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DEVLOPMENT OF CONCEPT INVENTORY ON NERVOUS SYSTEM (CINS) FOR STUDENTS OF STD. 12TH

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Abstract

Study of biological concept, such as, nervous system involves abstract mental process and various sources of misconception makes learning this concept more difficult. The effective learning and conceptual understanding can be thoroughly evaluated by using concept inventories. Considering the significance and extensive use of concept inventory for assessing student's conceptual understanding, exploring level of knowledge and bringing out their misconceptions, we decided to develop and validate biology concept inventory on nervous system. The aim of this tool is to reveal student's understanding and misconceptions about various sub concepts of nervous system. The process of development of concept inventory involves discussion with biology faculties and students for understanding difficulties regarding nervous system, validation of questionnaires, written test, analysis of data, design of Concept Inventory. The paper will also share detail process and experiences of designing concept inventory.

Introduction

Over the last few decades research in science education has repeatedly demonstrated, that students have a wide range of ideas, both scientifically accurate and inaccurate, about the world around them (Ausubel, 1968; Driver & Easley, 1978; Duit, 2006). Several students have lack of correct conceptual understanding of many concepts, even after successful completion of courses in which these concepts are taught (Hake, 1998, and McDermott, 1991). Due to our understanding of how people learn, educators have begun to place more importance on knowing what students understand about a topic when they enter a learning environment. Now it's well accepted fact

due to fast development of cognitive science research that students enter the classroom with tenacious, deep-seated ideas and fundamental reasoning processes that can serve to either help or hinder the incorporation of new concepts. The studies on student understanding of science concepts involve the use of number of qualitative and quantitative studies as well. To address the depth to which students' beliefs can be investigated is the development of the concept inventory (CI). A concept inventory is essentially a multiple-choice instrument which focuses on a narrow concept and whose distracters are based upon known student difficulties.

Most frequently used techniques for extracting students' ideas are: clinical interview, 2-tier diagnostic test, concept maps and multiple choice tests. Interview is a widespread technique used to identify students' meaningful understanding of a particular concept. Nowadays, in the biological science, concept maps, V diagrams, clinical interviews, portfolios and conceptual diagnostic tests, drawings, etc are using as new assessment strategies to encourage meaningful learning and conceptual understanding (Deshmukh, 2012). Apart from these various tools, to evaluate student's conceptual understanding of the concepts and to bring out the misconceptions, the extensively used standardized assessment tool is concept inventory (CI). Concept inventories are an assessment instruments with a multitude of possible uses that range from diagnostic and formative purposes to guide instructional planning, to summative purposes for evaluating overall learning and instructional effects at a student, classroom, and/or instructional program level (Rhoads et al, 2000). The uniqueness of concept inventory is that they tend to be highly focused on a small set of key constructs and understandings within a limited domain of academic content. Another characteristic of concept inventory is immense care is taken in developing plausible distracters that represent a range of partially correct understandings to completely incorrect understandings and misconceptions. Concept inventory is accessible tool to support iterative improvement in faculty teaching and it also help to enhance the scientific literacy of students (Smith et al., 2012). It also potentially used to provide information for instructors on how to improve teaching and as an instrument to yield data for basic education research. The concept inventory provides a learning opportunity for students and teachers and also useful to reveals students misconceptions. Considering the significance and uniqueness of concept inventory,

Lindell & Olsen (2002), defined concept invitatory as “research-based distracter driven multiple-choice instruments”. Similarly, according to Redish (2000), “a concept inventory is an outline of core knowledge and concepts for a given field and a collection of multiple choice questions designed to probe student understanding of these fundamental concepts”.

The Mechanics Diagnostic Test, which afterward well documented as a Force Concept Inventory, or FCI to measure students' conceptual understanding of motion and force was a starting point for concept inventory (Halloun and Hestenes, 1985). After FCI, many concept inventories were designed and validated for various subjects, such as, astronomy (Sadler et al., 2010); chemistry (Mulford, 1996); calculus concept inventory (Epstein and Yang, 2004); statistic concept inventory (Allen, 2006); Dynamics Concept inventory (Gray et al., 2013) etc. After implementation of concept inventories in various subjects' biology educators also decided to develop concept inventory for their courses as assessment tool. The biology community has not produced any assessment tools like FCI that one could use to measure learning gains objectively (Roy, 2001). There has been a call for creating Biology Concept Inventories, multiple-choice exams that test important biology concepts, analogous to those in physics, astronomy, and chemistry (Khodor et al, 2004). A group headed by Michael Klymkowsky in 2003 at the University of Colorado at Boulder developed concept tests to cover "introductory, genetics, molecular, cellular, and developmental biology" (http://bioliteracy.colorado.edu/). Anderson et al.(2002) published a concept inventory of natural selection. According to Klymkowsky et al. (2003), 'Biology concept inventory (BCI) should serve as a lever for moving our current educational system in a direction that delivers a deeper conceptual understanding of the fundamental ideas upon which biology and biomedical sciences are based'. From this concept inventory Klymkowsky expected a best formative evaluation tool to assess student's conceptual knowledge and diagnose misconceptions which provide input for necessary adjustment in instruction pattern. The development of concept inventories as assessment & continuous guiding tool was motivated by fact that it's a perfect blend of research and dissemination. In Context of Indian subcontinent, there is hardly any work can be found on this issue. As a consequence, seeing this as a challenge and opportunity which can be explored, we, team of college and science education research institute member decided to work on development concept inventory particularly suiting the Indian students' needs.

