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CONCEPT DEVELOPMENT TEST IN SCIENCE: A RESEARCH TOOL

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Abstract
The development of the concept has emerged as an important construct. It plays a vital role in the teaching learning process, as it helps learner move beyond rote memorization toward meaningful understanding. A concept is not merely a word or definition, but an organized mental framework that enables students to identify relationships, recognize patterns, and apply knowledge in real situations. In the field of education development of concept is particularly important because it strengthen higher order thinking skills such as reasoning, critical analysis, and creativity. It allows learner to construct knowledge actively rather than passively receiving facts. Moreover, the ability to grasp abstract ideas provides a foundation for future leaning, especially in subjects like science, mathematics, and social studies, where concepts are interrelated and build progressively. Therefore, focusing on the development of concept ensures that education is not restricted to superficial knowledge but promotes deeper understanding, lifelong learning, and the capacity to adapt to changing circumstances. The research paper is focused on the construction of a tool namely Concept Development Test in Science (CDTS). The tool will be used to evaluate the concept development on selected chapters of class nine science.

Keywords: Development of concept, Science, Concept development test in science

1. Introduction

The development of the concept has emerged as an important construct. It plays a vital role in the teaching learning process, as it helps learner move beyond rote memorization toward meaningful understanding. A concept is not merely a word or definition, but an organized mental framework that enables students to identify relationships, recognize patterns, and apply knowledge in real situations. When learners develop clear and well-structured concepts, they are better able to analyse information, solve problems, and transfer their learning to new context. Rathus (2012) described the concept as the building block of thinking (p.264). Whereas Morgan et al. (1993) defined the concept as symbolic construction, representing some common and general feature or features of many objects and events. Inglis and Aers (2008) explained that "A concept is an idea which serves to pick out certain features in an object of thought and distinguishes is from others". Thus, in the field of education development of concept is particularly important because it strengthen higher order thinking skills such as reasoning, critical analysis, and creativity. It allows learner to construct knowledge actively rather than passively receiving facts. Moreover, the ability to grasp abstract ideas provides a foundation for future leaning, especially in subjects like science, mathematics, and social studies, where concepts are interrelated and build progressively. Therefore, focusing on the development of concept ensures that education is not restricted to superficial knowledge but promotes deeper understanding, lifelong learning, and the capacity to adapt to changing circumstances. The research paper is focused on the construction of a tool namely Concept Development Test in Science (CDTS). The tool will be used to evaluate the concept development on selected chapters of class nine science.

Teaching of science at school level enables learners to develop concepts of science. This helps learners to apply the learned concept in their day to day lives to understand the various natural phenomenon.
Development of concept of science is one of the measure objectives of teaching and learning science at school level. Thus, NCF, 2005 was visualised good science education as true to the child, true to life and true to science. Ball and Millson (1984) highlighted educational value of concept development by using an example of teaching a topic measurement, which is as follow:

When the measurement is approached with an attitude of concept development, many simultaneous learning is possible: (1) An appreciation of the interdisciplinary nature of mathematics and science, (2) The overall concept of

measurement, (3) The overall similarities and differences between science and mathematics, and (4) Reinforcement of many subordinate concepts from science (such as length) and mathematics (such as number). Similar discussions could be pursued on other topics common to science and mathematics with similar benefits. (p.66).

