

EFFECTS OF KELLER SYSTEM OF INSTRUCTION (KSI) ON STUDENTS' ACADEMIC ACHIEVEMENT IN BIOLOGY

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Abstract

The study investigated the Effect of Keller System of Instruction (KSI) on students' Achievement in Biology. The design of the study was a quasi-experimental, non-equivalent pretest and posttest control group design. 7,612 Senior Secondary School one (SSS1) biology students in Abakaliki Education Zone of Ebonyi State formed the population of the study. A sample of three hundred and thirty-two (332) students from intact classes of four schools was used for the study. Four co-educational secondary schools in Abakaliki Education were purposively sampled for the study. Two schools were randomly assigned to the control group while the remaining two schools were assigned to the experimental group. The experimental group was taught biology with KSI while the control group was taught with the traditional method. The instrument used to collect data for the study was Biology Achievement Test (BAT). The instrument was face validated by experts in biology education, and measurement and evaluation. The reliability of BAT was determined using the Kuder-Richardson formula (KR-20) and a Reliability index of 0.80 was obtained. The instrument was also subjected to estimation of stability using a test-retest procedure. The stability coefficient obtained for BAT was 0.95. The data obtained from the study were analyzed using mean and standard deviation for answering research questions while (ANCOVA) was used for testing the hypotheses. The findings of the study revealed among others that: Keller System of Instruction (KSI) was significantly better than the conventional teaching method in enhancing students' achievement in biology; there was no significant interaction between gender and teaching method on students' achievement in biology. Based on the above findings, recommendations were made which include biology teachers should introduce KSI in their lessons to enhance students' achievement in biology; and educational trainings, workshops and conferences should be organized where the teachers could be sensitized on the efficacy of KSI in enhancing the students' achievement in biology.

Keywords: Achievement, Keller System of Instruction, Conventional Method of Teaching, Biology.

Introduction

Biology is the science that is concerned with the study of life and the interrelationship between organisms and their environment (Dajal & Adamu, 2019). Biology is given special recognition among other sciences because of its close relation to man as a living organism and its values in education. It is then not surprising that Biology is needed in

many establishments such as biotechnology, Genetic engineering, agriculture and pharmaceutical industries (Dajal & Adamu, 2019; Nwafor & Oka, 2018). As Nwafor and Oka, (2018) rightly noted, a sound working knowledge of biology is a prerequisite for entrance into such professions as medicine, engineering, agriculture, biotechnology, Anatomy, and many others.

A significant proportion of Nigerian students persistently have poor academic achievement in biology (Izuegbunam et al., 2018). According to Biology Chief Examiner's Reports (2016 - 2022), students' academic achievement in the Senior Secondary School Certificate Examination (SSCE) conducted by the West African Examination Council (WAEC) has been quite unimpressive, notwithstanding the importance of biology. The National Examination Commission (NECO) also reveal that achievement in biology continues to dwindle. The reports blamed students' lack of basic skills required in practical biology and the instructional method often used by teachers.

Achievement is the level of educational development of an individual as determined by an achievement test and based on a comparison of one's scores with the average score of the norm groups. According to Lorimer and Lechner (2015), it is a measure of the proficiency of an individual in something that has been learnt or taught. It follows that achievement refers to something accomplished, especially by superior ability, special efforts or great valour. Achievement in biology therefore refers to the accomplishments of the students concerning tests and examinations after a specified period of study.

The table below gives a clear picture of Ebonyi State students' achievement in biology in the year 2016- 2022.

Table 1: Ebonyi State students' achievement in biology in WAEC SSCE for the years 2016- 2022

| Year | Total entry | Total sat | Grades (1-6) | %Achievement (1-6) | %failed |
|------|-------------|-----------|--------------|--------------------|---------|
| 2016 | 6020 | 5974 | 2571 | 43.04 | 56.96 |
| 2017 | 6177 | 6122 | 3584 | 58.54 | 41.46 |
| 2018 | 6239 | 6200 | 2990 | 48.23 | 51.77 |
| 2019 | 6529 | 6483 | 3194 | 49.27 | 50.73 |
| 2020 | 6705 | 6619 | 3654 | 55.20 | 44.80 |
| 2021 | 6637 | 6562 | 2702 | 41.17 | 58.83 |
| 2022 | 7032 | 7008 | 2368 | 33.80 | 66.20 |

Source: West African Examination Council (WAEC) Statistic Division (2016 - 2022). Statistical Annual Report of Ebonyi State WAEC. Examination board.