Rationale: Biology is a rapidly expanding subject, both in the knowledge of living organisms which is continuously growing and the techniques by which this knowledge is obtained. The subject Biology intends to give students an understanding and appreciation of the vast diversity

of living beings, their special adaptations to their environments and evolutionary relationship. From the life processes students develop an understanding of basic structure and functions and their inter-relationship. The Biological Science Curriculum Study (BSCS, 1978) identified Biology as an integrated discipline in which the connections and interrelationships between levels are critical to understanding unifying principles; as well as a dynamic, process-oriented discipline focused on solving problems through observation, experimentation, and analysis, rather than a collection of static facts. Students learn the concept of living-nonliving, adaptation, classification of living world, and various life processes from the beginning of the school. The Life processes sub-strand journey is explored through the seven characteristics of living things: movement, respiration, sensitivity, growth, reproduction, excretion and nutrition. The journey for nervous system illustrates the complexity of biology and the underpinning processes that should be central to students' understanding. Although the different sections of life processes might be taught as separate entities, it is important to move students to an understanding of how these processes work together and are interrelated in controlling and coordinating the whole organism. There can be some common barriers that could prevent learning in aspects of life processes especially nervous system. They need to be identified in the scheme of work and addressed through teaching. To assess these abstract concepts students understanding there is a need to develop concept inventory and indigenous interactive material which enhances conceptual clarity and also makes learning enjoyable. This study aims at development, design and validate concept inventory on nervous system and afterward on various biological concepts which are difficult for students.

Understanding nervous system and brain function and dysfunction is critical in many fields, including medicine, psychology, law, engineering, education, and public policy. Therefore study of nervous system is critical and desirable. But during our interaction with students and faculties it was noticed that pupil finds it difficult to understand and their shy nature prevents them from asking questions and clearing their misconceptions thus remains unresolved. Concept Inventory for nervous system is therefore a much needed tool to achieve learning objectives and great support to teachers.

The topic nervous system was selected after discussions with many biology teachers and students for preparation of concept inventory. During discussion with teachers we realised that the students have misconceptions and difficulties about nervous system and other biological concepts. It was noticed that knowledge of nervous system involves many abstract

understandings and majority of student fall prey to rote learning without analyzing the actual concept which leads to misconceptions of various aspects of nervous system. Since Nervous system is center to various voluntary and involuntary body process controlling entire physiology of human function, it is desirable as a student of biology to know the basic structure & working mechanism of nervous system. Therefore, the goal of this concept inventory on control & coordination of nervous system is to develop and distribute tools to assess prevailing misconceptions in student's mind and to check whether students are learning what teachers think they are teaching.

The concept inventory on nervous system consists of 4 parts:

- Structure and function of central nervous system (Brain & Spinal Cord)
- Peripheral nervous system(PNS) and autonomic nervous system (ANS)
- Mechanism of reflex action and reflex arc
- Structure and function of neurons & generation, conduction and transmission of nerve impulses.

Review of the Related Literature: The wide use of concept inventories in physics, mathematics, engineering, chemistry, astronomy and biology was well studied. No doubt it function as to provide instructors with clues as to the ideas, scientific misconceptions, conceptual lacunae, with which students are working, and which may be actively interfering with learning. Hestenes et al, (1992) designed a Force Concept Inventory (FCI) to evaluate the students' conceptual knowledge of Newtonian physics. In this FCI, both the question and the response choice in MCQ are the subject of extensive research designed to determine both; what a range of people think when particular question is asked and what the most common answers are. The Chemical Concepts Inventory developed by Doug Mulford (1996) for his M.S. thesis at Purdue University in August, 1996 talks about emphasizes that concept inventory questions probe understanding, not memorized processes or definitions therefore when we use conceptual questions to assess student learning they would score worse than on traditional exams. According to D'Avanzo (2008), concept inventories are not traditional multiple choice tests, but they are designed for formative assignment. Biology faculty will need a good deal of help integrating use of concept inventory with student-active teaching method. Therefore, widespread faculty development program focusing on concept inventories along with student-active and scientific teaching could effectively be offered through biological teachers association and biological professional societies. Kalas et al (2013) developed and validated a

17-question meiosis concept inventory with 193 students of introductory biology and genetics courses to diagnose student misconceptions on meiosis. They used published methodology for question development, which included the validation of questions by 28 student interviews and by eight experts. The study revealed that, meiosis concept inventory is useful as diagnostic tool and an instrument to assess teaching effectiveness and student progress.

