

Nature and Causes of Learning Difficulties in Genetics at High School Level in Zambia

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Abstract

Genetics has been identified as one of the difficult topics in biology for high school students in Zambia. This paper reports a study conducted to determine the nature and causes of learning difficulties students encounter in genetics at high school level in Zambia. A survey design was used and data were obtained from students and teachers using interview schedules and self-completion questionnaires. Quota sampling procedure was used to select the sample from the target population. Data collected were analysed using content analysis approach. The study found that students had difficulties understanding among others genetic crosses, genetic terms, mitosis and meiosis as well as mutation. Factors identified to have caused learning difficulties included: inability by teachers to explain clearly to students; none teaching of the topic; topic taught near examination time, fast presentation of lessons by some teachers; belief by some students that genetics was difficult to learn; lack of appropriate learning aids and inadequate time allocated to teaching of the topic. Some of the recommendations made were that: teacher training institutions must prepare biology teachers adequately to teach this topic well; adequate time should be allocated to teaching of genetics; teachers need in-service training to enable them use appropriate teaching methods for teaching genetics.

1. Introduction

Genetics is one of the topics taught in biology at high school level in Zambia. This topic, which was introduced in the school certificate biology syllabus in the mid 1970s, covers the following aspects: variations, mitosis and meiosis, monohybrid crossings, sex-determination, co-dominance and mutation (Curriculum Development Centre, 2000).

Previous studies in Zambia have shown that genetics is perceived as a challenging topic for some students

and teachers. For example in a study by Rugumayo (1978), teachers cited genetics as one of the topics they needed help in order to teach it effectively. A baseline study conducted in 1994 by the ministry of education, found that genetics was one of the topics pupils regarded as difficult to learn in biology (MOE, 1994). Haambokoma and Mwale (1998) found that students at two national technical schools were of the view that teachers had difficulties teaching genetics effectively and therefore, students found it difficult to learn. In the same study, teachers also cited teaching of genetics as one of the areas they needed further professional development. Genetics was also one identified as challenging topic for female students by a group of teachers at a planning workshop for girls' science camp in August 1999 (Zambia National Commission For UNESCO, 1999).

Furthermore, reports of the chief examiner for the biology theory paper also indicate that candidates have had difficulties in answering questions on genetics in the final examination. For example the chief examiner's report of 1997 stated that candidates seemed not to know genetic terminologies and also lacked understanding of the usage of genetic symbols. In a nation wide study conducted in 2002 by the Department of Mathematics and Science Education of the University of Zambia, genetic was rated as the most difficult topic to learn by 38.5% of student respondents and to teach by 25.5% of biology teachers who participated in the study (Haambokoma et al. 2002). Genetic has also been reported to be a difficult topic to teach and for students to learn at high school level in Kenya (Inset Curriculum Review Committee, 2002), United States of America (Banet and Ayuso, 2000; Moll and Allen, 1987; Smith, 1988; Stewart, 1982 and 1983), Australia, New Zealand and the United Kingdom (Treagust and Tsui, 2002).

Although genetics has been identified as a difficult topic to learn among high school students in Zambia, the nature and causes of learning difficulties in this topic have not been investigated. Therefore, the purpose of this study was to investigate the nature and causes of learning difficulties experienced by students in genetics at high school level. It was hoped that this study would generate information which curriculum developers, textbook writers, heads of science departments, biology teacher educators and teachers of biology could use to improve the learning of genetics. It was also anticipated that the study would contribute to literature in this area.

In pursuing the purpose of the study above, answers were sought to the following questions: (1) Which areas of genetics do students find difficult to learn? (2) What is the nature of difficulties students experience in genetics? (3) What are the causes of learning difficulties experienced in genetics?

In this investigation, learning scientific concepts was assumed to be influenced by a number of factors, which were divided into two broad categories namely inputs and processes. Factors classified under inputs were: content to be taught; resources for teaching and learning; characteristics of teachers; characteristics of students; time allocated to teaching and the learning environment. Factors grouped under processes were quality of teaching; teaching strategies used; teaching approaches; use of teaching resources; learner participation and pace of lesson presentation. This theoretical framework derived from that given by Howies (2003) was used as a guide to explore the questions raised above.