Snow and Rabinovitch (1969) have tested conjunctive and disjunctive thinking in children of various ages by providing task based on conjunctive and disjunctive concept. The study comprised of ninety-seven children, grouped into five different age group. All the children were individually tested in two sessions. In each session two tasks were performed one conjunctive and one disjunctive. It was found that disjunctive concepts were harder to learn for all ages. It was also reported that conjunctive concepts were preferred as well as occurred more frequently in comparison to the disjunctive concept. Similarly, Walls et.al. (1974) were also reported that the disjunctive concepts were more difficult to learn than the conjunctive concepts. Abdullah and Lowell (1981) investigated children's ability to generalize science concepts. Two concepts of science were selected for the study that is concept of animal and concept of insect. Finding of the study suggest that the children of older age groups had a greater ability to generalize than the children of younger age group. Gilbert et.al. (2011) used a context-based model to facilitate the concept development and transfer of concept in science. Researcher used four context-based models. In first context-based model, the context is used as the direct application of concepts, in second the context used as reciprocity between concepts and applications, in third the context was provided by personal and mental activity, whereas in fourth one the context was provided as social circumstances. Researchers found that out of these four-context based model fourth one in which the context was provided as social circumstances works most effectively in addressing the prevailing problems that science face.

2. Objective

To develop a Concept Development Test in Science (CDTS), a research tool to study the development of concept in science at secondary school stage.

3. Hypothesis

Development of a Concept Development Test in Science, a research tool to study the development of concept in science at secondary school stage.

4. Development of a Concept Development Test of Science (CDTS) Objective

The development of a Concept Development Test in Science (CDTS) involves certain steps which are as follow:

4.1 Planning

The planning for the test was carried out with the help of numbers of an expert's opinion. The content selected from the class nine CBSE board science text book. Thus, the test is based on four selected chapters of class nine science text book belonging to CBSE board. The researcher planned to make an objective type multiple choice item. The test consists of 40 multiple choice items in the final form of CDTS. For scoring, it was decided that each correct item will carry one mark whereas each incorrect response for an item will carry zero mark. The blueprint of CDTS is given in Table 1, Table 2, and Table 3.

Table No. 1 Blueprint of Concept Development Test in Science (CDTS)(Draft)

Types of concepts / Content area	Relational concept	Conjunctive concept	Disjunctive concept	Total
Bio-science	1(09)	1(12)	1(09)	30
Physics	1(05)	1(06)	1(04)	15

(Physical science)				
Chemistry (Physical science)	1(05)	1(04)	1(06)	15
Total Marks	19	22	19	60

1. In table, the number given within a bracket indicates the total number of questions
2. In table, the number given outside the bracket indicates the marks allocated to each question

Table No. 2 Blueprint of CDTS (draft) in terms of marks

Types of concepts / Content area	**Relational concept**	**Conjunctive concept**	**Disjunctive concept**	**Total**
Bio-science	09	12	09	30
Physics (Physical science)	05	06	04	15
Chemistry (Physical science)	05	04	06	15
Total Marks	19	22	19	60

Table No. 3 Blueprint of CDTS (draft) in terms of percentage

Types of concepts / Content area	Relational concept	Conjunctive concept	Disjunctive concept	Total
Bio-science	15%	20%	15%	50%
Physics (Physical science)	8.33%	10%	6.67%	25%
Chemistry (Physical science)	8.33%	6.67%	10%	25%
Total Marks	31.66%	36.67%	31.67	100%

4.2 Writing items of the test

The preliminary draft of a test namely Concept Development Test in Science (CDTS) consist of sixty multiple choice items. Each item carries one mark. Thus, the test is consisting of maximum sixty marks at the preliminary stage. The items are prepared based on the specifications as mentioned in the blueprint of the test. The items are based on class nine CBSE board syllabus which includes the content area as shown in the table given ahead:

Table No. 4 Selection of area wise content theme for the test construction

	Name of Chapter	Concepts
Bio-science	1. Why do we fall ill? 2. The fundamental unit of life	Health, factors affecting health, disease and its causes, acute and chronic disease, infectious and non-infectious diseases, levels of disease, means of spread, principles of treatment, the principle of prevention, types of cells, osmosis, cell organelles
Physics (Physical science)	3. Motion	Motion, describing motion, uniform motion, non-uniform motion, motion in a straight line, displacement, the speed with direction, rate of change of velocity, uniform velocity, non-uniform velocity, acceleration, retardation.