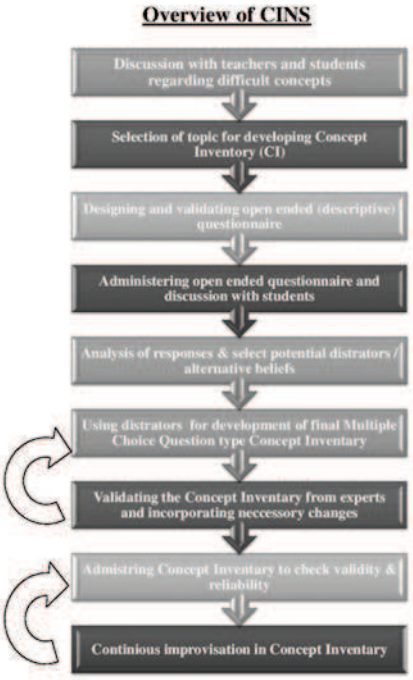
Anderson et al (2002) developed Conceptual Inventory of Natural Selection (CINS) to identify student's knowledge about natural selection, as well as their misconceptions. The 20 item multiple choice inventory asks students to reflect on scenarios regarding Galapagos finches, Venezualan guppies, and Canary Island lizards, and select options that best reflect what an evolutionary biologist would select. Garvin-Doxas et al (2007) were inspired by the success of the Force Concept Inventory, developed by the community of physics educators to identify student misconceptions about Newtonian mechanics. They organised the meeting of Biology Concept Inventory Team on 'Conceptual Assessment in the Biological Sciences' on March 3–4, 2007, in Boulder, Colorado. In this meeting 21 participants from 13 institutions have participated. The goal of the meeting was to organize and leverage current efforts to develop concept inventories for, Introductory Biology, Genetics, Evolution, Ecology, and the Nature of Science. Fisher and Williams (2012) compiled the list of concept inventories in biology which covers topics from evolution, genetics, plant growth and development, molecular biology, cell biology photosynthesis, respiration etc.

According to Ranaweera & Montplaisir (2010) study "*Students' illustrations of the human nervous system as a formative assessment tool*", students initially have poor understanding of the nervous system with many prevailing alternative conceptions. These alternative conceptions include both structural and functional components and often incorporate informal use of language. This study finding showed that, students include the heart as a major component of the nervous system, a reflex arc illustrated by the action rather than structure, and types of neurons (uni-polar, bipolar, or multipolar) differentiated by charge or number of cell bodies rather than structural arrangement.

Similarly, Nadelson (2010) used 27 multiple choice items, plus one open- ended item and diagrams to measure of understanding of macroevolution. Genetics Literacy Assessment Instrument (GLAI) was developed by Bowling et al. (2008) for undergraduates. 25 multiple choice questions with diagrams on Genetics Concept Assessment (GCA) was designed by Smith, Wood & Knight (2008) for gauging student understanding of genetics. For understanding genetics literacy Tsui & Treagust (2009) developed 13 two-tiered multiple-choice questions with diagrams.

Methodology used for Designing of Concept Inventory: Our Methodology is motivated by procedure followed by Klymkowsky's model of BCI. But, in our concept inventory we planned some little modification for betterment. Before starting to develop the CINS, we analyzed the need to alternative assessment other than traditional methodology and further decided to work with concept inventory tool as good option. At First stage we made extensive discussion with various faculties regarding learners' difficulties and misconceptions about biological concepts. After this discussion we selected topic of nervous system for preparation of concept inventory.

Further, at second stage we independently compiled lists of sub-concepts from state board and central board covering the topic of nervous system and analyzed the content taught at higher secondary school level. We then made a list and reconciled it with what was presented in the textbook of these boards. It was seen that both texts are little bit different in level of presentation but are designed for common objectives. Further, based on this we designed the open ended questionnaire. Next stage was to validate the designed open ended questions from experts. This was followed by administering the open ended questionnaire to student and discussing it with students for checking their understanding and misconceptions. We analyzed each and every response that became the source of 'distracters' for development of our CINS.



We used the Klymkowsky's model (2003) of development of biology concept inventory for the preparation of concept inventory on nervous system:

Discussion and Implication: During the process of designing concept inventory on nervous system, there was discussion with students and teachers regarding the difficulties about nervous system. Various problem faced by learners are noticed. Some of them are listed as follows:

- confusion between brain structure and nervous system
- difficulties in understanding and use of technical term
- brain areas are divided in multiple ways (multiple way of nomenclature).
- content given in textbook is hard/heavy to remember.
- teacher taught this topic without interest creation and motivation.
- teacher not relate topic with daily examples.
- different complex naming for common term such as (Telencephalon > Cerebrum > Cerebral Cortex > Cerebral Hemispheres and Midbrain > Mesencephalon etc.)

During the analysis of content of nervous system mentioned in the textbooks, it was observed that, all three boards cover the same concept with slight variation and bit difference of language. Content given is more informative and dry and difficult to understand just by reading. For through understanding of concepts there is need of use many teaching aid in teaching and traditional classroom teaching is not enough.

We also realized during interaction with students that, when we twisted or slightly modified the questions than students get confused. Many answers given by students were just mug up. There is not depth understanding of concepts.

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