USING EXEMPLARY MATERIALS TO ENHANCE STUDENTS' PERFORMANCE AND RETENTION IN HYBRIDIZATION

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ABSTRACT

This study examined how exemplary materials improve students' performance and retention in hybridisation. A quasi-experimental pretest-posttest-post-posttest non-equivalent design was used with a modified Solomon four-group design, using hybridisation conception achievement tests (HCATs). A multistage sampling technique was used to sample four intact chemistry classes from four senior high schools in Kwabre East, Ashanti, Ghana, who had not been exposed to hybridisation. The control and experimental groups had two classes each. The experimental group learnt with exemplary materials in the form of models, balloons, and computer simulations. Data were analysed with SPSS 20.0. No pretest sensitization was observed, as no statistically significant differences were found between the posttest scores of the pretested experimental group and those not pretested (p = 0.07) and the posttest scores of the pretested control groups and those without pretest (p = 0.06). The posttest findings showed a significant increase in performance ($p < 0.001$) of the experimental group a week after the treatment. Experimental groups significantly performed better than control groups ($p < 0.001$). The experimental groups' retention significantly increased three weeks after the posttest (p = 0.03). Again, experimental groups' retention was better than the control ($p < 0.001$). Learning chemistry (and science) should involve using exemplary materials and student-centred pedagogies to improve the performance and memory of chemical concepts like hybridisation. *[African Journal of Chemical Education—AJCE 13(3), July 2023]*

INTRODUCTION

Improving students' performance and retention of scientific concepts is essential in science education. The instructional approaches employed to teach scientific concepts influence the attitudes, performance, and retention of scientific concepts considerably among students [1, 2, 3, 4]. Retention of scientific concepts is known [5] to depend largely on the teaching methods and strategies the teacher adopts. These instructional methods and approaches, which are mostly learner-centred, include web-based learning activities, discussion and collaborative methods, demonstrations and practical activities, and exemplary materials like computer simulation and models. In all these, the conceptual knowledge of the teacher, who is to facilitate the science learning experience, also contributes significantly to the achievement and retention of the students [2, 4, 6, 7, 8, 9, 10, 11].

A number of studies have been conducted on hybridisation to ascertain students' conceptions of the concept and appropriate instructional approaches that would enhance their conception [12, 13, 14]. In one such study [14], the conceptual teaching approach in line with the cognitive theory was found to enhance the conception of pre-service teachers. Though suggestions have been given to enhance the performance and retention of learners in hybridisations [13, 14], the lack of understanding and poor performance of Senior High School students over the years in hybridisation in Ghana, in particular, is worrying as the performance of SHS candidates in the West African Senior Secondary Certificate Examinations on hybridisation has always been reported as low [15, 16, 17]. Again, preliminary observations made by the researchers in the Kwabre East Municipality and [18] showed that most of the lessons on hybridisation have been abstract and teacher-centred. Teachers have been using the conventional (traditional) method, which is known to be problematic and misconceived [7, 19] and have not utilised their Science Resource Centres, believed to be equipped with materials for the learning of the concept. Based on these studies therein, the current study employed the use of exemplary materials in learner-centred activities and the Solomon-four group design with Senior High School (SHS) students to see how it would affect their understanding of the concept of hybridisation. There is an urgent need to explore how the use of exemplary materials would affect students' performance and retention in hybridisation.

To provide an evidence-based approach to the effectiveness of using exemplary materials to enhance students' performance and retention in the concept of hybridisation, this study sought to answer the following research questions:

(1) How would pretesting affect students' performance on hybridisation?

(2) What is the effect of the use of exemplary materials on students' performance on hybridisation? and

(3) How would the use of exemplary materials enhance the retention of the concept of hybridisation among students?

Eight null hypotheses were tested at a 95% confidence interval to guide this study and answer the research questions. The study utilised the Solomon four-group design to answer research question 1 by formulating null hypotheses 1 and 2 as follows:

Ho1: There is no statistically significant difference between the mean posttest scores of the experimental groups with pretest and without pretest, and

Ho2: There is no statistically significant difference between the mean posttest scores of the control groups with pretest and without pretest.

Null hypotheses 3, 4, and 5 were set to answer research question 2 to ascertain the effect of the use of exemplary materials on students' performance in hybridisation.

Ho3: There is statistically no significant difference in students' mean pretest and posttest scores in the control groups.

Ho4: There is statistically no significant difference in the mean pretest scores and posttest scores of the students in the experimental groups.

