Exploring Concept Map and Its Role As Knowledge Assessment Tool (2009-2012)

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Abstract — **This study was carried out to explore and analyze Concept Map (CM) and its role as knowledge assessment tool in the educational setups (traditional, e-learning and m-learning). A CM is a two dimensional graph based visual diagram which includes many concepts and relationships among the concepts in a hierarchical manner, which helps the user to organize knowledge and to accommodate to different learning styles. This report provides a broad understanding of CM and research & development activities that took place during the period chosen for this study. Further to this, the findings are discussed briefly to provide a better insight of the field and suggest directions for future research.**

Index Terms— **Concept Map, Knowledge Assessment,**

I. INTRODUCTION

The scope of the review is that this review presents the holistic view of Concept Map and its role as learning assessment tool. For this study, the developments that took place between 2009-2012 in the educational settings with respect to the usage of CM as a assessment tool have been considered. The authors of this paper considered more than 30 research articles published during the selected period and surveyed them to give a summary about the applications of CM and its usage as an instructional and assessment tool during the above mentioned period. Due to the interest, those articles were surveyed in the context of CM as assessment tool. This review of literature study included peer reviewed journal articles, articles from Google Scholar, articles from select open access journals on the topic of interest and few conference articles.

A. Knowledge Assessment

Assessment is the process of gathering and recording information which is usually in measurable terms like level of acquired knowledge, amount of skills, attitudes, and beliefs. Knowledge Assessment focuses on the individual student or the learning community that include students of a class or workshop or other organized group of learners. According to a Wikipedia web article that quotes the Academic Exchange Quarterly [16] in which assessment defined as follows:

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"Studies of a theoretical or empirical nature (including case studies, portfolio studies, exploratory, or experimental work) addressing the assessment of learner aptitude and preparation, motivation and learning styles, learning outcomes in achievement and satisfaction in different educational contexts are all welcome, as are studies addressing issues of measurable standards and benchmarks".

Assessment is mostly used as an integral part of teaching and learning, as it determines whether the goals of education are being met or not. The outcomes of assessment are used to take decisions about learning took place, grades or scores, progress in education, lesson plan & instructional needs and also curriculum design. When assessment works better in an educational setup, it would achieve the following:

- It provides feedback
- It helps educators to define standards
- It evaluates progress of students
- It helps the students' and teachers' in self-evaluation.

In general there are different types of assessments are being used across the world [42], to mention a few, (i). Standardized assessment is provided in the form of tests. Every student has to take the tests in view of internal assessment. In India, almost majority of the educational institutions follow this type of assessments which is often criticized as teacher centric. (ii). Authentic assessment which is also known as alternative assessment is being used to measure students' understanding of a topic or lesson. Examples of these measurements are open-ended questions, written assignments and compositions, presentations, quiz and class room observation etc. Both (iii).Summative and (iv). Formative assessment are being used by the educators in order to gauges the understanding of the students in the class room and fields. But the summative is being carried out at the end of the course which often fails to improve the quality of learning obtained. More effective learning takes place only when the knowledge acquired is measured periodically (in stages) during the course being taught. This is possible when formative assessment is used in the learning environment.

B. Concept Map

CM is one of the Knowledge Representation techniques first proposed by John D Novak in 1970s. CM is a way of representing relations between ideas, images or words. In a CM, each word or phrase is connected to another and linked back to the original idea, which is known as *propositions* gives a meaningful learning. Various attempts have been made to conceptualize the process of creating CMs. It has

been suggested that the process of making knowledge explicit through concept mapping using *nodes* and *relationships*, allows the learners to become aware of what they know and as a result to be able to modify and update what they know. CMs are a way to develop logical thinking and study skills, by revealing connections and helping students see how individual ideas form a larger whole.

