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Influence of the Demo Kit on Remediating Senior School Students' Misconceptions in Mitosis and Meiosis in Ilorin, Nigeria

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Abstract: This study investigated the influence of the demo kit on remediating misconceptions held by senior school students in mitosis and meiosis. The quasi-experimental design of the pre-test, post-test, non-equivalent control group was adopted for the study. A multistage sampling technique was used to select 60 male and female biology students from two senior secondary schools in Ilorin metropolis. The instruments used for data collection was the Mitosis and Meiosis Conception Package (MMCP). Frequencies and chi-square were used to answer the research questions and test the null hypothesis, respectively. The findings revealed that biology students held misconceptions on mitosis and meiosis before and after instructions. However, there was a significant difference in the number of misconceptions held by students taught using the demo kit and those taught with the conventional method. It was recommended that biology teachers adopt the use of the demo kit for remediating students' pre- and post-instructional misconceptions on mitosis and meiosis.

Keywords: remediate, misconceptions, mitosis, meiosis, the demo kit.

Introduction

The subject of biology has remained an important impetus for the survival of life on Earth. This is because it is a natural science subject that deals with the study of life and the relationship between living organisms and their physical environment. Umar (2011) observed that knowledge of biology is fundamental for predicting and interpreting how the theories of nature can be applied for the continued existence of life on Earth. There is also no gainsay that the knowledge of biology has been fully grafted and applied in the production of food, shelter and clothing, which constitute the three basic necessities of life.

Despite the importance of biology to the study of living organisms, the performance of senior school students in external examinations conducted by the West African Examinations Council (WAEC) and National Examinations Council (NECO) is not impressive (Adeoye & Abimbola, 2016; Bichi, Ibrahim, & Ibrahim, 2019). Researchers like Ibe (2015) and Adegboye, Bello and Abimbola (2017) attributed students' unimpressive performance in biology to teachers' insensitivity to the nature of biology especially when planning instructional activities. In contrast, Abubakar and Jimin (2018) contended that the misconceptions of basic biology concepts was one of the main factors affecting students' performance in biology.

Misconceptions, according to Olorundare (2014) are words misunderstood or misinterpreted by students, which can impede meaningful understanding of science, thereby standing as a barrier to

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study. Misconceptions may arise from communication issues in the classroom, peer-group interactions and use of ambiguous words and expressions in textbooks (Dikmenli & Cardak, 2004). Researchers such as Dikmenli (2010) and Elangovan (2018) specifically identified mitosis and meiosis as hard-to-teach and hard-to-learn biology concepts for senior schoolteachers and students, respectively, due to the misconception and alternative conceptions of related concepts.

Mitosis and meiosis are important life processes that form the basis for many biology concepts such as genetics, reproduction, growth, development, and molecular biology (Adeoye, 2021). Taylor, Green, and Stout (2004) defined the cell as the smallest, simplest, basic, fundamental, structural and functional unit of living organisms capable of independent existence from which organisms are built. Cell division involves cell multiplication through the process of mitosis and meiosis. Mitosis leads to the production of two daughter cells which have the same number and types of chromosomes as the parent cell (Yanagida, 2015). Mitosis usually takes place during growth, cell replacement, regeneration of lost parts and asexual reproduction. Meiosis on the other hand is a form of nuclear division in which a haploid (n) number of cells are produced. Meiosis takes place in reproductive cells. It is a reduction division in which a single diploid cell gives rise to four haploid cells (Ramalingam, 2013).

The strategies and instructional materials adopted by teachers are important in determining students' learning outcomes. This is partly because the lack of instructional materials during instruction makes learning difficult (Abimbola, 2015; Adeoye & Abimbola, 2016). Hubbard (2003) identified the absence of the actual material meant for teaching and learning as the first barrier to learners' study. Other barriers to study as identified by Hubbard and included are too steep a learning curve, skipping a grade and misunderstood terminology. According to Applied Scholastics International (2018), the incidence of the lack of content materials could be removed through the use of the demo kit, modelling clay, and sketching. The focus of the present study is on the first barrier to learners' study, which acknowledged the use of the demo kit to remedy the lack of content materials during instruction (Abe, Bello, & Hamzat, 2019; Adeoye, 2021; Adeoye & Abimbola, 2016).