An analysis of the above results shows the fluctuating state of Ebonyi State students' achievement in biology. Dajal and Adamu (2019) attributed the abysmal achievement in biology at the Senior School Certificate Examinations to the methods (expository, demonstration and lecture method of teaching) employed by teachers in teaching biology

at the secondary school level. The above situation might lead to low enrolment in sciences in Ebonyi state.

The lecture method, Expository, and Demonstration are referred to as teacher-centred in the sense that the teachers are considered the possessors of knowledge (Muema et al., 2018). These teacher-centred methods of teaching stress more on the transmission of knowledge in a manner that emphasizes memorization; hence they have been classified by many researchers (Dajal & Adamu, 2019; Yaduvanshi & Singh, 2018) as poor methods of teaching. Yaduvanshi and Singh (2018), argue that teacher-centred methods discourage initiative, curiosity, and creativity in learners and do not offer the students an opportunity to interact effectively with their peers in biology classes. More so such methods do not give students enough time for mastering the units of what was taught.

Furthermore, Izuegbunam et al. (2018) stated that the teacher-centred methods do not encourage "hands-on activities". Teachers appear to use them to maximize the delivery of information to a large number of students while minimizing lesson duration. According to Izuegbunam et al. (2018), such a situation stifles students' achievement in/of the content being taught. The disadvantages of teacher-centred methods of teaching have resulted in the persistent search for teaching methods that expose students to challenges that make them participate actively in the teaching and learning process. Furthermore, the paradigm in teaching and learning biology has shifted from information delivery to the ways learners learn (Khawla & Ibtisam, 2018), in order to help learners cope with the challenges of the world's rapidly growing wealth of scientific knowledge. Consequent to the above challenges, some researchers (Dajal & Adamu, 2019) advocate for learner-centred methods of teaching.

Learner-centred methods of teaching are activity-based and make learners masters of their learning (Dajal & Adamu, 2019). It promotes students' interest in biology (Khawla & Ibtisam, 2018) and enhances their acquisition of mastery of the content taught. The learner-centred methods of teaching include Guided discovery, Cooperative learning, Concept mapping, Simulation games (Dajal & Adamu, 2019), Individualized instructions (Izuegbunam et al., 2018), and Mastery learning. Mastery learning raises and sustains the learners' motivation and interest to learn the next related concept. Mastery learning can be achieved through different teaching methods, one of which is the Keller System of Instruction (KSI) (Izuegbunam et al., 2018). It is also called the Keller Plan (KP) and it is commonly known as the Personalized System of Instruction (PSI) (Khawla & Ibtisam, 2018).

Keller System of Instruction is a teaching strategy in which students are allowed to study at their own pace, based on their individual capacity, and desire, in order to gain knowledge and self-learning skills with small amount of control and direction from the teacher (Al-Zaboun et al., 2016; Khawla & Ibtisam, 2018). Khawla and Ibtisam explained that KSI was pioneered by Fredrick Keller, Gil Sherman, Rodolpho Azzi, and Caroline Martusceli Bori, half a century ago; and that KSI is based on Skinner's Operant Conditioning Theory of learning which relies heavily on behavioural principles. The philosophy of KSI is that every student can achieve mastery if given enough time and

motivation, with the right teaching materials. According to Khawla and Ibtisam (2018), the main features of KSI include: Unit mastery requirement, Student self-pacing, Stress on the written word, Use of proctor, Lecture and demonstration as motivational devices (p. 317). In this instructional approach, the teacher acts as the course facilitator to the students in providing individualized learning plans and pointing out the students' areas of weakness and strength. Samba et al. (2010) argued that instructional techniques, depending on their nature, may exhibit a differential effect on gender.