Novak's work is based on the cognitive theories of David Ausubel (assimilation theory), who stressed the importance of prior knowledge in learning new concepts: "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly"[3]. Novak taught students as young as six years old to make CMs to represent their response to focus questions such as "What is water?" "What causes the seasons?" and states that "meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures"[28]. His team then found the idea of concept mapping to represent children's conceptual understanding and knowledge in the form of a concept map. Thus was born a new tool (IHMC CMAP tool) not only for use in research, but also for many other uses. An example of a concept map, showing the key concepts involved in concept mapping is shown in Figure.1 [43].
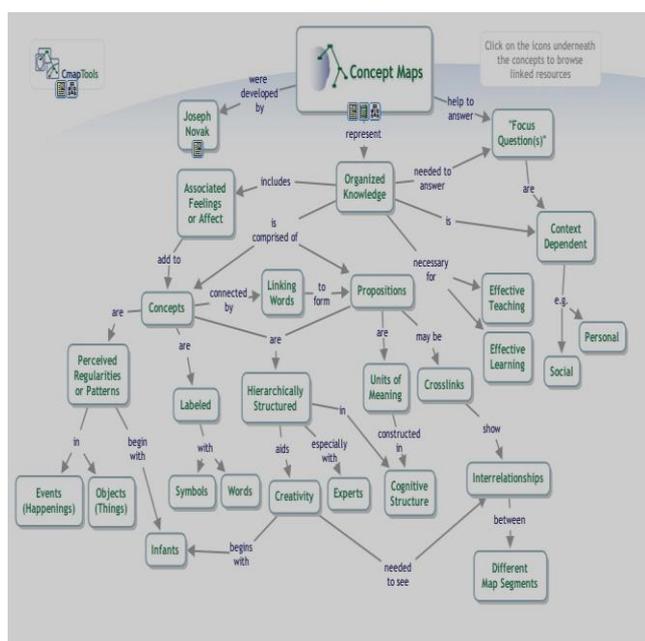

Figure 1. A Concept Map about Concept Map

Constructing the CM is very easy with a paper and pencil. When building a map, one is working with the flow of thoughts, group and sort concepts in a hierarchical manner. Today there are powerful tools available for constructing them digitally. Digital CMs are much easier to edit and organize because they will allow you to move objects and link them in new ways. A detailed guideline for constructing a concept map is provided in [27].

Review of Literature shows that concept maps are more flexible and represent concepts in an organized manner. It is evident that CMs are widely used in educational setups like schools and colleges to teach various subjects like science and mathematics, to assess the understanding level of the students with respect to knowledge structuring.

As CMs are flexible, they can be made simple or detailed, linear, branched, radiating, or cross-linked. Linear CMs are like flow charts that show how one concept or event leads to another. Hierarchical CMs represent information in a descending order of importance. The key concept is on top, and subordinate concepts fall below. Spider CMs have a central or unifying theme in the center of the map. Outwardly radiating sub-themes surround the main theme. Spider CMs are useful for brainstorming or at other times when relationships between the themes need to be left open ended. Cross-linked maps use a descriptive word or phrase and identify the relationship with a labeled arrow. The following sections classify and brief the different types of CMs that have been in use these days.

II. CLASSIFICATION OF CMs

Researchers suggested and reported different types and forms of CMs. The following sections provide a basic understanding on these types of CMs.

A. Traditional Concept Map

Novak's concept map is also called as Traditional Concept Map (TCM), which is being used to assess the understanding of the students in the class room. The node-arc method of representing the concepts and their relationship with each other plays a significant role in the teaching – learning process. It is very simple to construct the map using paper and pencil too. He presented a detailed guideline to help the users how to draw a map successfully [27]. Novak and his colleagues developed a tool for creation of the maps (IHMC Cmap Tool). This tool allows the users to create maps of their own and use locally, store in the web for others to use it, share among collaborative team members. It gives the users a comfortable stage to create maps as they wish and it supports many forms like hierarchy, flowchart and others. However Novak's Cmap [27] strictly follows the hierarchical structure only.

B. Refined Concept Map

Kharatmal and Nagarjuna [21] propose to refine the TCM with respect to the proposition words it uses. As the list of proposition is open and any one can use any word that best represents the relationship between two individual concepts. Since there is a need to use large number of words to represent the relationships, it is highly difficult for students to follow and understand them when used in the class room. It is well experienced in the science subjects. They argued for the refinement of the TCM and proposed the usage of limited set of linking words which is called the Refined Concept Map (RCM). RCM is used as a tool to teach the science subject in the school level broadly.
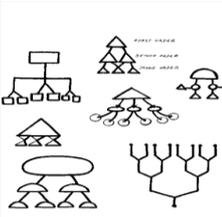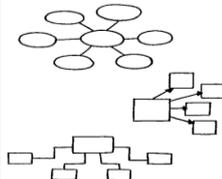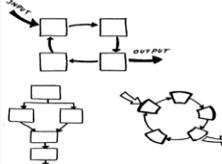
C. Visual Concept Map

Kumar [24] proposes to use the CMs in new form called

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Visual Concept Map (VCM) for educating differently abled children, who have difficulties in hearing and understanding speech. These children are highly sharp in grasping things better and perceive them properly by eyes. When comparing their learning in this way, it is found that they learn things very quickly than others. Special educators who help these children can use VCM in which pictures and motion clippings can be integrated in the map as nodes and the relations along with appropriate visuals can be employed to teach them the language vocabulary.

