STUDENTS' UNDERSTANDING OF HEREDITY AND VARIATION

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The present study examines the pedagogical knowledge of students on heredity and variation. Questionnaires were administered in secondary/senior secondary/undergraduate level students. The comparison of understanding of students of different levels and various classes has been examined .The analysis indicates that the students' understanding of Mendelian inheritance carry a great variation. Interestingly, 2nd year undergraduate students performed better than 4th year undergraduate students. The reason may be attributed to the fact that student-teachers have developed more interest in the curriculum so they perform well in their professional life .The students of school level need better in-depth understanding to develop more interest in the advanced technology of gene and genetics.

Keywords

Gene, heredity, variation, genetics, genetic concepts

Introduction

Genetics is the study of heredity and inheritance. Understanding certain genetic concepts can be difficult if we have no basic knowledge about gene. Genetics helps to explain how traits are passed on from parents to their offspring. Interestingly, variation is also a part of heredity because no two individuals are identical in every respect. Similarity and variation go hand-in-hand as the law of nature constitutes the raw material for a geneticist and breeder to work upon and evolve new strains, breeds, varieties, etc.

Therefore, it is necessary to understand whether the basic concepts of Mendelian inheritance that are transmitted to the students of school level by the teachers before reaching the college level are well understood and whether students utilise that knowledge at the undergraduate level appropriately. It has been found that the students have alternate conception about gene, allele, traits, i.e., about inheritance (Lewis, Leach and Wood-Robinson, 2000a, 2000b; Lewis and Kattmann, 2004; Chattopadhyay, 2005). According to Banet and Ayuso (2000), the difficulties to teach and to learn genetics remain a problem of students' comprehension.

Literature showed that most students from secondary school after formal teaching do not understand genetic concepts and they cannot describe the relationship between some cellular structures like chromosome DNA and genes (Shaw et al., 2008, Quinn, Pegg and Panizzon, 2009). Saka et al. (2006) have clearly demonstrated that future teachers possess inadequate understanding of some basic genetic concepts.

The questionnaires were administered to the students of both school and undergraduate pre-service teachers to evaluate their pedagogical knowledge on the basic concepts of genetics.

Objectives

The questionnaires filled in by the students were analysed and the results were described based on three objectives.

1. Variation in students' understanding of gene and its role.
2. Comparison of pedagogical knowledge of school students and undergraduate pre-service student-teachers.
3. Performance of pre-service student-teachers of 1st year and final year.

Sample

The students of different schools affiliated to CBSE in Bhubaneswar, Odisha and the students of Regional Institute of Education, Bhubaneswar were selected as sample of study. The sample of students was selected using simple random sampling technique. The study of gene starts from Classes X, XI onwards. Students of Classes X, XI of school level and 1st, 2nd, 3rd and 4th year B.Sc. B.Ed. students of undergraduate level were considered for the study. The sample included both boys and girls.

Tools

The descriptive and statistical analysis of students' answers was based on questionnaires. The questionnaires were administered relating to the basic genetic concepts pertaining to Mendelian inheritance. The topic was chosen from the syllabus of both secondary school level and undergraduate courses. The present paper focuses exclusively on gene and its role in heredity and variation. Questions were developed keeping in view the concept of gene, its role in sex determination and its importance in heredity and variation, etc.

The questionnaires were administered to the students and the purpose of study and method of response were explained to them, 45 minutes' time was given to the students to answer the questions in the class relating to their previous knowledge.

Results

Variation in students' understanding of gene and its role.

Students' understanding of some basic genetic concepts was verified analysing the answers to the questionnaires (Figure 1).

1. The first question was "What are genes and where are they located in our body?". About gene, only 12 per cent students were unaware of the fact that a gene is molecular unit heredity of a living organism and as a name given to some stretches of DNA and RNA that code for a polypeptide or for RNA chain. But 45 per cent students knew about its position in our body. About 55 per cent students gave confused answer. They were not clear about the term allele, trait, DNA and chromosome, nucleus, etc. The reason may be that in the textbook, the function of gene is highlighted but not much attention has been given to the location of gene.
2. The second question was: "How dominant genes differ from recessive genes?". About 95 per cent of the students expressed the work of both dominant and recessive genes correctly. Only 5 per cent of the students were unaware of the fact that the dominant trait refers to a genetic feature that hides the recessive trait in the phenotype of an individual and this has been clearly explained in the textbook.
3. In the third question, investigation about students' idea on role of male and female in determination of sex was done. The question

was: "How genetic combination of mother plays a significant role in determining the sex of a new born baby?".
Only 45 per cent of the students had clarity that the male has a significant role in determining the sex of a child. The males have sex chromosome XY and females have sex chromosome XX. During fertilisation, either 'X' or 'Y' chromosome may come. Thus, in determination of sex of a newborn baby, father's role is significant in human beings. But only 10 per cent of the students were aware of the fact that different species use different strategies for this. In some animals' environment, i.e., the temperature at which fertilised eggs are kept, determines whether the animals developing in eggs will be male or female. In other animals such as snails, individuals can change the sex thus indicating that sex is not genetically controlled, but in human beings it is largely genetically determined. It has been found that the students who have thoroughly gone through the Class X NCERT textbook were able to answer correctly.