Ho5: There is no statistically significant difference in the mean posttest scores of students in the experimental and control groups.

Null hypotheses 6, 7, and 8 were set to answer research question 3.

Ho6: There is no statistically significant difference between the mean posttest scores and post-posttest scores of the control groups.

Ho7: There is statistically no significant difference between the experimental groups' mean posttest and post-posttest scores.

Ho8: There is no statistically significant difference between the mean post-posttest scores of the experimental groups and the control groups.

METHODS AND MATERIALS

Description of the Study Area

The study was conducted in four different Senior High Schools in the Kwabre East Municipal area of the Ashanti Region of Ghana.

Research design

The study employed a quasi-experimental design using a modified Solomon four-group design. The pretest-posttest-post-posttest non-equivalent design from Arah, *et al.* [20] was adapted as a modification to the Solomon four-group design [21] to ascertain the students' retention of the concept of hybridisation. The research design layout is shown in Table 1.

Table 1: Research design layout

Group	Pretest		Posttest		Post-posttest
Experimental Group 1 (E1)	O_1	X	O_3	Y	O_7
Control Group 1 (C1)	O_2	-	O_4	Y	O_8
Experimental Group 2 (E2)	-	X	O_5	Y	O_9
Control Group 2 (C2)	-	-	O_6	Y	O_{10}

Where **X** = Experimental treatment (using exemplary materials); **Y** = A delayed period of three weeks after the posttest.

The Solomon four-group design combines the posttest only and pretest-posttest experimental designs used to ascertain the effect of pretesting (pretest sensitisation) on the instrument and, in this case, using exemplary materials [21]. The design is used to determine the extent to which the pretest affects the effectiveness of the treatment. That is to say that if there is enhanced performance in the students' conception of hybridisation, would it be because of or as a result of the pretest, or was it because of the effectiveness of the treatment? The design also has higher external validity than the other experimental designs. Again, with the Solomon four-group design, the generalisability increases, and the treatment can be replicated.

Population, Sample and Sampling Procedure

The target population for this study was the chemistry students in the Kwabre East municipality, with the accessible population being the first-year chemistry students in the municipality. The Kwabre East municipality can boast of eight senior high schools; six government-assisted schools and two private mission schools. A multistage sampling technique was used for this study. Firstly, four schools whose students were yet to be exposed to the concept were conveniently and purposively selected to ensure that the students did not interact with each other [22]. Then, a chemistry class was randomly selected from each of the four schools. Finally, two of the four selected classes were randomly selected as the control group and the other two as the experimental group.

In all, one hundred and four (104) students were sampled for the study. Forty-five formed the control, with twenty-three (23) taking a pretest (C1) and twenty-two (22) without a pretest. The experimental groups were made up of fifty-nine (59) subjects, having thirty-one (31) of them in the experimental group with the pretest and twenty-eight (28) in the group without a pretest.

Research Instrument

The instrument used was an achievement test (pretest, posttest, and post-posttest), known as the hybridisation concept achievement test (HCAT) adapted from Nakiboglu [13], Hanson *et al*. [14], and Cobbinah [18] based on the Ghana Education Service [23] and West Africa Examination Council's chemistry syllabi. The first part of the test contained eleven open-ended questions, while the second part had six multiple-choice items with two, three, or four-choice responses.

The pretest (PrHCAT) was administered to only two groups before the treatment – one from each of the experimental (E1) and control groups (C1). The posttest (PoHCAT), was administered to all four groups a week after learning to ascertain any changes in their performance. The post-posttest (PpHCAT), which was also the retention test, was administered to all respondents three weeks after the posttest to ascertain the effect of the exemplary materials on their retention of the concept of hybridisation. The researchers and two SHS teachers assessed the instrument's validity, format, and difficulty level for the students before it was pilot tested [21] with a sample of twelve SHS 2 students from the S. D. A. Senior High School. These students did not participate in the actual study. The HCAT had a good test-retest reliability of 0.861 over three weeks.