The demo kit is a collection of odds-and-ends materials such as beads, threads, bottle tops, cut pieces of paper, thumb tacks, used recharged cards, pen tops and erasers (Adeoye, 2021; Awoyemi, 2018; Onanuga, Saka, Adebanjo, & Olanrewaju, 2019). These items are carefully selected and used during the physical representation of principles, ideas, or data (Clearbird Study Manual, 2004). Demonstrations based on the principle of Applied Scholastic International (2018) involves the use of the demo-kit materials to describe the mechanics of given concepts, actions, situation or processes. Demonstrations are usually done on a table and objects selected from the demo-kit items are moved in relation to one another during the conceptualisation of concepts, processes and actions (Touretzky, 2003).

Research such as that of Awoyemi (2018) and Adeoye (2021) revealed the effectiveness of the demo kit at enhancing senior school students' performance in mathematics and biology, respectively. Furthermore, Onanuga, Saka, Adebanjo, and Olanrewaju (2019) discovered that the demo kit enhanced senior school students' performance in computer studies. Ahmed (2018) conducted research on the influence of study technology strategies on senior school students' achievement in ecology and discovered that students exposed to the use of the demo kit had better achievement. In the same vein, Jiyah (2016) found out that the combined use of hands-on with minds-on instructional strategies enhanced senior school students' achievement in understanding cell division.

In addition, findings from the existing literature indicated that the use of audio-visual and improvised instructional materials facilitated learners' understanding and achievement in different subject areas. For instance, Neboh (2009) observed that learning activity packages positively influenced students' achievement and learning retention in biology. Olasehinde (2018) also discovered that video media instructional strategy enhanced secondary school students' achievement in understanding cell-division concepts. Multimedia has been identified as an effective tool for facilitating students' achievement in biology (Sakiyo, Musa, & Waziri, 2018). Improvised teaching materials have been reported to enhance senior secondary school students' achievement in biology (Ayanda, Olayinka, & Adeoye, 2020).

The aforementioned studies indicated that concerted efforts had been made by different science educators in the use of instructional aids for teaching and learning. Much of the literature available and reviewed by the researchers indicated that most of the existing studies on the demo kit focused on the influence of instructional aids on students' achievement in different subject areas and not the remediation of misconceptions. The need to remediate students' misconception in mitosis and meiosis becomes important because several research findings, such as those of Dikmenli (2010) and Elangovan (2018), had earlier indicated that students held misconceptions on cell division. Thus, the present study investigated the influence of the demo kit on remediating senior school students' misconceptions in mitosis and meiosis in Ilorin, Kwara State, Nigeria.

Literature Review

Learning, irrespective of the form, is aimed at attaining a set of pre-set learning objectives thereby ensuring a permanent change in learners' behaviour. However, the brain (mind), heart (social skill) and hands (manipulative skill) all play significant roles in the attainment of any learning objectives (Roeser, n.d.). Evidence abounds in the literature that the place of the hands in the manipulation of objects and construction of knowledge by learners cannot be overemphasised. For instance, study technology experts such as Adeoye, (2021), Awoyemi, (2018) and Adeoye and Abimbola, (2016) posited that the use of the demo kit could assist learners in perfecting understanding through the manipulation of 'odd and end' materials.

The utilisation of the demo kit in the present study targets students' misconceptions on cell division and corresponds with cognitive constructivist theory of learning. The constructivism theory of learning was put forward by cognitive psychologists who had constructive epistemological perspectives (Piaget, 1968). Knowledge, according to cognitive constructivists is actively constructed by learners rather than passively absorbed (Piaget, 1968). The use of the demo kit for learning corroborates the constructivist theory in that it focuses on how learners interact with information and construct meanings from it using manipulation while the teacher acts as a facilitator of learning (Adeoye & Abimbola, 2016). It is worth observing that demonstration could be in person or, more indirectly, online or by video.

