Science Education International
34(1), 25-34
https://doi.org/10.33828/sei.v34.i1.3

ORIGINAL ARTICLE

How is Mendelian Genetics Taught in Malawi?

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ABSTRACT

Understanding genetics, an important topic in the study of biology, is critical for scientific literacy in agriculture, health, and forensic investigations. However, it has been observed that teachers find genetics difficult to teach and pupils do not perform well in it. Teachers can use expository teaching or active learning methods, but the secondary school curriculum in Malawi advocates the latter. The aim of this study was to find out how genetics is taught and how teachers justify their choice of method. This study used a multi-case design involving six teachers and observed their Mendelian genetics lessons and asked them to justify their choice of teaching method. The findings show that teachers mostly use expository methods utilizing lecture and question and answer teaching techniques. Contextual factors such as large classes, limited teaching time, and lack of resources were cited as reasons for their choice of expository techniques. In addition, they said that the topic was abstract and learners could not construct their own understanding. Furthermore, they indicated that they did not know what activities to arrange for the learners. The paper discusses the difficulties experienced in implementing active learning methods in teaching genetics and recommends possible avenues for teacher education and further research in Malawi.

KEY WORDS: Active learning; expository teaching; Mendelian genetics

INTRODUCTION

Understanding genetics, an important topic in the study of biology, is critical for scientific literacy in agriculture, health, and forensic investigations (Chu, 2008; Knippels et al., 2005). In Malawi school biology, genetics encompasses appreciation of variations in organisms, the cause and how to represent them, mitosis and meiosis as cellular mechanism of passing on inheritance from parents to offspring, and Mendelian genetics (Ministry of Education, Sports and Culture, 2013). However, in Malawi, like in many other countries, teachers and learners perceive genetics as a difficult topic to learn and this is reflected in their performance (Chu, 2008; Dlamini, 1999; Knippels et al., 2005; Mdolo and Mundalamo, 2014). This study was carried out in 2019 to find out how genetics is taught in some Malawian classes, using qualitative multiple case study design. Although this report comes 3 years later, it is still relevant as there has been no change yet in the secondary school or teacher education curriculum on this topic.

Problems of Learning and Teaching Genetics

It has been observed that teachers find teaching genetics difficult, and pupils do not perform well in it. At the theoretical level there are three main perspectives to explain the source of difficulty (Knippels 2002). From information processing model, genetics is said to require more working memory capacity than pupils have (Chu, 2008). Piagetian theory of cognitive development was prominent in the 1990s would suggest that difficulties in learning genetics emanated from its abstract nature and requirement of use of formal operation reasoning patterns such as probability, proportions and combinations. Survey studies showed that the majority of pupils in secondary classes had not developed formal operations thinking in spite of instruction (Mbano, 2003; Shayer and Adey, 1981). However, recent work has shown a decrease in using lack of formal operational thinking as an explanation for the difficulties associated with learning genetics and progressively ascribes more weight to misconceptions or alternative conceptions that learners bring to genetics classes (Knippels 2002). Constructivists stress the development of concepts through construction, which results in preconceptions, some of which can be misconceptions (Driver, 1980). These misconceptions have a significant influence on learning through learners' questions and explanations. In genetics many students confuse the terms such as gene, allele, chromosome, mitosis, and meiosis. The misconceptions may rise from textbooks, teaching methods or media (Machová and Ehler, 2021). Suggested methods for eliminating misconceptions and developing understanding include actively challenging learners' previous ideas and helping them reconstruct new understanding through activities such as problem tasks, discussions, experiments, and working with text or diagrams (Machová and Ehler, 2021). Johnstone (1991) provides another explanation when he describes the difficulty in science as arising from its multilevel nature. At low level, it involves description of observable characteristics such as flower color, seed coat, height, and tongue rolling. The next questions would be: What brings about these differences, and how are these differences inherited? This would lead to

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34(1), 25-34
https://doi.org/10.33828/sei.v34.i1.3

examining unobservable factors and mathematical modeling, such as is the case of Mendelian genetics. The next level would be molecular modeling and explaining inheritance using DNA. Working through these levels poses formidable challenges to both pupils and teachers.

Haambokoma (2007) and Musonda (2014) both using survey methods in Zambia to identify the difficult genetics topics as Mendelian genetics, mitosis, meiosis, genes, and chromosomes. Knippels et al. (2005) analyzed focus group interviews with teachers and found that they perceive the sources of difficulties in genetics instruction as having to do with terminology and vocabulary, mathematics, cytological process, abstract nature, and complex nature. In terms of vocabulary, there are so many new words introduced in genetics within a short time that are similar such as chromosomes, chromatids, homologous, and homozygote. In addition, the processes of mitosis and meiosis are confusing as they are similar in terminology and process, yet they are different in outcome. Mendelian genetics has a lot of mathematics, mostly to do with probability and combinations. Pupils have difficulties in transferring what they have learnt in mathematics to genetics. Musonda (2014) reported that pupils suggested reasons for the challenges in learning the above topics as rising from the complex terms not clearly explained, lack of practical laboratory work, teaching theoretically, lack of resources such suitable textbooks, as well as failure by the teachers to use ICT in the classroom. Whilst Haambokoma (2007) found that inadequate time allocated to teaching of the topic as one of the perceived sources of difficulty.