D. Forms of Concept Maps

A CM can take many forms, provided it includes concepts as nodes and illustrates relationships through lines and proposition statements in different layouts. The following table represents some of the familiar forms of CM:

Table. 1 Different forms of Concept Maps

Sl. No	Forms of CM	Description	Example
1	Hierarchy	Information structured from most to least important; or from most inclusive and general to less inclusive and specific	
2	Spider	Information organized outward around a central topic	
3	System	Information ordered like a flowchart with inputs and outputs	
4	Flowchart	Information ordered in a linear format	
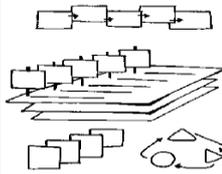
During the literature study, we found that a wiki webpage that contain information on kinds of CMs. The following are said to be special kinds CMs used to represent information and knowledge [17] in specific applications. Hence, any schematic approach with links or relationship mentioned, are being named as concept maps and the following are some of the examples of such diagrams. Further to this, a rigorous analysis needed to be carried out in order to add these forms to the family of CM forms. However, tracing them down to the origin and analyzing for mapping their characteristics with

CM characteristics will deviate from the aim of this study. Hence, taking this as new lead for further research would be better. The special Concept Maps include the following format types:

- *Picture Landscape Concept Map* - These maps present information in a landscape format.
- *Multidimensional / 3-D Concept Map* - These describe the flow or state of information or resources which are too complicated for a simple two-dimensional map.
- *Mandala Concept M*ap - Information is presented within a format of interlocking geometric shapes. A "telescoping" factor creates compelling visual effects which focus the attention and thought processes of the viewer.
- *Fishbone Concept Map* - Dr. Kaoru Ishikawa [17], a Japanese quality control statistician, invented the fishbone diagram. It may be referred to as the Ishikawa diagram. The fishbone diagram is an analysis tool that provides a systematic way of looking at effects and the causes that create or contribute to those effects. Because of the function of the fishbone diagram, it may be referred to as a cause-and-effect diagram.
- *Storyboard Concept Map* - A storyboard is a graphic, sequential depiction of a concept or narrative. Students recall major events of the story and then illustrate the events in the squares provided.
- *Venn Diagrams* - Venn Diagrams are often used in mathematics to show relationships in sets. It can also be used in Language Arts to show differences and similarities in literary pieces. They can also be used to compare and contrasts ideas, concepts, and theories.

III. CONCEPT MAPS IN EDUCATION

CMs are used as a teaching tool in various levels of educational institutions to better connect the relationships between concepts. These CMs will also help the students to map the new knowledge with previous knowledge and hence support meaningful learning of the concepts rather than memorizing concepts. Novak [27] first used CMs to assess the understanding level and knowledge structure of school students belonging to primary classes.

A detailed literature study carried out by Canas et. al [7] quoted many research works that describe the use of CMs with respect to Applications in Educational Settings and other domains as well. The report covered the developments from 1995 to 2005, considered a large number of articles and surveyed them to give summary about the applications of CM in various domains including education as a major domain of interest. The report presents broad understanding on the usage and applications of CM in various processes of education domain. Applications of CM include learning, measuring of understanding, to identify misconceptions, to explore conceptual change of the learners, for Collaborative Learning, for Assessment of Learning, to Organize and Present

Information and knowledge as organizer and for Course or Curriculum Development.

A. Concept Map as Instructional Tool

One of the powerful uses of CM is that it has been used teaching tool, thus encouraging teachers to use it as visualizing tool for teaching. CM is also regarded as meaningful-mode for learning patterns [27].

Canas et al.[7] the report presents broad understanding on the usage and applications of CM in various processes of education domain. Applications of CM include learning, measuring of understanding, to identify misconceptions, to explore conceptual change of the learners, for Collaborative Learning, for Assessment of Learning, to Organize and Present Information and knowledge as organizer and for Course or Curriculum Development. Further CMs can also be used for notes taking, summarizing important key concepts and relationships in the class room environments.

CMs are being used as a tool for Course Instructional design as advance organizers which provide an initial conceptual frame for subsequent information and learning for an effective course delivery. Large numbers of researchers have been using CMs in various processes of teaching as well as learning process. Also many others had used and experimented CMs for teaching Mathematics, Sportive Techniques, Science and Chemistry [27],[30],[33] for meaningful learning.