Gender is a sociocultural concept that refers to masculine and feminine qualities, behavioural patterns, roles, and responsibilities the society or culture expects of individuals (Yaduvanshi & Singh, 2018). Some researchers state that males have higher achievement in a competitive learning setting, while females excel better in cooperative learning settings (Iserameiya & Agbonghale, 2018). However, some revealed gender disparity across instruction techniques (Iserameiya & Agbonghale, 2018), and for others, there was zero disparity (Yaduvanshi & Singh, 2018). With the above conflicting and inconclusive reports on the interaction effect of gender and teaching methods on students' achievement, it is not certain the extent to which KSI can differentially affect male and female students' achievement in Biology. More so, since the competitive learning setting (for example self-pacing and use of lecture for motivational purposes) and the cooperative learning setting (for example, use of proctors) which have conflicting evidence of efficacy based on gender are both incorporated in KSI, it will be worthwhile to explore the differential effects of the Keller System of Instruction on male and female students' achievement in biology.

Statement of Problem

Despite the importance of Biology in many fields of human endeavour, students' achievement in biology is persistently poor. Biology is mostly taught with the teacher-centred methods of teaching which do not encourage active participation, initiative, curiosity and creativity. The situation stifles students' understanding and mastery of the contents taught. The poor achievement in biology exhibited by students might have contributed to the low number of students who get admitted into science-related courses in higher schools. There is, therefore, the need to adopt a teaching method that can sharpen students' cognitive abilities; enhance mastery of content and improve students' achievement in biology. Researchers especially in developed countries have been clamoring for the Keller System of Instruction for its efficacy in enhancing students' achievement in several subjects. Its efficacy in Ebonyi State classrooms for biology achievement calls for urgent investigation. The question the present study is faced with is: What is the effect of the Keller System of Instruction on students' interest and achievement in biology?

Purpose of the Study

The study examined the effect of KSI on students' achievement in biology. Specifically, the study ascertained the effect of KSI on students' achievement mean scores in biology, and the Interaction effect of teaching methods and gender on students' achievement in biology.

Research Questions

The following research questions were posed for the study.

1. What is the effect of the Keller System of Instruction (KSI) on students' achievement mean scores in biology?
2. What is the interaction effect of teaching method and gender on students' achievement scores in biology?

Hypotheses

Three null hypotheses were tested at an alpha level of 0.05.

H0₁: There is no significant difference between the achievement mean scores of students taught biology with KSI and those taught biology with conventional method.

H0₂: The interaction effect of gender and teaching methods on the achievement mean scores of students is not statistically significant.

Methodology

Quasi-experimental design was adopted for the study. The specific design was the pre-test, post-test, non-equivalent control group design. The area of study was Ebonyi State of Nigeria. The population of the study comprised 7,612 SSS1 biology students in twenty-nine (29) co-educational secondary schools (Source: Ebonyi State Secondary Education Board, 2024), in Abakaliki Education zone. The researcher used only co-educational secondary schools because of the need to observe males and females in their natural setting. A purposive random sampling technique was employed in selecting the four schools based on the availability of a functional e-library. Using a simple toss of coin, two of the sampled schools were assigned to the experimental group while the other two were assigned to the control group.

The Biology Achievement Test (BAT) was the instrument used for data collection for the study. It has two sections. Section A sought information on the personal data of respondents while Section B contained 50 test items of BAT. The test items were drawn from plant and animal nutrition; and Ecological Management which are the topics for the study. The instrument (BAT) was designed in a multiple-choice test format. Each test item has four options: A, B, C, and D, with only one correct answer among the options, while the other three served as distracters. The items were drawn using a table of specifications. Any correct answer was awarded one mark and scored in percentage; hence, the minimum score was 0% while the maximum score was 100%.

The Biology Achievement Test was face-validated by two specialists in measurement and evaluation and two specialists in biology education. The specialists vetted the items in terms of language clarity for the students, content coverage of the items and relevance of the items to the stated specific objective. For trial testing, BAT was administered to 50 SS1 students from non-target schools in Enugu Education zone in Enugu State. The scores from the trial testing of BAT were used for item analysis (discriminating power and difficulty index). Items with a discrimination power of 0.4 to 1 were accepted, while others were rejected, and with a difficulty index of 0.3 to 0.7 (Abonyi et al., 2006). 45 test items

remained after the item analysis. The Kuder-Richardson 20 (KR-20) coefficient of internal consistency for the instrument was 0.80. BAT had a stability coefficient of 0.95 which was determined using a test-retest procedure.