That teaching genetics posed challenges in Malawi was highlighted in 2010 at the annual workshop of 'Strengthening of Mathematics and Science in Secondary Education' (SMASSE), a Ministry of Education, Sports and Culture (MoEST) program designed to improve mathematics and science teaching, where biology teachers requested assistance in the teaching of genetics. Furthermore, the Chief Examiners' reports of the Malawi National Examinations Board (MANEB) showed that very few candidates attempted genetics related questions on the Malawi School Certificate Examinations and most of those who did attempt the questions gave wrong answers (Malawi National Examination Board, 2013, 2014, 2015, 2016, 2017). There are several reasons for the challenges in teaching genetics. Most biology teachers may not have studied genetics at secondary level, because it is not usually taught (Haambokoma, 2007). Genetics, as a topic, is left out because it comes at the end of the syllabus in the scope and sequence (Ministry of Education, Sports and Culture, 2013) and due to pressure of time in an overcrowded syllabus. Furthermore, some teachers are underqualified in that either they did not study biology at college level or they did but did not study education.

Statement of the Problem

Genetics, a topic in biology, is usually not taught because teachers find it difficult. The secondary school curriculum in Malawi advocates active learning method which stems from constructivism (Ministry of Education, Sports and Culture, 2013). Constructivists believe pupils construct knowledge and understanding as they interact with the physical and social world. Accordingly, teachers must facilitate this by organizing the pupils' experience so that pupils construct their own knowledge and understanding (Bodner, 1986). Vygotsky (1978) adds the social dimension by advocating that learning happens in two phases: first at interpersonal level as pupils interact and then at intrapersonal level as the learner internalizes what she or he has seen in others. Thus, active learning method has three aspects: physical experience (hands on), social level (interaction) and cognitive level (minds on). The question is how is Genetics taught in Malawian schools with large classes, underqualified teachers, and a paucity of resources?

Research Questions

How do teachers teach Mendelian genetics?
How do they justify their choice of teaching method?

LITERATURE REVIEW

Some terms in pedagogy, such as approaches, methods, strategies, and techniques are used interchangeably, causing a great deal of confusion. Hence, it is necessary to start by defining them. Teaching approach is a broad term describing a general orientation to teaching, anchored is some theoretical perspective (Gill and Kusum, 2017). *Teaching method* is undertaken according to an approach and involves "organized, orderly, systematic, and well-planned procedures, aimed at enhancing learning" (Hasanova et al., 2021, p. 371). "The term teaching method refers to the general principles, or pedagogy used for classroom instruction" (Hasanova et al., 2021, p. 372). Teachers choose methods depending on teaching approach, class size, and the subject. In general, a strategy is a plan for achieving goals usually over a long period of time. In teaching the goal is to ensure effective teaching and learning (Hasanova et al., 2021). In planning a strategy, the teacher will consider both approach and method, and plan activities accordingly. Teaching techniques are ways of carrying out a particular task, such as by lecturing, demonstration, questioning, group discussion, practical work, and individual exercises. In this regard, teaching approach is the umbrella concept from which teaching methods, strategy and techniques are derived. Figure 1 shows the relationship between the terms.

Teaching Approach

There are generally two approaches to teaching: teacher-centered and student-centered teaching. Teacher-centered teaching has its roots from behaviorism, which asserts that pupils come to school as empty slates on which teachers write. It advocates expository teaching method in which the teacher is seen as an authority of knowledge who transmits this to pupils. The common techniques involved are lecture, whole class question and answer, and demonstration. Laboratory work is done to confirm or illustrate what the teacher has stated

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(Eilks and Kapanadze, 2012). This approach has been shown to be less effective in science teaching than student-centered approach (Freeman et al., 2014). On the other hand, student-centered approach is based on constructivism. As a result of pupils constructing knowledge from experience they come to class with prior knowledge which influences their learning through questions they ask, investigation they want to do and explanations they give for their findings (Driver, 1980). It is believed that the pupils have internal motivation to learn and are active learners. The teacher is seen as a facilitator of learning rather than a transmitter of knowledge (Eilks and Kapanadze, 2012). Class work involves small group practical work and discussion. The term student-centered is a bit of a misnomer, as a truly student-centered curriculum would mean the pupils would determine what they want to learn and how they learn. This is rarely the case as most countries have set curriculum with examinations, as the case is in Malawi.

Teaching Methods

The categorization of participatory and non-participatory methods is more realistic than that of approaches described above. Non-Participatory methods refer to expository, direct instruction, under teacher-centered approach where pupils are passive recipients of information. Participatory or active learning methods refer to situations where pupils are actively involved in their learning. The active learning theory contends that "knowledge cannot be transferred intact from the mind of a person into another" (Eilks and Kapanadze, 2012, p. 117). Learning involves active integration of new information with pre-existing knowledge. Some principles of active learning involve activation of student's prior knowledge, minds on, hands on, cooperation, and communication activities. Science education advocates participatory or active learning methods. However, there are three distinct methods: expository, discovery learning, and inquiry-based learning. These present a continuum in terms of teacher control where in expository teaching the teacher has total control, in discovery learning the teacher retains partial control and inquiry-based where pupils have greater control. Expository method is a teacher centered way of teaching. The teacher gives explanations, interpretation, and implication of phenomenon and learners passively listen. It follows a deductive approach where learners are introduced to theories and principles and later given practice in their uses. Inquiry-based methods are more learner-centered but differ to their extent. Discovery learning, advocated by Brunner, gives the teacher the role of a guide. Learners answer a series of questions or solve problems designed to assist them develop understanding concepts at hand. Inquiry-based method is an extension of discovery learning where the learner has more control. The teacher may initiate the process by posing a problem and students work to solve the problem, designing their investigations, collecting data, interpreting data, hypothesizing, and testing their hypothesis (Anyafulude, 2013; Domin 2007; Sotáková et al., 2020). These three distinct methods are summarized in Table 1 adapted from Domin, 1999).