Chemistry (Physical science)	4. Is matter around us pure?	The mixture, types of the mixture, Tyndall effect, solution, suspension, colloid, separating the components of a mixture, evaporation, centrifugation

The items prepared for the preliminary draft of the test was modified based on the recommendations and criticisms given by the experts. Afterwards, the test namely Concept Development Test in Science is ready for the experimental tryout of the test.

4.3 Experimental Try-out of the Concept Development Test in Science (CDTS)

Conard (1951) explained that the experimental tryout of the test can be divided into three stages, these are the pretryout, the tryout proper, and the final trial administration. Further, Conard stated that:

> Pretryout means the preliminary administration of the tentative tryout units to small samples of examinees for the purpose of discovering gross deficiencies, but with no intention of analyzing pre tryout data for individual items. (p.251)

The pretryout (first administration) of Concept Development Test in Science was carried out on sixty-six students of class nine. These students were further not included in the tryout or second administration of the test. After the analysis of pretryout result, the test was ready for the tryout proper (second administration). The purpose of the second administration was to provide data for item analysis. The test was carried out on four hundred students of class nine. After completing the tryout proper (second administration) of the test, index of discrimination and difficulty value of each item was determined.

(a) Calculating index of discrimination:

A.K Singh (1996) mentioned the formula for calculating index of discrimination and difficulty value which is as follow:

Index of discrimination (V) = $R_U/N_U - R_L/N_L$

R_U = Number of examinees giving correct responses in the upper group

R_L = Number of examinees giving correct responses in the lower group

N_U = Total number of examinees in upper group

N_L= Total number of examinees in the lower group

(b) Calculating item difficulty:

Item difficulty (p) = $RU_+R_L/N_{U+}N_L$

R_U = Number of examinees giving correct responses in the upper group

R_L = Number of examinees giving correct responses in the lower group

N_U = Total number of examinees in the upper group

N_L = Total number of examinees in the lower group

Garrett & Woodworth (1926) mentioned that items with index of discrimination of 0.20 and more are regarded as satisfactory and also suggested that items of moderate difficulty (40-50-60% passing) are to be preferred over much easier or much harder items. Thus, the researcher selected items for CDTS with index of discrimination ranges from 0.2 to 0.59 with difficulty value ranges from 0.35 to 0.84.

Table No. 5 Index of discrimination and Difficulty value of items of concept development test in science (CDTS)

Item No.	Index of Discrimination	Item Difficulty	Selected/Rejected
1	0.05	0.94	Rejected
2	0.07	0.93	Rejected

3	0.17	0.74	Rejected
4	0.18	0.61	Rejected
5	0.22	0.29	Selected
6	0.44	0.52	Selected
7	0.19	0.49	Rejected
8	0.16	0.77	Rejected
9	0.15	0.44	Rejected
10	0.25	0.47	Selected
11	0.42	0.70	Selected
12	0.42	0.73	Selected
13	0.41	0.63	Selected
14	0.43	0.45	Selected
15	0.10	0.83	Rejected
16	0.43	0.55	Selected
17	0.22	0.64	Selected
18	0.17	0.73	Rejected
19	0.23	0.59	Selected
20	0.41	0.60	Selected
21	0.34	0.67	Selected
22	0.23	0.26	Selected
23	0.09	0.9	Rejected
24	0.15	0.58	Rejected
25	0.45	0.62	Selected
26	0.16	0.70	Rejected
27	0.33	0.67	Selected
28	0.28	0.40	Selected
29	0.43	0.53	Selected

30	0.44	0.50	Selected
31	0.15	0.89	Rejected
32	0.41	0.42	Selected
33	0.12	0.70	Rejected
34	0.25	0.46	Selected
35	0.37	0.63	Selected
36	0.22	0.41	Selected
37	0.43	0.64	Selected
38	0.33	0.65	Selected
39	0.44	0.55	Selected
40	0.43	0.56	Selected
41	0.30	0.52	Selected
42	0.32	0.66	Selected
43	0.42	0.53	Selected
44	0.31	0.73	Selected
45	0.24	0.24	Selected
46	0.18	0.63	Rejected
47	0.48	0.69	Selected
48	0.17	0.84	Rejected
49	0.19	0.76	Rejected
50	0.27	0.68	Rejected
51	0.25	0.57	Selected
52	0.38	0.63	Selected
53	0.23	0.25	Selected
54	0.43	0.45	Selected
55	0.25	0.66	Selected
56	0.09	0.82	Rejected