For the experimental group: BAT was administered as pre-test, marked, and the scores kept for the analysis. A study guide structured by the researcher based on the Keller System of Instructional method was used by the students in the experimental group. It was face-validated by experts and uploaded online on the website <https://odimkpachristy.com> using the link- <https://odimkpachristy.com/courses/study-guide-for-keller-system-of-instruction-group-experimental-package/> The researcher did not do the teaching but used the assistance of the class teachers who served as the research assistants. The class teachers were briefed on the treatment procedures. Unit quizzes were administered to students automatically, marked and graded, and feedback appeared immediately after the completion of unit content. The Mastery grade used was 80% while the number of repetition times was three times. The repetition test items were also attached to the study guide. At the end of the experiment, the test items of BAT were reshuffled, administered to the group as post-tests, marked and the scores kept for analysis.

For the control group: BAT was administered as a pre-test, marked, and the scores kept for the analysis. A lesson note on the same topics as the study guide was prepared by the researcher and was face-validated by three experts. The lesson note was used by the research assistants who were briefed on the lecture method procedure, to teach the control group. The researcher did not do the teaching in any of the classes to control the extraneous variables (teacher variable). The research assistants were instructed on the objective, scope, content of the topics to be treated, and nature of the research. The only tests that were administered to the control group were the pre-tests and post-tests. At the end of the treatment, the test items of BAT were reshuffled and administered to the groups, marked, and the scores kept for analysis as post-tests.

The research questions were answered using mean and standard deviation while the hypotheses were tested using a two-way Analysis of Covariance (ANCOVA) at 95% confidence level.

Results

Research Question 1: What is the effect of the Keller System of Instruction (KSI) on students' achievement mean scores in biology?

Data collected with the Biology Achievement Test administered to the experimental and control groups were used to answer the research question. A Summary of the result of the data analysis is presented in Table 2

Table 2: Pretest and Posttest Achievement Mean Scores and Standard deviation of Students Taught with the Keller System of Instruction and Conventional Method

| Teaching methods (Treatment) | Pre-test | | | Post-test | | Gain Score |
|-------------------------------|----------|-------|------|-----------|-------|------------|
| | n | Mean | SD | Mean | SD | |
| Experimental (KSI) | 182 | 31.81 | 9.02 | 61.21 | 16.68 | 29.40 |
| Control (Conventional Method) | 151 | 27.30 | 8.50 | 40.48 | 10.71 | 13.18 |
| Total/Gain Score Difference | 333 | 29.77 | 9.06 | 51.81 | 17.62 | 16.22 |

Table 2 shows that the experimental group taught with the Keller System of Instruction (KSI) had a post-test mean score of 61.21 with a standard deviation of 16.68. And a pre-test mean score of 31.81 with a standard deviation of 9.02. The result shows a mean gain score of 29.40. In contrast, the Table shows that the control group taught with the Conventional method had a post-test mean score of 40.48 with a standard deviation of 10.71. And a pre-test mean score of 27.30 with a standard deviation of 8.50. This shows a mean gain score of 13.18. This result shows that the two instructional methods KSI and the Conventional method enhanced the students' academic achievement in biology. However, the students taught with KSI had a higher achievement mean score than their counterparts taught with the Conventional method, with a difference of 16.22 observed between the mean gain scores. The Table could not show whether the observed difference in the achievement mean gain scores of the experimental and control groups was statistically significant or could be attributed to error variance. To ascertain the significance or otherwise of the observed difference, the result was subjected to inferential statistics with ANCOVA to test the corresponding null hypothesis 1 as shown in Table 4 below. Meanwhile, the standard deviation of the control group in the post-test score was lower than that of the experimental group. This implies that the individual scores of the students in the control group were more clustered around their mean than those of their experimental counterparts.

Research Question 2: What is the interaction effect of teaching method and gender on students' achievement mean scores in biology?

The adjusted achievement mean scores for the two levels of gender who were taught biology with KSI and those taught with conventional methods were used to assess the interaction. The summary of the result is shown in Table 3.