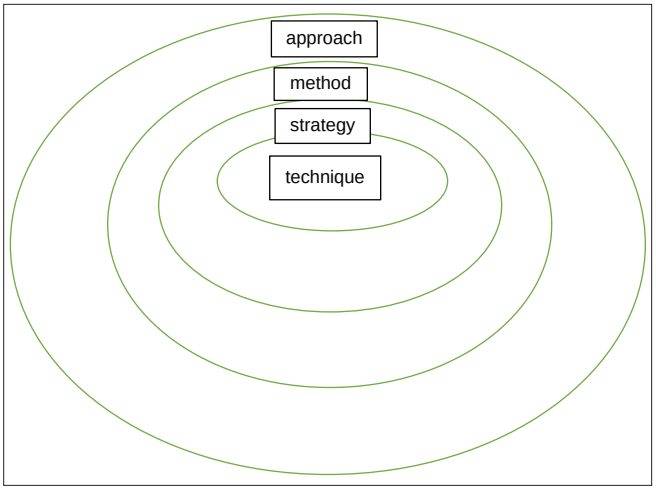

Figure 1: Relationship between teaching approach, method, strategy, and technique (adapted from (Hasanova et al., 2021)

Conceptual Frameworks

The three teaching methods - expository teaching, discovery learning, and inquiry-based learning can be characterized by a sequence of four teacher moves described by Henderson (1963), cited in Bhalwankar (1984), although with respect to mathematics teaching. These are State the rule (SR), Clarify the rule (CR), Justify the rule (JR), and Apply the rule (AR). Expository method has the sequence SR-CR-JR-AR while discovery and inquiry base methods have CR-JR-SR-AR sequence. Although these teacher moves were described with respect to mathematics teaching, they are appropriate for science teaching as well.

Another useful model to use in analyzing lessons is Bybee's 5 E model (Bybee, 2014) for active learning. The five Es comprise Engagement, Exploration, Explanation, Elaboration, and Evaluation. In Engagement phase, the teacher gets pupils to engage with new concept by arousing their interest, eliciting prior knowledge, and point out the learning outcomes. Explorations involve teacher arranging activities for pupils to explore the prior knowledge to the limit and start searching for additional knowledge. In Explanation phase, the teacher may directly introduce the new concept. During Elaboration, the pupils use the new concept to explain their findings and Evaluation is a way of assessing what has been learnt. There is some overlap with Henderson's teacher moves and Bybee's 5 E. Engagement involves introduction of the new topic by first eliciting prior knowledge, Exploration involves clarification of the rule, which comprise some inductive activity. Explanation involves stating the rule and elaboration is justification and application. Evaluation may be part of application of the rule.

Table 1: Teaching methods

Method	Outcome	Approach	Procedure
Expository teaching	Predetermined	Deductive	Given
Discovery learning	Predetermined	Inductive	Given
Inquiry based learning	Undetermined	Inductive	Student generated

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METHODS

The study used a qualitative multiple case study to explore how six teachers from six schools drawn from Lilongwe district in Malawi taught Mendelian genetics and how they explained their choice of teaching techniques used. The case study design would help us gain an in depth understanding of the teachers' actions and thoughts about teaching Mendelian genetics (Cohen et al., 2007), but it has the limitation in that the findings apply to the sample population and cannot be generalized outside this. However, the situation under study is typical of Malawian schools and therefore may be applicable in a general sort of way.

The second author observed the six teachers teaching a lesson respectively on Mendelian genetics and thereafter interviewed them on what teaching techniques they used and why, respectively, as part of his studies for his Master of Education. During the lesson observation, the researcher audio recorded the conversations and made notes of what was happening. The observer sat at the back of the classroom during lesson introductions and could move around when pupils were given tasks to do in groups while taking down notes. Furthermore, the researcher used a semi-structured interview schedule to interview the teachers after the observed lesson. The teachers were asked to describe the techniques they had used in teaching and why they made those choices. They were further asked to evaluate their lessons. Both the lesson, observation and interviews had been piloted.

Ethical Considerations

In the schools, the head teachers introduced the researcher to the teachers who were to participate in the study. Permission was sought from the teachers (participants) to interview them and observe their lessons. They were also informed that participation was voluntary, and they had the right to withdraw from the study at any point. They assured of confidentiality in reporting and the identity of the school and teacher were concealed through the use of pseudonyms.

Data Analysis

Data collected were analyzed using the conceptual frameworks. The lessons were coded using the teacher moves and Bybee's 5 Es. This provided the basis for describing the lessons and explaining the finding. Data from the interviews were coded using emerging themes.

FINDINGS

Demographic Data of Respondents

The study involved six biology teachers in six different schools, who have been teaching biology, in particular, the topic of Mendelian genetics. The teachers differed in terms of sex, educational qualification, and experience in teaching the topic, Table 2.