Further, CMs are also found effective in collaborative learning. Bruno *et.al* [10] analyzed the way in which university-level students perceive IHMC CmapTools in a remote learning context. Canas et al. [8] used LiveMappers.net, a learning environment that supports collaborative concept map-based projects among schools.

Gul Takdemir and Nergiz Ercil Cagiltayet [14] used CMs to introduce engineering course curriculum in engineering education institutions. Debopriyo Roy[11] argued for the importance of using specific kinds of concept maps, such as ladders in a technical writing class offered for computer science majors.

B. Concept Map as Assessment Tool

CMs are widely used as assessment tools both in the traditional classroom environment and e-learning environment. It has been regarded from the literature that CM as assessment tool reflects its unique strength among its varied uses, thus it encourages students to use meaningful-mode learning pattern. Ayala et al. [4] argued that embedding the formative assessment along with the core curriculum itself would help the teachers and students the get more benefits.

CMs are being used as a tool for instructional, assessment, curriculum design and other teaching learning activities. The following sections explore this role of CM as assessment tool in the classrooms and e-learning contexts.

C. CM as Assessment Tool in Classrooms

Since the inception, CMs have been widely used as an instructional tool for teaching subjects like science, chemistry, mathematics, grammar and others in the school level. This has been evidenced by a large number of researchers' works published so far. On the other hand apart from being used as a teaching tool, CMs have been used as an assessment tool in order to evaluate the prior knowledge and to enrich the same by acquiring new knowledge. In fact, the very purpose behind the inception of CM was to analyse how the new knowledge is accumulated with the existing as reported by Novak [27], CM was used to demonstrate this among the elementary level school children.

There has been a significant amount of growth in the studies that were carried out based on CM as Assessment tool in the classroom environment. As evidenced in [6], CMs has been used measure the structure of declarative knowledge in the form of multiple-choice, short-answer and concept maps provide valid evidence. CMs have been used to measure the change took place in knowledge structure and to measure the sensitivity of pre-and post-instruction in the undergraduate Marketing Principles course [36], measure the understanding of the learners [23,25]. CMs have been used for measuring the student satisfaction in the class room as part of assessment processes [10]. Mehmet Buldu and Nihal Buldu [26] used CMs in the class room as an assessment tool for measuring the student satisfaction. Canaset.al.[7] also reviewed articles on the applications of the CMs in various other domains like government settings, business and knowledge management.

D. CM as Assessment Tool in e-learning setups

Gouli et al. [41] contributed handy number of works that reported the use of web-based CM as an assessment tool for the students. They presented COMPASS, a web-based concept map assessment tool, which aimed at provide support to assessment as well as learning online. CMs were used to gauge the knowledge level of the students focusing on the propositions in the maps created, in various assessment tasks during the process of learning, to support individualized and collaborative learning [22] and assessment [8], obtain automated feedback to support reflection in concept mapping [19].

Anohina et al. [2] used CMs for adaptive knowledge assessment. They focused on using pre-built CMs in the adaptive assessment which had adopted 5 patterns for assessment purpose. The advantage reported was that the learner had opportunity to present with tasks appropriate to their knowledge level. Further they argued that CMs could be successful when used as a core of adaptive assessment systems.

Oboko et al.[29] used the adaptive scaffolds in form of concept maps in web-based e-learning systems that played the role of instructor cum learner guide. The learner made to create concept maps from prior knowledge to represent his understanding of a domain. The concept map had taken into

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account the knowledge of the learner in that topic by integrated evaluation, and then used it to adapt to the next level. The scaffolding and the adaptation were implemented using production rules.

Cho et al. [9] attempted to improve concept mapping via an integration of the concept mapping procedure with self-explanation in order to improve the efficacy of training. They investigated whether concept mapping can be further improved by incorporating self-explanation activities by controlling the total training time.

Schwartz & Dylan Arena [34] argued that increasing abilities to make good learning choices would be one among 21st century skills. *Learning choices* is a dynamic construct that suits the realization that people will need to continue to learn and adapt. They proposed a choice based assessment method, in which dethrone knowledge was used as the primary construct of assessment.

Hwang et.al [19] investigated an instant assessment and remediation approach to find how that approach could significantly improve the learning achievement and learning attitude of students. The study used a concept map-oriented mobile learning system with an instant feedback mechanism is provided. The experimental results reported that that the provision of proper assessment tools helped students make reflections and engage in higher-order thinking in the field. Also a comparison with traditional in-the-field learning and immediate assessment and feedback mechanism was carried out.

