new instructional approaches than attempting to discover hypothetical instructional approach that will not readily be accepted and used in place of the more time-tested traditional instruction.

CONCLUSION

This study was designed to test the efficacy of blending unconventional instructions with the traditional instruction, as well as finding out whether the use of multiple-instructional strategy has any advantage over the use of single instructional approaches. From the findings of the study, it was realised that blending traditional method with novel instruction is far more productive than the use of either the traditional alone or the novel instruction alone. The findings also confirmed that using multiple-instructional strategy has far more positive effect on students' learning than just using one teaching method. It was again, found that choice of instructions to be used for the blending process equally impact on the productivity of the blend. By these findings therefore, teachers and instructional designers are made aware that for students to be able to perform very well, the set of instructions that should be used must not be completely strange to the students (i.e. it should allow for the normal classroom convention that the students are familiar with). The findings also confirmed the theories of multiple-intelligence and individual differences in learning style preferences, implying that educators should thoughtfully factor in these theories in their instructional designing in order to arouse the interest of many of their learners, and to motivate them to learn. For effective implementation of these new ideas, there is the need for further research to

determine which instructional blend would meet the curriculum objectives of the various content areas; and to also determine how multiple-instructional strategy could be made integral principle of instructional designing without inflating the time required for instructional delivery. Multimedia equipment such as computers, digital projectors and interactive boards may be required in schools to help meet such conditions. Nevertheless, the success of such an endeavour in the educational enterprise is solely subject to the readiness of teachers to go the extra mile in their commitment to improving learning through continuous involvement in local research. Therefore, in conclusion multiple instructional strategies could be a reasonable endeavour in instructional designing.

RECOMMENDATIONS

Educators need to review principles of instructional design to re-emphasis the necessity of incorporating multiple instructions in every teaching/learning situation. This will make room for addressing individual differences in learning style preferences. Also, instructional design principles should seek to preserve prevailing classroom culture to reduce the tendency for learners to be exposed to unfriendly idiosyncrasies of some teachers who pretend to be using their own novel instructional approaches.

ACKNOWLEDGEMENTS

The authors thank the staff and students of the two institutions used for the study.

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