Table 2 shows the characteristics of the participants such as sex, educational qualification, and work experience as a biology teacher. The participants were just identified as form four biology teachers. Two of the participants had degrees in education specialized in biology. These may be considered to have enough content knowledge and pedagogy for teaching Genetics. The other two participants, who had general degree, may have the content but may lack the effective teaching techniques for the teaching of Mendelian genetics. The participant with diploma in education may have knowledge of the teaching techniques but may not have enough content to teach effectively. Whilst the participant with primary school teaching certificate and Malawi Schools Certificate of Education (MSCE) may lack both the content and the pedagogy for teaching this topic.

Table 2: Demographic data for respondents

Teacher identity	School	Sex	Educational qualification	Work experience (years)
Kondwani	Banga	M	B.Ed.	5
Chakwindima	Ngolokela	M	B.Ed.	7
Sapulaya	Dema	F	B.Sc. (Environment)	16
Ginito	Mlala	M	B.Sc. (Fisheries)	1
Sadulo	Chithowe	F	Dip. Ed.	3
Tebulo	Navundi	M	MSCE	14

NB: All names of schools and teachers are pseudonyms

Description of an Example of a Lesson

One lesson is described in full and analyzed to give a sense of what happens in a lesson. Thereafter, the rest of the five lessons are summarized.

Lesson by Sadulo

The participant was a 25-year-old female biology teacher, with a Diploma in education and three years teaching experience. The aim of the lesson was to allow pupils to work out the ratios of genotype and phenotype in F2 of a monohybrid cross. During the lesson introduction she went straight to introduce Mendelian experiments. She explained that Mendel used peas in his experiments. She said that he started by selfing (crossing plants of the same characteristics) pure lines of tall plants. She drew a cross shown below to explain how this resulted in all tall plants (Figure 2). This is basically SR, as it is an explanation with no elicitation of prior knowledge. The pupils are assumed to have no prior knowledge and to be passive recipients of knowledge.

The teacher then asked the pupils to state the processes that are taking place. The pupils' responses included meiosis, formation of gametes, in breeding. The teacher asked, "What do you mean by inbreeding?" This CR, getting pupils to clarify meaning. The pupils did not respond and teacher answered her own questions. This is reverting to SR.

She then described the outcome of selfing dwarf plants (Figure 3).

The teacher went on to describe how Mendel crossed the pure breeds of tall and dwarf plants. The teacher asked a pupil to

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come up with the outcome of the cross on the board. Figure 4 shows what a pupil wrote on the chalk board.

After this, pupils were asked to work in groups to come out with products of selfing F1 generation. The pupils discussed in groups and came up with genotypes, genotype ratios and phenotype ratios. Pupils were asked to present their findings on the board; Figure 5 shows how the pupils represented the cross of F1. The teacher went over the process of working out selfing of F1 and asked the pupils to define the terms: homozygous and heterozygous.

This is an extension of CR as they are consolidating technical terms that have been introduced.

The teacher now explained that genes occur in pairs. She asked pupils to explain what phenotype is and give the phenotype ratio. She guided the pupils by asking them to identify those that are tall. The teacher explained that the recessive genes