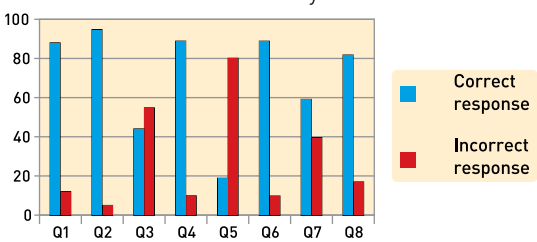

Figure 1. Percentage of students' response to different questions

4&5. The fourth and fifth questions were given to test the students' concept about the role of gene in determining and controlling the characteristics. The questions were: "How are the characteristics transmitted to progeny and how do the genes control the characteristics?". About 90 per cent of the students of both school level as well as undergraduate level were aware that the characteristics were transmitted to the progeny through gene. Only 10 per cent of students had no clear idea about that. However, about 80 per cent of students were unable to clearly explain how the genes control the characteristics. They were unable to explain the work and role of genes in making proteins in the cell. The fact may be that most of the students do not understand the significance of the concept given in the textbook. Only 20 per cent of the students had clarity that every characteristic of an organism is triggered by hormone. Thus, amount of hormone made will depend on the efficiency of enzyme. This enzyme activity is controlled by a gene. Cellular DNA is the source of information for making proteins in the cell. A section of DNA that provides information for one protein is the gene for that protein.

6. The sixth question was asked, "What do you understand of F1 and F2 generation?". Almost 90 per cent of the students of both school and undergraduate levels were aware of these two terms. The fact may be that the two terms were clearly explained in the textbook. Only 10 per cent of the students had a different concept that F1 and F2 generation is obtained by crossing between the same species only.

7&8. The seventh and eighth questions were related to acquired and inherited traits. The questions were: "How acquired and inherited traits differ from each other and why are the traits acquired during lifetime of an individual not inherited?". About 60 per cent of the students were able

to distinguish between the two terms — acquired and inherited traits. About 40 per cent of the students were confused about these two terms. As 40 per cent of the students were not aware of these terms, they were not able to answer the question as to why are the traits acquired and not inherited. Eighteen per cent of the students had misconceptions. Only 82 per cent of the students had clarity of concept that change in non-reproductive tissues cannot be passed on to the DNA of the germ cells. Therefore, the experiences acquired during lifetime cannot be passed on to its progeny and thus cannot be responsible for variation. The reason may be that the students are unable to link the previous concept to the present concept.

Comparison of Pedagogical Knowledge of School Students and Pre-service Student-teachers

The students' understanding about basic genetic concepts of different classes was compared. The comparison of answers of identical question shows a great variation. This analysis aimed to verify whether the understanding of basic concepts of genetics at school level was modified or not during their undergraduate study. A lot of variation was seen in five questions, i.e., related to sex determination, role of gene in determining the characteristics and knowledge on acquired and inherited traits. The students' knowledge at school level is satisfactory related to role of father in the determination of sex of a newborn baby in animals, including human beings. But surprisingly, the undergraduate students had no knowledge about role of father in determination of sex of a newborn baby in animals except human beings. Both undergraduate and school students had very less knowledge about the role of gene in determination of a character. They were aware of the role of gene in transmitting the characteristics from parents to progeny but, how it happens, they did not have much idea. Seventy per cent school students were unable to explain it properly, whereas about 37 per cent undergraduate students were also found incapable of giving proper explanation (Figure 2). The school students had clarity of concept about acquired and inherited traits whereas the undergraduate students had misconceptions and were confused about these two terms. The reason for this may be attributed to their ignorance and inadequate knowledge about the concept.