According to Hubbard (1972) the demo kit is potent in providing solutions to the barrier created by lack of content materials thereby remediating misconceptions. Misconceptions are wrong ideas, or beliefs that are not based on correct information nor understood by people (Hornby, 2015). Olorundare (2014) posited that misconceptions impede meaningful understanding of science thereby

standing as a barrier to study. Thus, the identification of misconceptions constitutes an important and prominent stage in remediating students' poor performance in any subject area.

Atilboz (2004) studied the level of understanding and misconceptions of students of mitosis and meiosis and discovered that they experience difficulties in understanding cell related concepts such as deoxyribonucleic acid, chromosome, chromatid, homologous chromosomes, haploid and diploid cells. Ogundare et al (2020) investigated the effects of a concept-mapping instructional strategy in remediating senior school students' misconceptions in ecology and found out that biology students held many misconceptions about ecology but the use of concept-mapping remediated most of the misconceptions. Maizuwo (2011) investigated the effectiveness of demonstration teaching strategy on students' misconceptions of concepts in organic chemistry and concluded that student's misconceptions obstruct meaningful learning and should be firstly remediated using appropriate innovative strategies.

Purpose of the Study

The main purpose of the study was to investigate the influence of the demo kits on remediating misconceptions held by senior-school students about mitosis and meiosis. Specifically, the study:

1. identified the misconceptions about mitosis and meiosis held by biology students;
2. determined the influence of the demo kit on remediating misconceptions held by biology students about mitosis and meiosis.

Research Questions

In this study, the following questions were generated:

1. What are the misconceptions about mitosis and meiosis held by biology students?
2. What is the influence of the demo kit on remediating misconceptions held by biology students about mitosis and meiosis?

Research Hypothesis

The null hypothesis below was formulated and tested in this study.

H_{01}: There is no significant difference in the number of misconceptions held by students taught mitosis and meiosis using the demo kit and those taught using the conventional method.

Methods

Research Methodology

The research design adopted for this study was the quasi-experimental design of pre-test, post-test, non-equivalent and non-randomised control-group design using the 2 x 2 factorial design.

Sample

The population for the study comprised all senior-school students offering biology in Ilorin, Kwara state, Nigeria. The target population for this study was all Senior Secondary School Two (SSS II) students offering biology in Ilorin metropolis. Purposive sampling technique was used to select two co-educational senior secondary schools in Ilorin metropolis, which were classified as experimental

and control groups. The experimental and control groups composed of classes of 35 and 25 students, respectively.

Tools/Techniques

The instrument used for collection of data was Mitosis and Meiosis Conception Package (MMCP), which was designed by the researchers. This instrument was appropriately validated and a reliability index of 0.71 was obtained using Scott's pi statistics.

Procedure of Data Collection and Analysis

A letter of introduction was handed over to the administrators of the schools selected for the study to seek the permission and assistance of the biology teachers and students. Consent forms containing information about the research were given to the teachers and students to indicate their willingness to participate in the study. All ethical issues were addressed in the consent forms. After determining the participation status of the schools selected for the study, the demo kit instructional package was used to train the research assistant from the experimental school on study technology principles and how to remediate misconceptions, with a focus on mitosis and meiosis.

In the second week, MMCP was administered as a pre-test to determine students' misconceptions about cell division prior to their exposure to treatments. In the third week, the experimental group was exposed to the use of the demo kit's instructional package, targeting misconceptions already identified from the pre-test of the MMCP. Participants in the control group were exposed to a placebo using the conventional method. The MMCP was administered as post-test during the fourth week. The data obtained from the pre-test and post-test of MMCP was analysed using descriptive and inferential statistical tools. Research questions were answered using frequencies and percentages while the null hypothesis was tested using chi-square statistics at 0.05 level of significance.

Results

Research Question 1: What are the misconceptions about mitosis and meiosis held by biology students?

Table 1 indicated that participants in the experimental group held misconceptions on items 3, 4, 6, 7, 8, 10 and 11 while they held correct conceptions of items 1, 2, 5 and 9. The pre-instruction misconceptions held by participants in the control group were found in items 1, 4, 5, 6, 7, 8, 10 and 11 while participants in the control group held correct conceptions of items 2, 3 and 9, respectively.