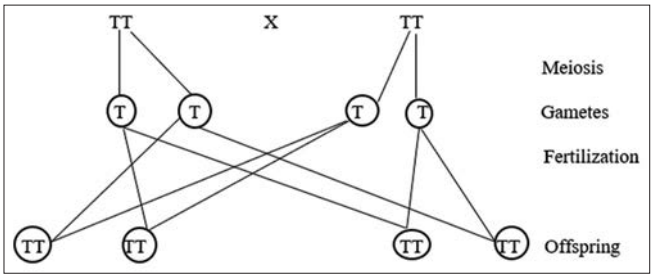

Figure 2: Pure lines Tall plants selfed

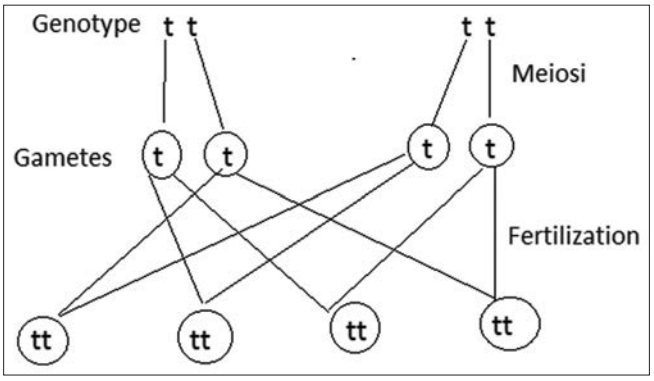

Figure 3: Pure lines Dwarf plants selfed

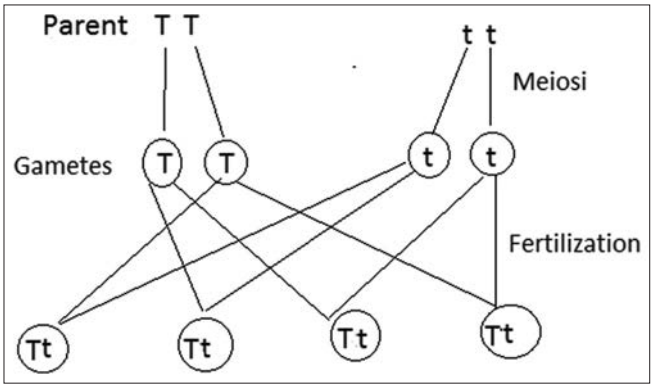

Figure 4: A cross between tall and dwarf plants

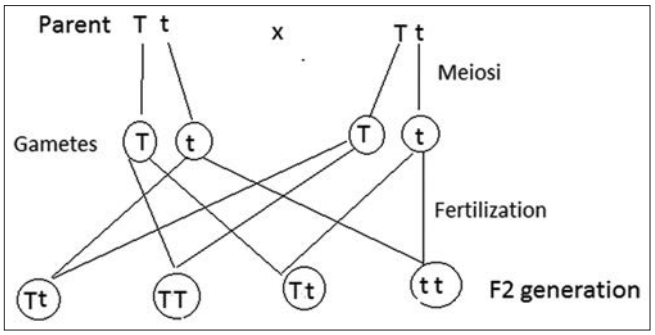

Figure 5: A cross of F1

are not expressing themselves in the phenotype. The teacher concluded through asking questions. This is continuation of CR. Pupils continue to elaborate on what they have learnt. The teacher then introduced sex determination in humans. This seems to overload the lesson. They should have been given more practice with working out genotypical ratios. Through question and answer the teacher explained that sex of a human is determined by X and Y chromosomes: XX for female and XY for male. This is SR, telling pupils how sex is determined. She gave the pupils homework to work out the probability of having a male or female child. This was AR. However, pupils will work on this with no guidance. In conclusion asked pupils what they had learnt, including definitions of homozygous, heterozygous, and phenotype.

Overall the lesson proceeded from SR-CR-CR-CR-SR-AR.

Post Lesson Interview

The teacher said that she used small group work, question and answer, explanation, discussion, and practice. On small group work, the teacher said "small group work was used because other pupils are just dormant as such a teacher can teach and teach without pupils understanding." The aim of the small group work was to involve the pupils in the lesson. Here, the reason seems to be more on participation rather than actual learning/construction of meaning or social interaction.

The teacher said that question and answer as a teaching technique was used to provoke thinking in pupils. However, the questions were of recall type, mostly definition of terms. She further said that explanation was used to clarify the answer. This is the teacher transmitting the information to pupils. She further said that discussion was important to involve everyone in the class. This is more on participation than construction. It can be observed that discussion is simply variation of small group work which involved pupils just talking to each other. On the other hand, group work sometimes involved joint problem solving. She further explained that practice was used to ensure that the pupils master the concepts so that next time they do not forget this. This about learning skills. On the short falls the teacher said she had problems in consolidating all the answers of the pupils because of the time factor. The teacher failed to come up with alternative teaching techniques that would have made the lesson more effective. Overall the teacher's views seem to be "Involve pupils in small group work and discussion,

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Table 3: Summary of the six lessons

Teacher	Qualifications	Experience	Teacher moves
Sadulo	Dip.Ed.	3	SR-CR-CR-CR-SR-AR
Sapulaya	B.Sc. (Environ)	16	CR-CR-SR-SR-SR-CR-SR-CR-CR-SR-AR
Tebulo	MSCE	14	CR-SR
Kondwani	B.Ed.	5	SR-SR-SR-SR-CR-SR-SR-CR-SR
Chakwindima	B.Ed.	7	CR-SR-SR-CR-CR-SR
Ginito	B.Sc. (fish)	1	SR-SR-SR-SR-SR SR

so that they participate, explain to them so that they understand and give them practice to acquire the skill."

Summary of the Six Lessons

Table 3 presents a summary of teacher moves in the six observed lessons.

Table 3 shows the common moves for the teachers were SR and CR. AR was observed in two lessons only and none of the lessons had JR. SR mostly involved description of Mendel experiments, working out the genotypic and phenotypic ratios, and defining the technical terms. CR involved some elicitation of prior knowledge at the beginning of the lesson, deducing what terms mean and working out ratios. AR involved group work to work out genotypic and phenotypic ratios. Pupils were not called to explain what caused the observed ratios. Examining Bybee's 5E shows that they were limited because the lessons hardly had student activities. Engagement (CR) was mostly done through whole class question and answer, resulting in teacher-centered lessons. Explanation (SR) was mostly through lecture. Exploration (CR) mostly involved working out ratios in small group. Elaboration (JR) and Evaluation (JR/AR) were not clearly observed.