Data Collection and Analysis

Both the experimental and control groups were taught by the reseachers for three weeks. The control groups were taught with the conventional teaching method, with no teaching learning resources. The students were completely passive in this case; this embodied the use of the researcher's explanations and textbooks. The fundamental principle is that knowledge is transferred from the teacher to the students. The experimental groups were taught using exemplary materials - latex balloons, Molymob® Chemistry Organic Molecular Model kits (students' set) and computer-assisted animations on hybridisation. The concept of hybridisation was introduced, adopting the idea of hybrid fruits in agriculture, where oranges, tangerine and "orangerine" (a hybrid of orange and tangerine) were used [18]. The balloons, molecular model kits and computer simulations gave the students a three-dimensional real view of the orbitals to enable them to relate the types of hybridisation, shapes and bond angles of the various types of hybridisation through group discussions and presentations. Additionally, various relevant portions of the videos from www.YouTube.com [24, 25, 26, 27, 28] were also used. The group discussions facilitated collaborative learning, critical thinking, and imaginative and problem-solving abilities. Additionally, the groupings allowed the students to interact with the exemplary materials. The groups occasionally shared their views with the entire class through group presentations and whole-class discussions.

The data collected was analysed using version 20.0 of SPSS. Responses from both the experimental and control groups were analysed using independent-sampled and paired t-tests to test the null hypotheses. The t-tests were performed with the assumptions that the data collected was continuous, normally distributed, and with homogeneity of variance [21].

RESULTS

One of the strengths of the Solomon four-group design was to ascertain the effect of pretesting on the students' performance or treatment (pretest sensitisation). In effect, pretest sensitisation determines the effectiveness of the treatment. In essence, this determines whether the mere act of taking a pretest influenced the scores on subsequent administration of the posttest. It was then essential to identify the extent of the pretesting and how it affected the students' performance. This addressed the first and second null hypotheses.

The effectiveness of the treatment and that of pretesting on the performance of the students were determined by comparing the scores of the experimental group with the pretest (E1) with those without the pretest (E2), and the control group with the pretest (C1) with those without pretest (C2). Independent-samples t-tests were used to determine whether there is any statistically significant difference between the two sets of groups at a 95% confidence level. Table 2 compares the mean scores obtained from the experimental group with the pretest (E1) and those without the pretest (E2) at a 95% confidence level.

Table 2: Independent-sample t-test of posttest scores of experimental groups with and without pretest

Test	N	Mean	SD	*t*	Sig
E1 posttest	31	54.87	7.898		
E2 posttest	28	50.96	8.144	1.869	.07

Table 2 showed that the performance of the experimental group with the pretest was higher than the group without the pretest; however, there was no statistically significant difference in the posttest scores of the experimental group with the pretest (M = 54.87, SD = 7.90) and those without pretest (M = 50.96, SD = 8.14); $t(57) = 1.87$; $p = 0.07$. The result suggests that the pretest did not significantly affect the performance of the experimental group with the pretest and that the increased performance was not due to pretesting. The result is in support of null hypothesis 1 and was not rejected.

To confirm the effect of the pretest on the posttests, the posttests of the control groups were also tested for significance (and to test null hypothesis 2) at a 95% confidence level. The result is shown in Table 3.

Table 3: Independent-samples t-test of means posttest scores of control groups

Test	N	Mean	SD	*t*	Sig
C1 posttest	23	33.52	8.10		
C2 posttest	22	27.59	11.60	1.98	.06

There was statistically no significant difference in the posttest scores of the control groups with pretest (M = 33.52, SD = 88.10) and those without pretest (M = 27.59, SD = 11.60); $t(37.37)$ = 1.98; p = 0.06. The result suggests that the pretest did not significantly affect the control group's performance independent of the treatment and that the increased performance was not due to the pretesting. The result supported null hypothesis 2 and was therefore not rejected. This confirmed the earlier assertion that the pretests (or pretesting) did not significantly affect the posttests or the students' performance (as also shown in Table 2). Hence, the increased or improved means (performance) was, to a considerable extent, due to the effectiveness of the treatment and not the pretest.

Since the data from Tables 2 and 3 showed that the pretesting did not affect the performance (posttests) significantly and that there was no statistical difference between the posttest of the two main groups, the posttest and post-posttest data from both groups (those with and without pretests) were considered together. In this regard, data for the control group was a combination of the two control groups (C1 and C2), with a total of 45 and that of the experimental group (E1 and E2), with a total of 59.

To ascertain any statistically significant difference in the pretest and control posttest scores, an independent t-test was done between the pretest and posttest of the control group at a 95% confidence level. The result is shown in Table 4.