Table 1: Pre-Instruction misconceptions about mitosis and meiosis in experimental and control groups

S/N	Alternative conceptions about mitosis and meiosis	Experimental Group		Control Group	
		Misconceptions (*N*)	Correct Conceptions (*N*)	Misconceptions (*N*)	Correct Conceptions (*N*)
1	The process of mitosis and meiosis aid respiration in living organism	12	23	14	11
2	Mitosis is the division of cell into four daughter cells while meiosis is the division of cell into two daughter cells	8	27	6	19
3	Mitosis is an important process for sexual reproduction	24	11	9	16
4	Meiosis occurs during growth of plants	19	16	21	4
5	Meiosis is a cell division which follows the duplication of only one chromosome	14	21	17	8
6	Chromosome is a pair of genetic materials which is responsible for the formation of zygote	22	13	15	10
7	In early metaphase, the nucleoli disappear	31	4	19	6
8	In early anaphase, the daughter cell and the chromosomes have half of the parent cell	24	11	21	4
9	Telophase is divided into early telophase and late telophase	8	27	3	22
10	In metaphase I, the chromosomes move near the chromatids	25	10	18	7
11	Crossing over occurs when the nucleus has not yet divided and new offspring has not yet been formed	26	9	20	5
Total		**7**	**4**	**8**	**3**

Research Question 2: What is the influence of the demo kit on remediating misconceptions held by biology students about mitosis and meiosis?

The post-instruction results of misconceptions on mitosis and meiosis held by students in Table 2 revealed that students exposed to the use of the demo kit (experimental group) held two misconceptions (items 6 and 11) and nine correct conceptions (items 1, 2, 3, 4, 5, 7, 8, 9 and 10) while those taught with the conventional method (control group) held six misconceptions (items 5, 6, 7, 8, 10 and 11) and five correct conceptions (items 1, 2, 3, 4 and 9) about mitosis and meiosis after instructions.

Table 2: Post-Instruction misconceptions about mitosis and meiosis in experimental and control groups

S/N	Alternative conceptions of mitosis and meiosis	Experimental Group		Control Group	
		Misconceptions (***N***)	Correct Conceptions (***N***)	Misconceptions (***N***)	Correct Conceptions (***N***)
1	The process of mitosis and meiosis aid respiration in living organism	7	18	9	16
2	Mitosis is the division of cell into four daughter cells while meiosis is the division of cell into two daughter cells	5	30	4	21
3	Mitosis is an important process for sexual reproduction	13	22	11	14
4	Meiosis occurs during growth of plants	8	27	6	19
5	Meiosis is a cell division which follows the duplication of only one chromosome	11	24	15	10
6	Chromosome is a pair of genetic materials which is responsible for the formation of zygote	19	16	17	8
7	In early metaphase, the nucleoli disappear	15	20	16	9
8	In early anaphase, the daughter cell and the chromosomes have half of the parent cell	13	22	13	12
9	Telophase is divided into early telophase and late telophase	4	31	5	20
10	In metaphase I, the chromosomes move near the chromatids	12	23	14	11
11	Crossing over occurs when the nucleus has not yet divided and new offspring has not yet been formed	21	14	15	10
Total		**2**	**9**	**6**	**5**

Table 3 indicated that students' held misconceptions about mitosis and meiosis before and after instructions. However, the use of the demo kit remediated five misconceptions (71.43%) out of the seven held by students in the experimental group before instruction, while the conventional method of teaching remediated two misconceptions (28.57%) out of the eight that were identified before instructions. This implies that the demo kit remediated most of the misconceptions held by students about mitosis and meiosis.

Table 3: Contingency table of misconceptions in the pre-test and post-test of experimental and control groups

Groups	Misconceptions		No. of Remediated Misconceptions	% of Remediated Misconceptions
	Pre-instruction	Post-instruction		
Experimental	7	2	5	71.43%
Control	8	6	2	28.57%
Total	**15**	**8**	**7**	**100%**

Research Hypothesis

H_{01}: There is no significant difference in the number of misconceptions held by students taught mitosis and meiosis using the demo kit and those taught using the conventional method.