Teaching Techniques Employed by the Teachers

Lecture

All teachers lectured at one point during the lessons, though it was more prominent with Kondwani who started with a projector and switched to using chalk and talk due to electricity blackout. The teacher exposed pupils to genetic terms such as genotype, phenotype, dominant, and recessive genes and co-dominance. It was clear that pupils could not grasp the terminology as they failed to define the terms. Teachers justified the use of lecture as a way to save time, to cover more content, and as a solution to resource constraint. Below are some representative extracts:

> *. I had a large amount of content to be covered as this is third term and they are about to write national examinations.* (Kondwani)
>
> *… As you are aware it is not easy to come up with experiments in genetics at secondary school at the same time, we do not have materials for demonstration.* (Sapulaya)
>
> *… Pupils develop listening skills and that it is important when introducing the lesson apart from that the class was very large to have activity base lesson. (*Ginito)

Question and answer

All teachers in this study at one point used the question and answer technique. Teachers introduced, developed, and concluded their lessons using this technique. During introduction, Kondwani, Chakwindima, Sapulaya, and Tebulo started by asking the pupils oral questions on what they already know or learnt about genetics. While, Sadulo and Ginito went straight to the topic of the day without asking pupils prior knowledge on genetics. However, the teachers asked questions that mostly demanded recall of information. All teachers said questions are important in revising previously taught concepts which are important to connect to the new ideas about genetics. However, during the questions and answer sessions many pupils remained quiet. During the lesson of Sapulaya, only one pupil was able to ask a question:

> "*How can they come up with the genotypic ratio?*"

The question was referred to the whole class and it was a fellow pupil that answered. The teacher summarized the answer. Ginito used questioning to find out pupils' knowledge about Mendelian genetics, but the unfortunately the questions were asked in a fast manner without allowing time for reflection. In the end it was the teacher who answered his own questions. Another challenge of question and answer techniques was in the lesson presented by Ginito, where he asked: the pupils questions; *"What color are the flowers?"* Pupils answered the questions in chorus. "*Red and white*." The way question and answer was utilised in the teaching of Mendelian genetics was not effective because most of the questions were answered by the teachers themselves. This could easily discourage pupils from engaging as they know that in the end the teacher would answer his own question. Teachers suggested that question and answer as a teaching strategy was generally used for assessment, attracting attention, and to stimulate thinking, for example:

> *… As you could see some of the questions that I asked were of national examinations standards as such I am preparing them for that national competition.* (Kondwani)
>
> *… Question and answer as a teaching strategy helped to know about the pupils' preconceptions about Mendelian genetics. This assists on how to handle the lesson and correct the misconceptions.* (Chakwindima)
>
> *… Question and answer provokes thinking if well used.* (Sapulaya and Sadulo)
>
> *… Question and answer was used to ensure that pupils are involved throughout the lesson.* (Tebulo)
>
> *… Question and answer was used to make sure that pupils are kept alert during the lesson as the teacher may ask them to respond to the question any time.* (Ginito)

Explanation as a teaching technique

In this study, it was observed that explanation as a teaching technique was utilized by all teachers. This is the time pupils get facts about what they should learn. In addition, explanation was to clarify some points and simplify those that pupils had problems with.

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Teachers said explanation was used mainly to introduce and clarify concepts and to allow the pupils to construct their own picture of the concept, as evidenced below:

> … *explanation was used because the topic on genetics is difficult to the pupils and the teacher has to explain to ensure that pupils understand the concepts. However, with enough time experimentation would be better. (*Ginito)
>
> … *Explanation is important because a teacher guide the pupils, clarify points, and help pupils to internalize the concepts.because this topic is more abstract explanation is more convenient as this strategy does not require learning materials. (*Sadulo)
>
> … *Genetics is abstract and that is why I used both Chichewa and English to clarify the points better. (*Sapulaya)

Small group discussion

Small group discussion is very important technique as it enhances pupils' interactions if properly utilized. According to Omatseye (2007), discussion is a child-centered teaching technique, in which pupils are divided into groups and they are encouraged to discuss on the subject matter given. During class observation, Chakwindima, Sapulaya, Sadulo, Tebulo, and Ginito grouped pupils to discuss problems given to them. Pupils in groups discussed and agreed on what to be reported to whole class. After group work presentations, whole class discussions followed.

Although small group discussion was observed in all the lessons except for Kondwani's, its effectiveness and reasons for using it varied from teacher to teacher depending on how the lesson had been organized. In addition, the small group work organization differed from teacher to teacher. For example, Chakwindima, Sapulaya, and Sadulo had permanent biology learning groups. While for Tebulo and Ginito, the groups were formed haphazardly during the lesson. For example, Ginito said, *"These desks form one group and those another group and so on."* There was no criterion for group formation. Some groups were for boys only while others were for girls only and some mixed. Some of the teachers did not take into consideration pupils' ability when forming these groups as it was observed that some groups were more active than others.

Chakwindima used small group discussion based on sharing use of a textbook. He asked the pupils to go into their usual groups and distributed senior biology text books. He gave the instructions such as:

> … *read the passage on Mendelian genetics from the textbook of Senior biology and answer the questions that follow. One member will present the answers to the whole class.*

In this class, the groups were already there as they seemed well-organized, with group leaders. There were eight members per group with one text book of biology per group. The pupils answered the questions about variations after reading the text from the book. The teacher supervised the group work. Then the group secretaries presented their work to the whole class. Pupils were able to isolate causes of variations as environmental factors, age, and genetic factors. As group members were reporting, other class members could ask questions which engaged the whole class discussion and the teacher could consolidate the discussion. The whole lesson became a comprehension exercise.

Another example of group work was observed in the lesson by Sapulaya. Before the pupils went into groups the teacher wrote the question on the board for pupils to copy. The teacher read the question to the pupils:

> … *In wild rabbits the fat beneath the skin is white. Certain domestic breeds have yellow fat. When a pure strain of wild rabbits is crossed with domestic rabbits, f1 individual have all white fat. If f1 is mated (selfed) to give f2 generation, white and yellow fat are found in proportion of 3:1. Show in a genetic diagram form how this ratio is arrived at.*

The teacher instructed pupils that after doing the task one representative from each group should present the findings to the whole class. In one group, the pupils were stuck and asked the teacher to simplify the question further, which the teacher did. After the allocated time came to an end some groups had not yet finished the task. So only groups that had finished presented their work by choosing one student to present the findings on the board.