2. Methodology

The study used a sample survey design. It was felt that this design would enable the researcher to collect data from a wide range of respondents. The target population was all school leavers who studied biology in grade 12 (in this study they have been referred to as students) and teachers of biology. Data were obtained from a sample of 51 students/learners (27 males and 24 females) who studied genetics in grade 12 during the period 1989 to 2003 and were at 40 different high schools located in different parts of Zambia and 23 teachers (18 males and 5 females) with teaching experience ranging from 1½ to 27 years. The sample was drawn from the study population

using quota-sampling procedure. This method was preferred because there was no need for information such as sampling frame, total number of respondents and their location in order to pick the sample.

Data were collected from respondents using interview schedules and self-completion questionnaires. The contents of the interview schedules and questionnaires were derived from the research questions. The researcher conducted one- to-one interviews with some respondents (both students and teachers). Interview schedules for interviewing learners were also given to research assistants who were trained to interview school leavers who studied biology at grade 12 level. They were also given self-completion questionnaires to distribute to teachers of biology and request them to complete. Interview was the main method of obtaining data from respondents. However where respondents could not be interviewed, they were given a questionnaire to complete. This made it possible to gather data from respondents where direct contact with the researcher was not possible.

Data collected were analysed using content analysis approach. This involved identifying, categorizing and listing responses according to themes. Frequency of mention per theme was counted and quotations of some of the responses obtained were also used in order to illustrate directly the respondents' views.

3. Findings

The findings of the study are presented below under the following headings (1) areas and nature of learning difficulties experienced (2) factors which contributed to learning difficulties.

3.1 Areas and nature of learning difficulties experienced

Difficulties were reported in the following areas of genetics: crosses; calculations; genetic terms; mutation, mitosis and meiosis; sex determination; variations; co-dominance. The nature of difficulties reported, in each of the topics above are given below.

3.1.1 Crosses: 21 students (41%) responded that they had difficulties in dealing with genetic crosses. Included in this area were the following aspects punnet squares, backcrosses and family trees. The majority of them stated that they were not able to come up with correct crosses when given a word problem. One male student who learnt genetics in 1997 put it as follows "I had problems doing crosses and let alone predicting the outcomes of certain crosses." With respect to backcrosses, one learner who studied genetics in 2001 expressed the difficulty as follows: "When it came to back crosses, I could not find the genotype and phenotype of parents using the progenies." Nine (9) teachers (39%) also stated that learners had difficulties carrying out genetic crosses from a given statement.

3.1.2 Calculations: 5 students (10%) expressed experiencing problems in this area with respect to determining percentages, chances and probabilities when given a problem to solve. Six (6) teachers (26%) expressed similar sentiments about calculations. Regarding ratios, one teacher said: "learners are unable to find ratios especially when figures are given." On probabilities another teacher respondent stated, "learners fail to calculate probability of occurrence of progenies."

3.1.3 Genetic terms: This area was identified as being difficulty to learn by 11 students (22%). They indicated that they had difficulties mastering the meaning of genetic terminologies. One student said "I found it difficult to understand and define certain words used in genetics because some of them were similar to each other e.g. homozygous and heterozygous." Another one expressed the following sentiments "What I found difficult was understanding the meaning of terms such as genotype, phenotype, homozygous black, heterozygous black, dominant, recessive." Nine (9) teachers (39%) also reported the same difficulties expressed by learners with regard to genetic terms. One teacher who had been teaching for 27 years stated:

The problem learners have is interpretation of key words such as phenotype, genotype, homozygous, heterozygous, dominant, recessive, gene, allele, homologous pair, haploid and diploid numbers, co-dominance and incomplete dominance.

Another teacher who had been teaching biology for 12 years expressed a similar sentiment as follows “most pupils do not clearly understand terms associated with genetics for example Gene, Chromosome, Allele, Alleles, Genotype etc.”

3.1.4 Mutation: In this area, 14 students (27%) indicated that they had difficulties understanding how mutation came about. Three (3) teachers (13%) also stated that students had difficulties in understanding how mutation came about.