Table 4: Independent t-test of pretest and posttest of the control groups

Test	N	Mean	SD	*t*	Sig
Pretest	54	10.54	4.64		
C_posttest	45	30.62	10.30	-12.86	.00

Table 4 showed there was a statistically significant difference in the pretest scores ($M = 10.54$, $SD = 4.64$) and the posttest scores of the control group ($M = 30.62$, $SD = 10.30$); $t(97) = -12.86$; $p < 0.001$. The result suggests that there was an improvement in the students' performance on hybridisation in the control group after learning with the conventional method. The null hypothesis 3 was then rejected. Table 5 compares the mean scores of the pretests and the posttest of the experimental group.

Table 5: Independent t-test of mean scores of pretest and posttest of the experimental groups

Test	N	Mean	SD	*t*	Sig
Pretest	54	10.54	4.64		
E_posttest	59	53.03	8.20	-34.27	.00

Table 5 showed that there was a statistically significant difference in the scores of the pretest (M = 10.54, SD = 4.64) and posttest of the experimental group (M = 53.03, SD = 8.20); t(111) = -34.27; p < 0.001. The result suggests that the students in the experimental group performed better after learning with the exemplary materials. The null hypothesis 2 was therefore rejected.

Since Tables 4 and 5 showed that there was an improvement in the performance of both control and experimental groups, which did not support the null hypotheses 1 and 2, there was a need to compare the posttest mean scores of the control and experimental groups to ascertain any significant difference and the extent of improvement between them. This analysis is presented in Table 6, which shows the independent t-test of the control and experimental groups to ascertain any significant difference.

Table 6: Independent t-test of posttest of combined control and experimental groups

Test	N	Mean	SD	*t*	Sig
C_POSTTEST	45	30.62	10.30		
E_POSTTEST	59	53.03	8.20	-12.36	.00

The results from Table 6 showed that there was a statistically significant difference in the posttest scores of the control group (*M* = 30.62, *SD* = 10.30) and posttest of the experimental group (*M* = 53.03, *SD* = 8.20); $t(102) = -12.36$; $p < 0.001$. The result suggests that using exemplary materials for learning hybridisation enhanced the performance significantly more than using the conventional method. The null hypothesis 3 was therefore rejected.

To ascertain students' retention of the concept of hybridisation, the results from the posttests were compared with those of the posttests. Additionally, to ascertain the extent to which the use of exemplary materials affected the performance, the results from the experimental groups were compared with those of the control group to test the null hypotheses 6, 7 and 8. Again, the post-posttest results from the control and experimental groups were analysed to ascertain any change in their conceptions. In Tables 7, 8, and 9, the mean scores of the posttests and post-posttests of both the control and experimental groups (at 95% confidence level) were compared.

Table 7 shows the paired samples t-test of the control group's mean scores of the posttest and post-posttest to ascertain the extent of retention due to the use of the conventional teaching method as demanded by null hypothesis 6 (Ho6).

Table 7: Paired samples t-test of mean scores of posttest and post-posttest of the control group (N = 45)

Test	Mean	SD	*t*	Sig
C_POSTTEST	30.62	10.30		
C_POST-POSTTEST	29.40	8.96	0.73	.47

The results from Table 7 showed that there was no statistically significant difference in the control groups' posttest (*M* = 30.62, *SD* = 10.30) and post-posttest (*M* = 29.40, *SD* = 8.96) scores; $t(44) = 0.73$; $p = 0.47$. The result suggests that the performance of the students who used the conventional method for learning hybridisation three weeks after taking the posttest was the same as their posttest performance and that there was no change in their retention. This supports the null hypothesis 6; hence, the null hypothesis was not rejected.

A comparison of the experimental groups' mean posttest and post-posttest scores to ascertain any statistically significant difference between them and then determine the extent of their retention is shown in Table 8.

Table 8: Paired samples t-test of mean scores of posttest and post-posttest of the experimental group (N = 59)

Test	Mean	SD	*t*	Sig
E_POSTTEST	53.03	8.20		
E_POST-POSTTEST	55.83	7.64	-2.27	.03

A statistically significant difference was observed between the experimental groups' posttest (*M* = 53.03, *SD* = 8.20) and post-posttest (*M* = 55.83, *SD* = 7.64) scores; $t(58) = -2.27$; $p = 0.03$. The result suggests a significant increase in the retention of students' conception of hybridisation after learning with exemplary materials. The results support null hypothesis 7; hence, the null hypothesis was not rejected.

Table 9 compares the mean post-posttest scores of the control and experimental groups to ascertain any statistically significant difference between them and determine the extent to which the use of exemplary materials affected the retention of the students.