De Lievre Bruno et.al [10] analyzed the way in which university-level students perceive IHMC CmapTools in a remote learning context. The activity was done remotely and in collaboration to conceptualize the main features of a course in the human sciences. They used the CmapTools as an aid for structuring learning material. They argued that this activity of structuring the material is pertinent in terms of the conceptualization activities that they asked students to perform in lab exercises for a university course.

CMs have been suggested for computer based knowledge assessment as a self-assessment tool [1]. This work suggests the importance of identifying the concept mapping tasks to be addressed during the computerized knowledge self-assessment. The result, a taxonomy of concept mapping was presented and with explanation.

Grundspenis [12] presented the analysis of questionnaires focusing on CMs as assessment tool and mentioned that the feedback obtained from the students reveal the necessity of developing rubrics for evaluation of maps in the intelligent knowledge assessment system (IKAS).

Berlanga et al. [6] presented the theoretical considerations, design and requirements of a tool that can provide formative feedback on learner's textual assignments using CM. The tool enables the users to know their position in the field of interest

by comparing different reference models that are generated semi automatically.

Zak et al. [40] used CMs to assess K–8 pre-service teachers' understanding of basic ecological concepts. It was reported that CM was a useful tool for providing insight into the understanding of learners. The teachers organized, associated, and described the relationships among 16 basic ecological concepts used during the assessment. The findings revealed the general understanding on the topics and patterns of omissions of select concepts were also reflected.

IV. FINDINGS

From the literature study, it has been evidenced that CMs are widely used in the traditional teaching and learning process in order to assess the knowledge structure of the students. Reports considered for this study reveal that CM has been used as an effective tool both for teaching - learning as well as assessment. Further the articles published very recently are revealed that more researchers have been using CM in e-learning and m-learning environments effectively by integrating it with intelligent and semantic computing techniques. The following are the gist of the findings;

1. CMs have been widely used in both class room, e-learning as well as m-learning environments effectively.
2. Adaptive e-learning is the focused area which is evidence from the majority of the research articles considered for this study.
3. This study also found that potential research problems exist in the context of usage of CM in mobile learning processes such as tools and methods that take CM to the recent mobile devices like note book, tablet, smart phones etc.,
4. Research on the impact of CM among the students in the context of cognitive process that taken place, perceived usefulness and effectiveness were also found during this study.
5. Few works have reported that the CMs can be used for choice-based learning.

This study considered articles from familiar research databases like Google Scholar and DOAJ (open access journals), the finding may not be providing a complete picture on the roles of CM in education and other fields. The authors of this paper were interested in studying the role of CM as FA tool and considered the articles published from 2009 to 2012. As mentioned earlier, the literature report of Canas et al. [7] had considered articles belonging to the period of 1995-2005 and gave summary. The time span 2006-2009, which is not included for this study, can be considered to be the gap in the research done so far.

V. CONCLUSION AND FUTURE WORKS

This study was carried out to explore knowledge assessment and the role of concept map as assessment tool. Select papers from the period 2009-2012 have been

considered and the findings from this study were also presented. The findings of the study convey the following; (a) As CM is more flexible in nature, there is a scope for integration with other approaches of learning environment. (b) As an emerging tool with different roles in learning environment, CM has a huge opportunity for new research avenues as stated below;

1. Integrating the innovative and new ideas that make mapping interesting process can be focused enabling the 21st century educators and learners use new techniques

2. Potential research avenues are possible in the area of intelligent concept mapping systems in the fields of e-learning and m-learning with respect to observing the user behavior, identifying their choices and interests etc.

3. New schemes to assess the knowledge of the learners (both formative and summative assessment) may be another area of interest where lot of research issues can be addressed

4. Mobile learning - New CM based techniques for m-teaching and m-learning is the need of the hour as new powerful and handy mobile devices like smart phones, i-phones and tablets have started attracting people and will gain their popularity and existence with students in the very near future.

5. More rigorous works towards the usage of CM with open ended research issues like formalizing the mapping processes would be another potential area for future directions.

6. Further attempts can be made to integrate game theory approaches in the game-based learning environments.

Further, a limited set of articles from the time frame mentioned (2009-2012) had been considered for this study, hence, there is a need to do a rigorous research in extending this study to cover the gaps identified in terms of time span and roles of CM in other domains apart from education can be considered for future enhancements of this paper.

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