3.1.5 Mitosis and meiosis: 14 students (27%) indicated having learning difficulties in this area. Regarding the nature of difficulties, some stated that they had difficulties understanding the meaning of the terms ‘meiosis’ and ‘mitosis’. For instance one student said, “I could not understand what meiosis and mitosis were.” Others expressed difficulties in distinguishing meiosis from mitosis while, some indicated that they were unable to master the various stages of mitosis and meiosis. One respondent who studied genetics in 2003 put it as follows “The problem I had, was understanding the different phases involved in the two processes of [meiotic] cell division.” The difficulties expressed by students in meiosis and mitosis were also observed by 11 teachers (48%). One teacher said, “pupils have difficulties in understanding the phases of meiosis and mitosis.”

3.1.6 Sex- determination: In this area, 13 students (25%) reported that they had difficulties deciding whether the off spring was a male or female as well as how the X and Y-chromosomes operated to cause differences in sex. For example, one respondent who studied genetics in 2002 said, “I had a problem determining whether the off spring was a girl or boy”

And another one said, “I could not understand how the X and Y chromosomes pair themselves to produce the off spring and determine its sex.” Regarding sex linkage, students indicated that they had difficulties understanding the concept of sex linkage. However, only 2 teachers (9%) were of the view that students had difficulties in this area.

3.1.7 Variation: 4 students (8%) indicated finding this area difficult to learn. The problem they expressed was differentiating between discontinuous variations and continuous variations as the following response from a learner who studied genetics in 1997 indicates. “I could not distinguish the 2 types of variations. I was also mixing up examples of continuous and discontinuous variations.” The difficult expressed by students in distinguishing between continuous and discontinuous was also echoed by 3 teachers (13%). For example one teacher who had been teaching biology for 27 years put it as follows “The problem some students have is inability to distinguish between discontinuous and continuous variations in plants and animals, and relate these to correct examples in real life”.

3.1.8 Co-dominance: 5 students (10%) indicated having difficulties in understanding this aspect and 4 teachers (17%) who participated in the study also identified this topic to be difficult for some students.

3.2 Contributing factors to learning difficulties

With regard to what contributed to learning difficulties given above, the following factors were cited by respondents:

3.2.1 Inadequate Explanation: 15 students (29%) attributed their having difficulties in learning genetics to teachers’ inability to explain adequately during lessons. A respondent who learnt genetics in 2001 put it as follows: “The topic was not well presented to us to get the concepts. This is so because the teacher was not explaining well”. Another respondent who studied genetics in 1997 explained his having problems in learning

genetics as follows “The teacher wasn’t good at explaining. It is like he too did not understand the topic. Because of the teacher being mixed up in his explanations, I too got mixed up and could neither understand nor follow his lessons”.

Eight (8) teacher (34%) respondents also agreed with sentiments expressed by some learners that some teachers did not give good explanation to students. One teacher who had been teaching biology for over 20 years expressed his opinion as follows “Some biology teachers are not conversant with the correct use of the language of genetics. So they find it difficult to explain key words. Therefore, students do not get adequate and effective explanations necessary to enhance understanding”.

3.2.2 Topic not taught: Another reason given by 9 students (18%) was that the topic was not taught to them. One respondent who studied genetics in 2001 said, “We were not taught the topic but instead we were let to read on our own from the given notes without any explanation.” One teacher explained why some teachers did not teach the topic as follows:

Teachers themselves do not know the subject matter because in colleges the topic is either not taught or not properly taught to trainee teachers hence teachers tend to shun the topic when they go into schools for fear of embarrassing themselves in front of pupils.

3.2.3 Speed of lesson presentation: The fast rate, at which some teachers presented lessons on genetics, was given by 10 students (20%) as a reason for their finding it difficult to learn it. For example one male respondent who did genetics in 1997 said, “The teacher was too fast, I was not accorded the chance to take my time in learning the things I had heard for the first time”. Another respondent who studied genetics in 2002 put it as follows “The teacher was too fast when teaching the topic making it difficult for me to grasp everything.”

3.2.4 Unfriendly Teachers: In this respect, 3 students (6%) stated that some teachers never liked to be asked questions by learners on issues pupils did not understand during the lesson. The following response from one respondent who studied genetics in 1992 illustrates this “The unfriendly nature of the teacher made us fear to ask questions for clarifications”. Another respondent who studied genetics in 1997 put it as follows “The teacher got emotional when we said we did not understand certain concepts”.