Table 3: Adjusted Achievement Mean Scores and Standard Error of Method and Gender Interaction

| Group | Gender | Mean | Std. Error | 95% Confidence Interval | |
|--------------|--------|--------------------|------------|-------------------------|-------------|
| | | | | Lower Bound | Upper Bound |
| Experimental | Male | 58.92 ^a | 1.61 | 55.75 | 62.09 |
| | Female | 61.21 ^a | 1.34 | 58.58 | 63.83 |
| Control | Male | 40.84 ^a | 1.66 | 37.58 | 44.11 |
| | Female | 42.24 ^a | 1.55 | 39.20 | 45.28 |

a. Covariates appearing in the model are evaluated at the following values: Pre-test score = 29.77.

Table 3 shows the adjusted achievement mean scores and standard error of the students to determine the interaction effect of methods and gender. The Table shows further that the adjusted achievement mean score of the female students of the experimental group was higher than that of their male counterparts. Similarly, the adjusted achievement mean score of the female students in the control group was also higher than that of their male counterparts. However, the Table could not establish whether the interaction of method and gender was statistically significant to cause an effect on the students' academic achievement. Hence, the result was subjected to inferential statistics to test the null hypothesis 2 with ANCOVA as shown in Table 4 below.

H0₁: There is no significant difference between the achievement mean scores of students taught biology with KSI and those taught biology with a conventional method.

Table 4: Summary of Analysis of Covariance Result of Achievement Mean Scores of Students taught Biology with KSI and Conventional Teaching Method

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared |
|-----------------|-------------------------|-----|-------------|--------|------|---------------------|
| Corrected Model | 40958.62 ^a | 4 | 10239.66 | 54.11 | 0.00 | 0.40 |
| Intercept | 36957.52 | 1 | 36957.52 | 195.28 | 0.00 | 0.37 |
| Pre-test | 5262.01 | 1 | 5262.01 | 27.80 | 0.00 | 0.08 |
| Group | 26100.35 | 1 | 26100.35 | 137.91 | 0.00 | 0.30 |
| Error | 62075.08 | 328 | 189.25 | | | |
| Total | 996822.00 | 333 | | | | |
| Corrected Total | 103033.70 | 332 | | | | |

a. R Squared = 0.398 (Adjusted R Squared = 0.390)

Table 4 shows the summary of ANCOVA which was conducted to compare the effect of KSI and the Conventional method on students' academic achievement in biology while controlling for the pre-test effect. The results indicated that there was a statistically significant difference ($F(1,328) = 137.91, p = 0.00 < .05$) between the experimental group ($M = 61.21, SD = 16.68$) and the control group ($M = 40.48, SD = 10.71$) with a mean gain score difference of 16.22. The partial Eta squared value of 0.30 shows the magnitude of the difference in the means (effect size), which when compared with Cohen's guidelines

(0.2 – small effect, 0.5 – moderate effect, 0.8 – large effect) was considered small. Therefore, hypothesis two (H_{02}), which states that there is no statistically significant effect of the Keller System of Instruction (KSI) and the Conventional Teaching Method on students' achievement mean scores in biology as measured by their mean post-test scores in BAT was, therefore, rejected at a 0.05 alpha level. This means that the earlier observed difference in the mean achievement scores of the two groups as shown in Table 2 was significant. This further shows that the Keller System of Instruction was more effective in improving the students' academic achievement in biology than the conventional method.

Hypothesis 2: There is no significant interaction effect of teaching methods and gender on students' achievement mean scores in biology.

Table 5: Summary of One-way Analysis of Covariance Results of Interaction Effect of Methods and Gender

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared |
|-----------------|-------------------------|-----|-------------|--------|------|---------------------|
| Corrected Model | 40958.62 ^a | 4 | 10239.66 | 54.11 | 0.00 | .040 |
| Intercept | 36957.52 | 1 | 36957.52 | 195.28 | 0.00 | 0.37 |
| Pre-test | 5262.01 | 1 | 5262.01 | 27.80 | 0.00 | 0.08 |
| Group * Gender | 16.23 | 1 | 16.23 | 0.09 | 0.77 | 0.00 |
| Error | 62075.08 | 328 | 189.25 | | | |
| Total | 996822.00 | 333 | | | | |
| Corrected Total | 103033.70 | 332 | | | | |

a. R Squared = 0.398 (Adjusted R Squared = 0.390)