Table 4 shows that the calculated Chi-square (χ^2) value 80.44 was greater than table Chi-square value (χ^2) of 77.93 computed at 0.05 level of significance (χ^2 (59) = χ^2_{cal} 80.99 < χ^2_{tab} 77.93). This implies that there is a significant difference in the number of misconceptions held by students taught mitosis and

meiosis using the demo kit and those taught using the conventional method. Therefore, the null hypothesis formulated was rejected.

Table 4: Chi-square statistics showing the differences in the number of misconceptions held by students taught mitosis and meiosis using the demo kit and those taught using the conventional method

Group	Students' Misconceptions about Mitosis and Meiosis		Total	*df*	Cal. χ^2	Tab. χ^2	Remark
	Observed	Expected					
Experimental	28	7	35				
Control	16	9	25	59	80.44	77.93	H_{01} Rejected
Total	**44**	**16**	**60**				

**Insignificance at $p < 0.05$*

Discussion

The finding of this study revealed that a significant difference existed in the number of misconceptions held by senior school students taught mitosis and meiosis using the demo kit and those taught using the conventional method of teaching, in favour of students exposed to the demo kit. At first, the number of misconceptions about mitosis and meiosis held by students in the experimental and control groups were almost similar, that is eight and seven, respectively. However, the number of misconceptions remediated after the exposure of students in the experimental group to the demo kit were significantly different from those of the control group.

This finding may be ascribed to the unique features of the demo kit, such as stimulation of learners' imaginative thinking and selection of different sizable materials which can be moved relative to one another to show the mechanics of a given processes. This probably facilitated the meaningful learning of the content and consequently improved students' achievement. In addition, the experimental group had the opportunity to use the demo kit as many times as they wanted, because each student was encouraged to collect their own the demo kit contents and this might have aided the continued learning of the content by students after the normal classroom lessons. It was vividly clear that the demo kit facilitated the teaching and learning of mitosis and meiosis due to the number of misconceptions remediated after instruction.

The pedagogical implication of this finding is that the demo kit is perfect for learning about microscopic and cellular related topics in the Nigerian Senior Secondary School Biology Curriculum. The results of this study corroborate that of Adeoye (2021) where the researcher observed that the use of study technology tools such as modelling clay and the demo kit enhanced senior school students' performance in cell division than the convectional method of teaching.

Furthermore, the findings of the present study tallies with that of Onanuga et al(2018) who discovered in their separate studies that students exposed to the demo kit had a better achievement than those exposed to the conventional method. The findings of this study have substantiated the submissions of Dikmenli (2010), Jiyah (2016) and Elangovan (2018) that students' misconceptions about mitosis and meiosis were remediated with the adoption of appropriate hands-on with minds-on instructional tools and strategies.

Conclusion

The study concludes that students held misconceptions about cell division before and after instructions. However, the use of the demo kit helped to remediate students' misconceptions about cell division. Thus, the demo kit can be adopted for the remediation of students' misconceptions about cell division to improve their achievement and understanding of biology concepts. By implication, instructors and the entire academic community involved in the implementation of the curriculum ought to adopt the use of the demo kit to assist learners in the remediation of their misconceptions. This also includes use of the demo kit in open and distance learning provision.

Recommendations

The following recommendations were advanced based on the findings of the study:

1. Biology teachers should be sensitive to students' pre-instructional and post-instructional misconceptions and endeavour to identify them.
2. The demo kit should be use by teachers to remediate students' misconceptions about cell division and other related biology topics.

Suggestions for Further Studies

Future researchers could carry out related studies with a focus on other forms of manipulatives. In addition, the current study could be replicated but at a different geographical location and involving larger sample sizes to investigate the consistencies of findings for the conduct of meta-analysis studies. It would also be valuable to research the use of the demo kit to support learning in remote, distance and online learning given that the kit can be constructed by individual learners and its use demonstrated by video.

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