3.2.5 Scheduling of the topic: Teaching of genetics, few weeks before writing the final grade 12 examination was given by 8 students (16%) as a factor which made it difficult for them to master the topic. One respondent, who studied the topic under consideration in 2001, had this to say “The topic was taught nearly at the end of the year when the examinations were around the corner and by that time most of us had lost concentration to learn”. Another respondent who studied genetics in 2003 put it as follows “The topic was introduced so late. The late introduction of the topic made me to lose concentration in it because I was busy preparing for the examination”. Nine (9) teachers (39%) also expressed similar sentiments. One teacher who has been teaching biology for 12 years said “Genetics is taught at the end when pupils are about to write their examination so pupils have no enough time to read and understand the many new terms and definitions they have learnt”.

3.2.6 Inadequate time: Another factor expressed by 4 students (8%) was that the time allocated to the teaching and learning of genetics was too short and this made it difficult to learn the topic well.

3.2.7 Negative attitude: 6 students (12%) indicated that they had a belief that genetics was a difficult topic and that this made them not to put any effort in learning the topic. One respondent who studied genetics in 2002 put it as follows “I had a negative attitude towards genetics because senior pupils commented that it was difficult. So even before I learnt the topic, my mind was closed”. Another respondent who studied genetics in 1993 said:

The teacher was very good but I had it in mind that it was a difficult topic to understand because every one was talking about it. So from the start, I never liked it. I never used to study the topic and I even cancelled every question on genetics before the examination

Seven (7) teachers (30%) also indicated that pupils had a perception that genetics was a difficult topic to learn even before they were taught and therefore, never concentrated when they were being taught. One teacher put it as follows:

Before they come to learn genetics, most pupils have the prejudice notion that it is very tough. This makes a pupil lose interest in the topic especially when they are told that no matter how much they will try, they will not succeed.

3.2.8 Discouragement from teachers: Some students reported that some teachers were not encouraging when it came to learning genetics. Instead they were told that the topic was difficult. One respondent said, “the teacher threatened us that this topic was difficult. Due to threats by the teacher that it was difficult, I took it as a difficult topic”. A similar sentiment was expressed by a teacher “Students are often discouraged by some teachers who tell them that genetics is difficult”.

3.2.9 Poor mathematical knowledge: Another factor given by 5 teachers (22%) for learners having difficulties in genetics was their inability to carry out mathematical calculations involving probability. For example, one teacher who had been teaching biology for 24 years said “poor mathematical background of some pupils makes it difficult for them to change the four possible combinations to percentages”.

3.2.10 Lack of learning resources: 5 students (10%) cited lack of appropriate reading material as a factor, which contributed to learning difficulties in genetics. One student gave the following response “Since there were no detailed books to go through after the lessons, I was finding it difficult to grasp the meaning of some terms”. Related to the issue of textbooks, 4 teachers (17%) indicated that the textbooks available were generally written in difficult language and hence students found it difficult to understand genetics. Nine (9) teachers (39%) observed that lack of teaching and learning aids such as video tapes, computer programmes, charts etc to illustrate what was being taught was a hindrance to learning of genetics. For example one teacher said “Lack of suitable teaching aids for use in the teaching of genetics makes learning unrealistic, boring and creates no desirable impact on the mind of the pupils”.

3.2.11 Lack of practical activities: Another factor cited by 4 teachers was that no practical activities were usually done when learning this topic as a result, pupils had difficulties understanding in that they were not actively involved in the learning process. For example one said “Since the topic is mainly taught theoretically the concepts do not get retained for a longer time unlike if experiments were done”.

3.2.12 Unfamiliar topic: 4 teachers (17%) indicated that learners met the topic for the first time in grade 12 unlike some topics in biology which they had covered in the lower grades, making it difficult for them to understand it quickly. One said “genetics is only introduced in grade 12. Pupils do not meet anything related before that time”.

3.2.13 Too many terms: Some students indicated that there were too many new and similar terms in the topic, which confused them. They cited terms such as phenotype, genotype, heterozygous, homozygous, allele, alleles etc.

4. Discussion

The study set out to investigate the nature and causes of learning difficulties in genetics at high school level. From the responses given by students and teachers it is clear that the majority of respondents regarded genetics as a difficult topic to learn. This confirms findings of earlier studies (MOE, 1994; Haambokoma and Mwale, 1998; Haambokoma et.al 2002). Areas identified as being difficulty included genetic crosses, genetic terms, mitosis and meiosis, mutation and sex-determination.