Table 5 shows the ANCOVA statistics to determine the interaction effect of method and gender on students' academic achievement in biology. The Table shows that there was no statistically significant interaction effect of method and gender on the students' academic achievement in biology ($F(1,328) = 0.09$, $P = 0.77 > 0.05$). Therefore, hypothesis two (H_{02}), which states that there is no statistically significant interaction effect of teaching method and gender on students' achievement mean scores in biology was accepted. This implies that the methods of instruction and the students' gender could not interact significantly to influence the students' academic achievement scores in biology. Therefore, the two-way interaction of methods and gender had no statistically significant effect on students' academic achievement in biology.

Discussion

The result presented in Table 2 indicated that KSI enhanced students' achievement in biology more than the conventional method. Furthermore, the summary for hypothesis 1 in Table 4 revealed a significant difference in the mean achievement scores of students taught biology using KSI and those taught using the conventional method. The disparity observed in the mean achievement scores of students taught biology using KSI and those

taught using conventional methods was therefore attributed to the difference in the teaching method adopted for the teaching of the two groups. The finding is not surprising because KSI encourages active participation of students more than conventional methods of teaching (Khawla & Ibtisam, 2018). KSI allows multiple opportunities for students to undergo remedial instructions and tests to enable students to demonstrate mastery of every unit by the time the terminal assessment is administered (Foss et al., 2014). Nnamani, and Oyibe, (2016); Filgona, Filgona and Sababa (2017); and Friskawati et al., (2017) had earlier discovered that KSI proved to be better than the conventional methods of teaching. The finding is also in consonance with the findings of Paiva et al., (2017) who maintained that with KSI's features of unit mastery, self-pacing, stress on the written word, use of proctors; and flexibility, students' understanding and mastery of unit of instruction were enhanced.

The findings on the interaction effect of teaching methods and gender on students' achievement revealed that male and female students had higher mean achievement scores when KSI was used to teach biology but the male and female students taught using conventional method had lower mean achievement scores. It follows that the achievement by the two groups was not based on their gender but attributed to the type of teaching method used. In the conventional method class, the students' learning experience appears more passive when compared with KSI which is student-centred. The KSI, unlike the conventional method, encourage more teacher-student interaction and accommodates individual learning styles. It is therefore not surprising to discover that both male and female students have higher mean achievement scores when KSI was used than when the conventional method was used. The summary of the result for Hypothesis 2 also confirmed that there was no significant interaction effect of gender and teaching method on students' achievement in biology. This showed that there was no interaction effect between teaching methods and gender because the effectiveness of KSI remained superior across genders and groups. The present study supports Al-Zaboun, et al (2016), and Khawla & Ibtisam, (2018) who noted that KSI enhanced students' achievement in biology more than the conventional method. The findings from the present study are also in line with Filgona et al. (2017); and Friskawati et al. (2017) who had earlier stated that there was no interaction effect of teaching method and gender on students' achievement in biology when KSI was used.

Conclusion

From the result of the study, it was concluded that the Keller System of Instruction (KSI) is significantly better than the conventional teaching method in enhancing students' achievement in biology and that there is no statistically significant interaction effect of gender and teaching method on students' achievement in biology. For both male and female students, KSI is superior to the conventional method in fostering achievement in biology.

Implications of the Study

The implications of the study are:

1. Achievement in biology is improved using learner-centred methods that encourage mastery, individualization, self-pacing and use of proctors. Secondary school teachers often employ teacher-centered methods which do not stimulate interest in biology.
2. Biology curriculum developers do not integrate KSI principles in the curriculum especially at the senior secondary school levels.

Limitations of the Study

1. The number of schools that had ICT facilities was small and this made it difficult for more schools and students to be included in the study.
2. Some students were not ICT literate and this might have limited the speed of using study guide.

Recommendations

Based on the findings of the study, the following recommendations were made.

1. Biology teachers should be encouraged to adopt KSI in their lessons to attract and motivate students to learn biology.
2. Biology curriculum developers should integrate KSI principles in the curriculum especially at the senior secondary school levels.
3. The government should fund educational training, workshops and conferences where KSI could be explained to secondary school teachers.

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