Development of Microbiology concept Inventory for Undergraduate students.

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Abstract:

Concept inventories can identify the key misconceptions that students hold about various topics in different subjects. We can use concepts inventories to measure students understanding of fundamental concepts in various disciplines. Microbiology is one of the subject that is newly introduced in the curriculum at undergraduate level and to teach effectively it is necessary to measure learners learning. This can be accomplished by use of concept inventories. During this research researcher has created and validated concept inventory based on fundamental concepts of microbiology. Microbiology concept inventory was developed in two stages. The first stage was development of T/F test with provision of open ended response. In the second stage the MCQ test was developed using statements of students or most common misconceptions to create distracters for MCQs test. The final MCQ test consisted of total 20 questions and validated through item difficulty, item discrimination and point biserial correlation coefficient. The item analysis of the test indicated that The test has good validity and discrimination power. The final concept inventory revealed the learning gains of students in understanding fundamental concepts of microbiology.

Key words: *Microbiology, Concept inventory misconceptions.*

Introduction:-

Several concept inventories have been developed previously by various researchers in order to identify common student misconceptions or alternate conceptions in various disciplines.

In 1985, Hestens et al developed first concept inventory to measure the learning gains of students in concepts of Physics. This is known as force Concept Inventory (FCI). FCI was a set of 30 multiple choice questions based on Newtonian concepts of force and administered as pre test and post test to undergraduate students. FCI has proved that it is efficient in overcoming students misconceptions.

After the success of FCI various other concept inventories have been developed and administered successfully in various other disciplines in order to measure students misconceptions. Until now various concept inventories have been developed and administered successfully in various disciplines, such as Diffusion and Osmosis, concept inventory, Biomechanics concept inventory of natural selection, Astronomy and space science concept inventory, chemistry concept inventory, Biomechanics concept inventory, Statistics concepts inventory, Biology concept inventory, Enzyme substrate concept inventory, Meiosis concept inventory, Biological experimental design concept inventory, Homeostasis concept inventory.

In 2017, Paustian et al have developed and validated the Microbiology concept inventory to measure students understanding of core concepts of microbiology using the American Society for Microbiology Curriculum Guidelines. The analysis of pretest post test scores of this concept inventory had showed an increase in understanding of concepts after instruction. Thus the researcher has an interest in determining the alternate conceptions or misconceptions of the students in microbiology concept subject at home university. But before that researcher need to know the important fundamental topics from microbiology curriculum those students find difficult to understand. The topics selected through the checklist filled by subject experts and their interviews. Based on these selected fundamental topics concept inventory was developed.

This research paper illustrates the process of development and validation of the microbiology concept inventory and analyzing its validity and

reliability in measuring students understanding of microbiological concepts.

Need and significance of the Study

Students learn differently, individual students have different learning styles. It is very important for a learner to understand different concepts of various disciplines. In order to evaluate students understanding of basic concepts in microbiology subjects, it is necessary to have such measuring instrument. Thus the researcher has prepared microbiology concept inventory. Concept inventories can identify key alternate conceptions that students hold about a topic. They are helpful for the subject instructors to identify misconceptions of students and accordingly improve their teaching strategy. Concept inventories can also find out previous knowledge of students about the topic under study and also helps teachers to compare performance of students in different subjects. Accordingly instructors can modify their teaching styles and adopt new interactive teaching methodologies and can design their own activities to improve conceptual understanding of students.

Objectives of the study

1. To determine commonly held misconceptions of students in microbiology subject.
2. To select the fundamental concepts in microbiology subject at undergraduate level.
3. To develop concept inventory to find out major misconceptions of students in microbiology subject.
4. To demonstrate the validity and reliability of the microbiology concept inventory.

Methodology

The Process for the development of concept inventory was adopted from the research work by Adams and Weiman (2010) and the process for the development of Host Pathogen concept inventory by Marbach et al (2009)

Population

The population of this research study comprises of students of undergraduate colleges in the Satara district.

Sample

For the present research 320 students from different undergraduate colleges in Satara district were selected by purposive sampling method.

Tools

A check list for subject experts was used to find out the concepts in microbiology which students find most difficult to understand.

In order to determine students understanding about the selected concepts and to find out commonly held alternate conceptions of students, the researcher had developed a list of True/False questions with provision of open ended response to each question.

Procedure

Identification of most fundamental microbiological concepts from subject experts point of view.

For this purpose researcher had interviewed some subject experts. Discussions with the subject experts helped researcher in selecting fundamental microbiological concepts for development of concept inventory. A checklist was also given to subject experts that included all important topics from microbiology syllabus at undergraduate level.

Determining students thinking about the selected topics

In order to determine students thinking about the selected concepts and to find out commonly held alternate conceptions the researcher had developed True/false questions based on the selected topics from microbiology syllabus at undergraduate level. In this T/F test students were allowed to write open ended response for their answers. The responses compiled together and coded manually. Analysis of responses revealed some common misconceptions of students in microbiology subject.