The study revealed a number of factors which students and teachers who participated in the study, thought

made it difficult to learn genetics. One of the factors cited is the inability of some teachers to explain certain aspects of genetics adequately to learners. Lack of proper explanation makes it difficult for students to comprehend the topic. One possible reason for teachers not being able to explain could be that they do not understand the topic well possibly because their background is poor in this topic. Extent of mastery of the topic has a major influence on the quality of explanation a teacher can give to students (Hashweh, 1987).

Another factor, which came through, was that some students were not taught this topic. One reason for this is that some teachers are not comfortable teaching this topic and therefore they deliberately omit it. Others push the topic towards the end of grade 12. When time comes to teach it, they simply tell students to read on their own because examinations are near. When a topic (like genetics) is not taught to students, it becomes difficult for them to learn it on their own without guidance (Brophy and Good, 1986; Hiebert 1999; National Research Council, 2000). Fast pace of lesson presentation by some teachers was also another factor cited by learners. When a topic like genetics is presented too fast, students especially slow ones experience difficulties following the lessons and hence lose the interest to learn the topic (Reece and Walker, 1997). Furthermore, new information given to students too quickly is not retained because it cannot be processed by the short-term memory (Petty, 1993). It would appear that teachers did not allocate adequate time to teaching of genetics and this had a negative effect on students' learning of the topic. Some studies indicate that reducing the amount of instructional time and particularly the amount of time students are involved in the learning activities lowers learning achievement (Denham and Lieberman, 1980; Marzano, 2000; Scheerens and Bosker, 1997).

Scheduling of genetics towards the end of grade 12 was also cited to have contributed to students having difficulties in understanding this topic. The major reason for this is that the concentration of students during lessons is low because of pending examinations. They concentrate much more on thinking about the coming examination than on what they are being taught. Concentration on the topic being taught is an important pre-requisite to learning what is being taught.

The unfriendly attitudes of some teachers, towards students when teaching this topic also make it difficult for learners to understand. For example some teachers did not allow learners to seek clarification on issues they did not understand possibly, for fear of failing to respond correctly to questions asked yet; allowing students to ask the teacher questions helps them to understand (Reece and Walker, 1997). Asking questions is an important part of the learning process (Petty, 1993) and contributes to learning. Other teachers tell students that the topic is difficult and thus discourage them from putting effort to learn the topic because of what they have been told by the teacher.

Another contributing factor cited by some respondents was that some students come to lessons on genetics with a negative attitude towards the topic. Hence no matter how much a teacher tries such pupils do not make efforts to understand what is being taught. When learners have no interest in a topic, they tend to pursue it with less eagerness and persistence (Maqsd, 1992). Positive attitude towards a topic is an important pre-requisite to learning it (Reece and Walker, 1997).

5. Conclusion and recommendations

The study has revealed aspects of high school genetic in which students have difficulties understanding. The study has also established that causes of difficulties include inadequate explanations, topic not taught in some cases, quick presentation of lessons, some unfriendly teachers to pupils, inappropriate scheduling of the topic, negative attitude of some learners towards the topic, poor mathematical background of some students.

In view of the findings presented above, the following recommendations are made: (1) Institutions training teachers of biology must ensure that trainee teachers cover appropriate genetics content adequately and

are taught appropriate methodologies to enable them teach this topic with confidence. (2) Heads of science departments in high schools must ensure that adequate time is allocated to teaching and learning of genetics in the scheme of work. (3) Genetics should not be taught in the third term of grade 12 so that students' attention is not divided between learning genetics and thinking of the final examination. (4) Teachers should use participatory teaching methods and pace their lessons in such away that students can follow. (5) Teachers should be encouraging, friendly and open to questions from students during lessons on genetics. (6) Textbook writers should ensure that biology textbooks meant for high schools cover genetics adequately in a way students can understand. (7) Teachers must give adequate explanations to students using visual aids, practical activities and relating things taught to real life situations. (8) The law of segregation and independent assortment must be covered to avoid students having difficulties in areas such as sex determination and variations. Overall, teachers need further training in teaching genetics and in this case, lesson study approach could be more appropriate. This approach has been used in Japan to improve the quality of teaching (Baba and Kojima, 2004) and it is being introduced in other countries like United States of America (Wang-Iverson, 2002) because of its merits.

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