Table 9: Independent sample t-test of mean scores post-posttests of experimental and control groups

Test	N	Mean	SD	*t*	Sig
C_POST-POSTTEST	45	29.40	8.96		
E_POST-POSTTEST	59	55.83	7.64	-16.21	.00

Table 9 showed a statistically significant difference in the post-posttest scores of the control groups (M = 29.40, SD = 8.96) and experimental groups (M = 55.83, SD = 7.64); $t(58) = -16.21$; $p < 0.001$. The result suggests that students who learnt the concept of hybridisation with exemplary materials had higher retention than those who learnt with the conventional method. The results did not support null hypothesis 8; hence, the hypothesis was rejected.

DISCUSSION

Before beginning an intervention or treatment, educational researchers typically want to understand their subject's behaviour by pretesting, which may have an impact on the instrument's internal and external validity [21]. One of the common internal validity threats is the testing threat, which occurs when the scores of the posttest are influenced by the subjects being exposed to the pretest. It happens that after pretesting, the subjects (students in this case) gain experience that may affect their next score, whether they participated in the treatment or intervention. Their experience with the stress and pressure of the test environment (and other factors) would enable them to perform the next time differently. Even if the students would not participate in any treatment or intervention, they could decide to find answers to the previously unfamiliar questions, and this might cause an improvement in their performance if they are to take any subsequent test (posttest). One of the strengths of the Solomon four-group design is identifying the possible effects of pretesting. It utilises four different groups, with two control groups and two experimental groups. One of each of the control and experimental groups would be pretested, while all four groups would be posttested [21].

Best and Khan [21] assert that comparing the posttests of the two experimental groups allows the researcher to determine the effect the pretest had on the treatment. If the comparison of the results of the posttest for the two groups differ (where there is a significant difference), then the pretest affected the treatment. Additionally, the posttests of the control groups could be compared to ascertain any significant difference. This would similarly show whether the pretest itself affected behaviour, independently of the treatment. If the outcomes of the comparison are significantly different, the pretesting process has affected the outcomes and needs to be improved. From Table 2, although the mean of the posttest scores of the experimental group with pretest (M = 54.87, SD = 7.90) was higher than those without pretest (M = 50.96, SD = 8.14), the result showed no statistically significant difference between the two groups (p = 0.07). This was in support of null hypothesis 1. So the null hypothesis was not rejected. This showed that the higher performance was not due to the pretest but largely as a result of the effectiveness of the treatment. Again, Table 3 also showed a similar relation between the posttest scores of the control groups. The control group with pretest (C1) had a higher mean (*M* = 33.52, *SD* = 88.10) than the control group without pretest (C2) (*M* = 27.59, *SD* = 11.60). However, no statistical difference was observed between the groups ($p = 0.06$), showing that the pretest did not affect the behaviour of the students, independent of the treatment. This confirmed the earlier observation with the experimental groups. Tables 2 and 3 then supported the null hypotheses 1 and 2; hence, null hypotheses 1 and 2 were not rejected. Although the mean scores of the groups with pretests (E1 and C1) were higher than that of those without pretests (E2 and C2), there was statistically no significant difference between the performance of the experimental group with pretest (E1) and without pretest (E2) and between the control group with pretest (C1) and without pretest (C2). Pretesting, therefore, did not significantly affect the performance and treatment. The increased or enhanced performance of the students from the experimental group was, to a very large extent, due to the effectiveness of the treatment.

From Table 5, the mean scores of the experimental groups (*M* = 53.03, *SD* = 8.20) were higher than those of the pretest (*M* = 10.54, *SD* = 4.64). This increase in the mean score was statistically significant ($p < 0.001$) at a 0.05 level of significance, which did not support null hypothesis 4. So the null hypothesis was rejected. Again, Table 4 showed a significant increase in the control groups' mean scores (*M* = 30.62, *SD* = 10.30). A statistical difference was observed between the control group's pretest and posttest ($p < 0.001$). So from Tables 4 and 5, there were improvements in the students' performance in hybridisation after learning with the conventional method and with exemplary materials. This was in agreement with [22], who also found no significant pretest sensitisation, with improvement in the experimental group's performance over that of the control group. Although there was a significant increase in the performance of the students in both the experimental and control groups, Table 6 showed that the mean score of the experimental group was higher (M = 55.83, SD = 7.64) than the control group (M = 30.62, SD = 10.30). There was a statistically significant ($p < 0.001$) difference between the mean posttest scores of the control and experimental groups. This showed that the exemplary materials used for learning hybridisation significantly improved students' performance. This supported the assertion that using exemplary materials and activity-based learning enhances students' understanding [1, 29]. Also, using meaningful teaching and instructional methodologies has been recommended [30] to improve students' performance and retention in hybridisation, which was done in this study (instead of the conventional teaching approaches).