Creating Multiple Choice test from T/F questions

The researcher developed a multiple choice test from T/F questions. After the process of reviewing and coding the responses, the MCQs test developed using most common incorrect responses as distracters. The multiple choice questions were reviewed for clarity and accuracy. This preliminary concept inventory was analyzed for item difficulty,

item discrimination and its point bacterial correlation coefficient.

Delivering the instrument.

The final concept inventory was delivered to students as pre test and post test also

Assessment of results using statistical analysis

The data obtained was analyzed by statistical analysis methods as given by Ding et al (2006). Each question of the final concept inventory was analyzed with respect to five statistical parameters such as item difficulty index, item discrimination index, item point bacterial correlation coefficient, Reliability index and Ferguson's delta.

Table No.1:
Number of student responses to microbiology T/F test

Number of total questions in T/F test	Total no. of T/F responses	Total number of open ended responses
20	6400	624

Table no. 2:
Microbiology topics and Number of questions framed

Sr. No.	Topic	Question number
1	Bacterial Cytology	1, 18
2	Microbial Physiology	2, 5, 6, 12
3	Microbial metabolism	7, 8, 9, 10
4	Bacterial genetics	21
5	Mutation	16
6	Molecular biology	13, 14, 15, 17
7	Medical Microbiology	3, 4, 11
8	Immunology	19
9	Air microbiology	20

Table No. 3
: Item analysis of Concept inventory

Question	Item difficulty (P)	Item discrimination (D)	Point biserial correlation coefficient
1	0.75	0.33	0.35
2	0.8	0.4	0.40
3	0.55	0.46	0.22
4	0.6	0.4	0.25
5	0.7	0.2	0.30
6	0.75	0.6	0.35
7	0.85	0.46	0.47
8	0.8	0.26	0.40
9	0.65	0.46	0.27
10	0.55	0.26	0.22
11	0.7	0.26	0.30
12	0.6	0.53	0.25
13	0.7	0.4	0.30
14	0.65	0.33	0.2
15	0.75	0.6	0.35
16	0.8	0.40	0.40
17	0.8	0.53	0.40
18	0.65	0.33	0.27
19	0.65	0.46	0.27
20	0.6	0.4	0.25
	Average – 0.69	**Average – 0.40**	**Average – 0.29**

The researcher analyzed the incorrect reasoning given by students to T/F questions. The most common student responses includes-

Table no. 4
Bacterial cytology- student responses and misconception

Topic	Question no.	Students response	Misconception
Bacterial	1	Non-capsulated bacteria produce more toxins so they do not require capsule	Capsule formation in bacteria is associated with toxin production.

Table no. 5
Microbial physiology- student responses and misconception

Topic	Question no.	Students response	Misconception
Microbial physiology	3	Oxygen in at least in small amount is required for bacterial growth	All bacteria requires oxygen for growth
	7	Bacterial cell size in exponential phase is larger than initial size	Cell size increases along with cell number gradually over the growth phases.

Analysis and interpretation of data
Validation of the concept inventory
Item difficulty index

40% items of concept inventory are moderately difficult or moderately easy. Remaining 60% items of inventory are in the range of average to difficult. No item was found to be very difficult or very easy. The average difficulty index of 0.69 indicated that all the question items are acceptable.

Item discrimination index

The question items having discrimination index in the range of 0.4 to 0.6 indicated that the items have very good discrimination index. The items with discrimination index in the range of 0.3 to 0.39 indicated reasonably good discrimination while the items with index in range of 0.2 to 0.26 indicated marginal or acceptable discrimination. Thus all item are acceptable.

Point biserial correlation coefficient

All the test items showed rpbs values above criteria value i.e. 0.2, so none of the question found defective. all the test item showed good positive correlation which indicated that each question item addresses a specific concept measuring general test knowledge.

Kuder Richardson Reliability index

The r test value of 0.88 is greater than the criteria value indicated that the concept inventory in reliable test.

Ferguson's delta

This value greater than 0.9 indicated that the test as a whole offer good discrimination.

Finding of the research

1) The microbiology T/F test prepared by the researcher contained most of the questions based on fundamental topics in microbiology.
2) Majority of the students answered all the 20 questions of T/F test. Some students answered T/F test with correct reasoning and some students with incorrect reasoning.
3) After analysis of T/F responses researcher find out some misconceptions of students about fundamental microbiological concepts.
4) The comparison between pretest and post test scores revealed that the conceptual understanding of students has been enhanced after instruction.

Conclusions

From the analysis of microbiology T/F test and concept inventory the researcher has find major misconceptions held by the students in microbiology and includes the following-

1) Capsulated bacteria produce more toxin and thus are more pathogenic.
2) All bacteria require oxygen for their growth without oxygen no bacteria can survive.
3) Bacterial cell size increases along with cell number gradually during growth phase.
4) Fermentation occurs only in absence of oxygen and only anaerobic bacteria can undergo fermentation.
5) Mutation in genetic code always gives defective product and is harmful

6) Gene transfer in bacteria always require direct cell to cell contact.

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