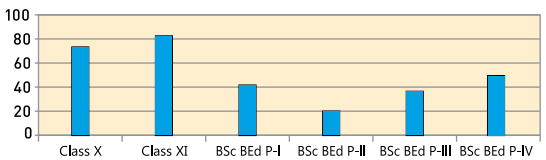

Figure 2. Percentage of incorrect response of students of different classes related to role of gene in controlling the characteristics

Performance of Pre-service Student-teachers of 1st Year and Final Year

The knowledge on basic genetic concepts somewhat modified acquiring more knowledge on Mendelian inheritance in 2nd year undergraduate students as it is included in their curriculum. But, surprisingly, the final year undergraduate trained teachers, i.e., future teachers did not show a better performance in comparison to their juniors though they were studying advanced genetics, i.e., molecular biology, biotechnology, recombinant DNA technology, tissue culture, etc., included in their curriculum. The future teachers showed less interest in answering the questionnaires. All together they were not able to answer more

than 50 per cent of the questions and some students answered only about 35 per cent of the questions correctly.

Discussion

Analytical

The branch of genetics is expanding day-by-day. The knowledge on gene and its characteristics is very important for its utilisation in the application for the betterment of society in the field of biotechnology. The basic genetic concepts should be fundamentally more strong in future teachers to make them professionally successful.

Students opting for study in biology show variation in their understanding of basic genetic concepts. The 1st and 2nd year undergraduate students have clear concepts in comparison to final year students who may have additional professional future building activities. This inadequate understanding might influence the learning of more complex genetic concepts and social implications of genetic modified organisms. This can be explained taking into account the questionnaire related to acquired and inherited traits. In answering these questions, most of the school students had clear concepts about these two terms but most of the undergraduate students did not. This simple example can give us an idea as in how the simple misunderstanding might give rise to distorted understanding of more complex idea related to genetics.

Graphical

Figure 1 shows a lot of variation in students' response to various questions related to gene and its role in heredity and variation.

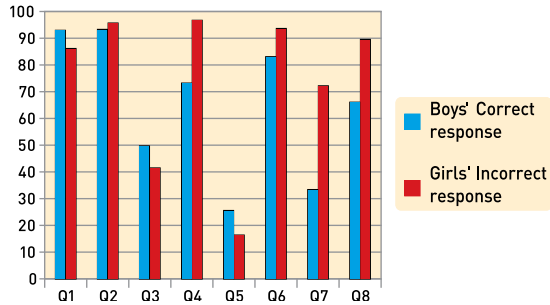

Figure 3. Comparison of correct responses to different questions by boys and girls

Figure 2 represents the incorrect response of students of different classes regarding Q.5, i.e., how gene controls the characteristics? Seventy-four per cent of Class X students were unaware of that, whereas 82 per cent of Class XI students were unable to explain correctly. The undergraduate students responded comparatively better. About 49 per cent Part IV B.Sc. B.Ed. students gave incorrect response, whereas Part II B.Sc. B.Ed. students gave higher number of correct answers.

When the answers of questionnaires were analysed and compared between the responses of boys and girls, Figure 3 indicated that there were negligible differences between boys' and girls' correct responses except for Q 7 and Q 8. Answers to Q 7 and Q 8 show that girls gave more correct responses than the boys. Regarding sex variables, no final conclusion can be drawn because results of studies are consistent with regard to sex variables.

Thus, the result of the present study expects to throw light in the field of science and education and accordingly inspire teachers, educationists and others to build up bright academic accomplishments particularly on the concept of Mendelian inheritance.

Conclusion

The present study involving the students of school level and undergraduate level has clearly shown that many students have less understanding on Mendelian concepts in the field of heredity and variation. The nature of students' misconceptions at different classes and source of alternative conception were analysed. The learning of misconceptions has been understood as a result of the simultaneous exposition to an extensive variety of genetic subjects and the inability to reason on ontologically distinct levels of genetic phenomenon (Duncan and Reiser, 2007; Shaw et al., 2008). Efforts must be made to analyse the contribution of prior knowledge mediated by secondary education to students' performance and professional development (Infante-Malachias et al., 2010). Despite the efforts made in application of alternative strategies to transmit genetic knowledge, these difficulties to teach and to learn genetics are continuously described and remain a problem of students' comprehension (Banet and Ayuso, 2000; Orcajo and Aznar, 2005).

The concept about Mendelian inheritance and the terms related to that are explained clearly in the NCERT textbook of Class X. The analysis of result showed that the pre-service teachers during their study time were not aware of their future role as a teacher in their professional life. If they carry the alternative conceptions about basic genetic concepts from school to undergraduate level then its application will influence the science and technology and its application for betterment of the society. Therefore, it is necessary to think critically and to develop the method to improve education in genetics. There must be a correlation between curriculum and its implementation in the professional career.

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