It must be noted that many pupils are not enthusiastic about group work. In most cases, the majority of pupils did not participate in group activities. This happens when pupils realize that nothing or very little happened from previous groups. The group ineffectiveness may be the product of poorly designed group tasks as well. A carefully thought out, creative, and purposeful task greatly reduce pupils' passivity and engender much more positive feelings about group work (Erickson et al., 2006).

The group work organized by Tebulo, for example, was not effective since the teacher was not well prepared for the activity. The teacher only had one type of flowers to be observed and then pupils discuss variations. The lesson was conducted during rainy season when flowers are in season and the teacher has collected a variety of them for pupils to describe. Such group work cannot be effective as pupils do not have common experience as a basis for discussion. Ginito, on the other hand, had a variety of specimen of flowers, beans, and maize seeds, so comparison of the colors was meaningful during the discussion.

Much as these teachers emphasized discussion as an effective teaching method, not much was seen during the classes observed. In all the lessons, there were few individuals who dominated in both group and whole class discussions and the teachers could refer to such pupils more than everyone else in the class. It appeared that most of the pupils switched off. This made the lessons not student-centered. There were many pupils who were just pretending to be part of the discussion but contributed nothing.

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34(1), 25-34
https://doi.org/10.33828/sei.v34.i1.3

However, the need for group work cannot be over-emphasized as Erickson et al. (2006) observed that group work enhances learning. Weak pupils working individually are likely to give up when they get stuck; but when they work cooperatively in groups they keep going. At the same time strong pupils faced with the task of explaining and clarifying material to the weaker often find gaps in their own understanding and fill them.

During post-lesson interviews teachers said group work as a teaching technique was used to help pupils participate in the learning process and to utilize the insufficient resources that were available:

> *… it allows pupils to participate and learn from each other. The exercise that was given required pupils to answer in groups that gave a chance to pupils to reflect on the responses in their groups and endorse what was to be presented. Furthermore, group work allows teaching to take place with limited resources as you may remember one book was used by eight pupils. (*Chakwindima)
>
> *… group work was used because other pupils are just dormant as such a teacher can teach without pupils understanding. So, group work would involve them in the production of the solutions to the tasks given.* (Sadulo)
>
> *… pupils in a discussion class are not passive listeners neither is the teacher a sole performer. There is interaction among pupils themselves and between the teacher and pupils. Some pupils are more active during discussions either in pairs or small groups. Those who are shy to talk to the whole class were able to contribute in their group discussion. (*Chakwindima)

Sadulo and Tebulo said that they used discussion for teaching genetics because every student was involved during the activity. Whilst Sapulaya and Sadulo said that discussion was used because some pupils learn from each other better than from the teacher:

> *... so the difficult terms could be leant better from fellow pupils. And pupils can put the definitions in their own language, that they can understand best.*

These lessons showed that discussion was used to make pupils interact with peers, teachers, and content on the Mendelian genetics. However, pupils had little content to discuss, which suggests that the choice of this technique was not appropriate One teacher who did not employ this technique, when asked why, responded:

> *... this is a difficult topic to the pupils as such the teacher has to give out information first, otherwise pupils would have nothing to say in their discussion. (*Kondwani)

Demonstration

This technique was used by one respondent; however, it is important to note that it is not easy to demonstrate most of the concepts in Mendelian genetics.

> *… In this case for pupils to do an activity we need to know how to do it. Some pupils did not know tongue rolling and when I demonstrated it, the pupils knew what tongue rolling was all about.* (Tebulo)

Table 4: Reasons for choice

Theme	Technique	Some examples
Cognitive reasons	Lecture	• Cover more content • Prepare for exams • Develop listening skills
	Question and answer	• Assessment, • To stimulate the thinking • Elicit preconception
	Explanation	• Introduce • Clarify concepts
	Small group work	• Pupils help each other • Allow the pupils to construct their own picture of the concept.
Management reasons	Lecture	• Save time • Cover more content • Solution to resource constrains • Large class difficult to do activities
	Question and answer	• Attracting attention • Participation in the lesson
	Small group work	• Help pupils participate in the learning process • Utilise the little resources that were available • Student-student interaction • Student – teacher interaction • Shy ones participate
Pedagogical reasons	Lecture	• No idea of what practical to do

Reasons Teachers Gave for Teaching Technique Used

Three themes emerged from the teachers' responses, namely: Cognitive, management, and pedagogical reasons. Table 4 presents a summary of the reasons given.

Summary

All of the six teachers used expository, and none used discovery learning or inquiry-based teaching methods. The focus of the lesson was to pass on information such as definition of terms (genotype and phenotype) and practice working out the outcomes of monohybrid crosses. The common teaching techniques used were lecture and question and answer. However, some teachers such as Chakwindima and Sapulaya used small group discussion and whole class discussion. There was no modeling nor representation. Teachers used textbooks, board and chalk and specimen as resources for teaching. All described the techniques they had used and gave reasons for their choices.