57	019	0.81	Rejected
58	0.24	0.69	Selected
59	0.26	0.72	Selected
60	0.41	0.53	Selected

The total number of items present in the Concept Development Test in Science (CDTS) at the time of tryout proper was 60. Thus, the test contains total 40 items in its final form after calculating the index of discrimination and difficulty value.

(c) Reliability of the final tests was obtained by Kuder-Richardson (K-R_{20}). Gay et. al (2012) stated "KR-20 is a highly regarded method of assessing reliability but is useful only for items that are scored dichotomously" (p.167).

$$KR_{20} = [\ n/(n-1)]\ [\ \sigma_t^2 - \Sigma\ pq\ /\ \sigma_t^2$$

Where KR_{20} = Estimated reliability of the full-length test

n = Number of items in the test

σ_t^2 = Variance of the whole test

p = Proportion of correct answer on an item

q = Proportion of the wrong answer on an item

Σpq = Sum of the product of pq for all n items of the test

The reliability (KR_{20}) obtained for the Concept Development Test in Science (CDTS) was 0.73.

(d) Miller et al. (1995) mentioned "The goal in the consideration of content validation is to determine the extent to which a set of assessment tasks provides a relevant and representative sample of the domain tasks about which interpretations of assessment result are made" (p.75). Thus, the content validity of CDTS was also established by identifying the subject (science)-matter content and instructional objectives as well as each item was examined by the experts of subject matter to whom the test was submitted for collecting feedback.

Thus, the Concept Development Test in Science contains 40 multiple choice questions, in which 22 items belong to Physical Science whereas 18 items belong to Bioscience respectively. Each item carries one mark for correct response and zero for incorrect. There is no negative marking in the given test.

5. Delimitations

(i) The study is delimited to the student of class IX only.
(ii) The researcher has used only four chapters of the class nine science textbook.
(iii) The study is delimited to CBSE board schools only.

6. Discussion

Variety of research tools were used in previous researches to test and analyse the development of concept among students in different subject area, among different age groups and at different educational levels. Such as Snow and Rabinovitch (1969) used four decks of concept cards, consist of two sets. Each set is consisting of one conjunctive concept and another one is consisting of disjunctive concept. Abdullah and Lowell (1981) basically investigated children's ability to generalize science concepts with respect to age, IQ, gender and mental age. Further, Gilbert et.al. (2011) used four context-based model in which the first one was context as the direct application of concept, second is context as reciprocity between concepts and applications, third is context provided by personal and mental activity and fourth is context as social circumstances. Meanwhile, Kokkonen (2017) investigated concepts and concept learning in Physics using a systemic view. Bruner (1956) classified concepts into three types namely Conjunctive concept, Disjunctive concept and Relational concept. Here, the research tool which is developed by the researcher named Concept Development Test in Science (CDTS) is basically based on the Bruner's ((1956) classification of concept.

7. Conclusion

The development of concept in science is one of the important goals of teaching and learning of science. Unless, the children will develop the concepts in science completely they will not be able to connect the learned concept of science with their own life neither will they realise the importance of that learned concept.
Thus, the research paper is intended to develop a research tool that will be used to measure the development of concept in science. Therefore, the research tool was named Concept Development Test in Science (CDTS). The Concept Development Test in Science (CDTS) was developed for class nine, in selected content area of science.
The Concept Development Test in Science (CDTS) can be used by science teacher for both formative and summative assessment. The research tool can also be used for research purposes in order to measure the development of concept in science.

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