Every effective learning is expected to have a lasting effect on the conception of students, and they would be able to recall these learning experiences after some time [31, 32]. Tables 7 to 9 showed how the posttest and post-posttest performance of students in the control and experimental groups differ from each other. Table 7 showed that the control group's mean posttest score (M = 30.62, SD = 10.30) reduced on taking the post-posttest (M = 29.40, SD = 8.96) three weeks after taking the posttest. Although there was a reduction in the performance of the students after the posttest, no statistically significant difference was observed between the posttest and post-posttest scores of the control group; $t(44) = 0.73$; $p = 0.47$. This supported the null hypothesis 6, and hence, the null hypothesis was not rejected. In effect, even though there was a reduction in the performance, as shown in their mean scores, the reduction was not significant, and hence their retention did not change significantly after the three weeks delay time. The control group's conception was therefore retained.

In comparing the posttest scores of the experimental group with their post-posttest scores, Table 8 showed that the students performed better in the post-posttest ($M = 55.83$, $SD = 7.64$) than in the posttest ($M = 53.03$, $SD = 8.20$). This increase in performance three weeks after taking the posttest was found to be statistically significant; $t(58) = -2.27$; $p = 0.03$. The statistical significance supported null hypothesis 7, and the hypothesis was rejected. This suggested a significant increase in the retention of the students after learning with exemplary materials. To ascertain the performance of the experimental group in the post-posttest compared to that of the control group, the independent t-test in Table 9 showed how the use of exemplary materials affected the retention of students in hybridisation. Table 9 revealed that the students from the experimental group performed far better than those from the control group in the post-posttest. The mean score of the experimental group ($M = 55.83$, $SD = 7.64$) was almost twice that of the control group ($M = 29.40$, $SD = 8.96$). This high performance was statistically significant ($p < 0.001$). The result did not support null hypothesis 8, so the null hypothesis was rejected. This supported the claim that using student-centred teaching strategies and concrete learning materials improves students' knowledge for lifelong learning [11, 12]. Using the conventional approach led to a decrease in retention. The concept learned seemed to have been stored in the short-term memory and was forgotten in a short while [31]. On the other hand, the use of concrete concept-depicting materials resulted in the concept being stored in long-term memory and unconsciously solidifying the students' understanding of the concept, the retention of learners who used the conventional method could not be significantly enhanced [12, 33, 34].

The posttest and postposttest results suggested that using exemplary materials to learn the meaning of hybridisation enhanced their performance, retention, and retrieval of the concepts. This supported the view that the use of the constructivist approach to learning enhances conception, where students were allowed to explore, find answers or meanings on their own through the use of concrete materials and interact with these materials and colleagues [35, 36]. This reduction in performance when the conventional method was used for the learning of hybridisation could be the cause of the poor performance of SHS students in responding to questions on hybridisation in the WASSCE [15, 16, 17]. As observed from the study, students who learned with the conventional method had a decline in their already low performance of hybridisation just after three weeks. Their performance is obvious after a year or two, as against those who learnt with exemplary materials. Those who learnt with exemplary materials had their interest in and understanding of the concept of hybridisation sustained during and even long after learning, as their retention of the concept was higher. This sustained understanding of concepts was also observed when students' retention were improved through the use of laboratory-based learning [37]. In this regard, retention of the concept may not be significantly different after a year or two. Chemistry teachers are thus encouraged to use student-centred learning approaches and materials, such as exemplary materials, to improve chemical concept retention and promote lifelong learning in general.

CONCLUSION

The findings from this study showed that there was no significant pretest sensitisation. While the performance of the learners who learnt with exemplary materials was significantly better than those who learnt without these materials, their performance increased significantly. There was, however, a significant reduction in the performance of the learners who learnt without the exemplary materials. The retention of learners in the experimental groups significantly increased three weeks after taking the posttest. There was, however, a reduction in the performance of the learners in the control group. The use of exemplary materials for learning hybridisation helped in the formation of concrete images and concepts in long-term memories, which had a long-lasting effect on the learners' conception. In effect, using exemplary materials such as balloons, molecular kit (ball-and-stick) models, and computer simulations in activity-based learning has the potential to improve students' performance and retention of the concept hybridisation.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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