DISCUSSION

How is Genetics Taught

The findings show that the six teachers taught genetics using expository method, with teacher moves SR-CR-AR and no JR. Furthermore, there was Explanation, Exploration, and Engagement from Bybee's 5E and no Elaboration and Evaluation. The teachers used a variety of teaching techniques mainly lecture, question and answer, and small

group discussion. They used very limited resources such as textbooks, specimen and the chalk board. The findings are similar to those findings of other studies done in Malawi and other countries (Chifwa, 2015; Constantinou, et al., 2018; Mdolo and Mundalamo, 2014). Chifwa (2015) in a study in Zambia found, that:

The majority (13; 72%) of the teachers used lecture method to teach genetics while some teachers (5; 28%) used group work. All the teachers observed used question and answer technique at some point during the lessons but asked low order questions. They did not use teaching aids or practical work when teaching genetics. Further, they did not give homework to the pupils. (p iv-v).

It is interesting that these teachers used expository teaching method whilst the curriculum advocates active learning method. They seem to be aware of the curricular requirements, the benefits of active learning method, but cite contextual constraints such as lack of time, large classes, lack of resources, and lack of knowledge of activities to use or alternative approaches (Mdolo, 2010). This situation is common in many countries, where teachers choose to teach using expository methods rather than active methods such as inquiry-based teaching and learning (IBSL/T):

Even though science educators value opportunities that IBSL/T offers to learner, they often show reluctance in enacting IBST approaches in their teaching, as they consider those approaches as time-consuming leading to conflict with the requirement to deliver curricula content. (Constantinou et al., 2018, p. 11).

The advantages of expository methods include being able to cover large amount of content in a short time and teaching in whole class setting which is easy in large classes. However, the disadvantages are well known, such as no participation of learners, which is critical for development of concepts. Domin (2007) found that expository learning can be can be enhanced by giving learners opportunity to reflect on content through tasks given after lab sessions, lectures, reading and the writing of lab reports. In the case of the six teachers in this study, only one teacher gave homework. Chifwa (2015) also found that teachers did not give homework when teaching genetics. Lack of homework makes learners not to benefit from expository teaching.

It seems that these teachers somehow believed that direct instruction works best. This may stem from their own experience as pupils where much teaching was through chalk and talk. It is asserted that teachers will generally teach in the ways they were taught (Ball, 1990; Sakshaug and Wohlhuter, 2010). It may also come from lack of pedagogical knowledge, which was seen in this study by their confession that they could not think of alternative ways of teaching or what activities to arrange for the learners. This points to poor preservice and in-service education.

Reasons Teachers gave for their Choices

When asked to give reasons for their choices of teaching technique, teachers gave cognitive, management, and pedagogical reasons. Lecture seems to have been perceived to assist in clarifying meaning, handling large amount of content, and large classes. These teachers saw that genetics was a difficult topic and therefore explanation was better than allowing pupils construct their understanding. Construction of own knowledge was seen as impossible as the topic was abstract. The teachers did not know what practical activities to use to give pupils some experience. In addition, it was difficult to do activities in a large class.

There were several reasons given for using small group discussion, such as increasing participation, giving opportunity for student-teacher interaction and student-student interaction, and using limited resources. There was implicit understanding that pupils learn better by interacting with peers. What was missing in their explanations was articulation of their choice of teaching method or what is prescribed in the syllabus. It would seem the teachers had a good grasp of teaching techniques but did not articulate the supporting theories. This may be as a result of lack of knowledge or lack of reflection. There was implicit desire to do active learning method, but they had challenges such as lack of knowledge, large classes, and limited resources.

Active learning, which includes inquiry-based learning has many advantages such as development of understanding, positive attitude to science and acquisition of practical and thinking skills. However, it seems to be a challenge to teachers mostly due to contextual factors mentioned above. Fundamentally, it also requires much preparation in terms of tasks students are to do, be it practical or discussion (Shamsudin et al., 2013). In addition, management of the activities can be difficult due of lack of time and large classes. Das Neves et al. (2021) in a study of competences required for implementing active learning methods found that engineering teachers identified the following competences as necessary: Working cooperatively, empathy with their students, giving good feedback throughout the learning process, ICT competences, ability to select and adapt teaching methodologies to class context and creativity. These six teachers lacked most of these factors; furthermore, they worked alone, and could not think of alternative way of teaching to select from for example.

CONCLUSION

The aim of this study was to describe how genetics, a difficult topic in school biology, is taught and how teachers justify their choice of teaching method. The study used a conceptual framework which described science teaching methods in three categories, namely: Expository learning, discovery learning, and inquiry-based learning. The curriculum recommends the last two: discovery or inquiry-based learning. However, it was found that teachers in this study used mostly expository method utilizing lecture and question and answer techniques. Although they are aware that use of small group activities would enhance learning, they hardly used them, mostly because they lack knowledge of what activities to use in teaching. From

these findings it is recommended that in Malawi the preservice and in-service teacher education should be revised such that it enables teachers to develop competences in active learning teaching method. There is need for more research, looking at the rendering of genetics in the curriculum and textbooks and its impact on the practice. Furthermore, there is need to explore how action research can help in development of communities of practice which can bring about desired change.

ETHICAL STATEMENT

The researchers got permission from the Education Division Manager who wrote a letter of introduction to the head teachers of the schools where the study was conducted.

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