Changing Classrooms into Knowledge Laboratories

… A Possible Scenario Replacing Everyday Lectures?+++

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Abstract

Present day classroom practices can benefit from the use of new technologies and teaching methodologies. Using inquiry-based learning and knowledge-based techniques in classroom situations, the paper relates the experiments conducted over two semesters at the Singapore Maritime Academy. In the experiments, the lectures were replaced with student activities, which resulted in engagement of students with the content. Constructivist methods were used to develop knowledge-based artefacts, which could be reused and further refined through future classroom processes. Techniques used to capture student activities using software suit CmapTools are also described in detail.

Keywords: *Constructivist learning, CmapTools, concept maps, knowledge laboratory, knowledge building in classrooms.*

INTRODUCTION

A major concern for teachers for descriptive subjects is to engage the learners during classroom-based lectures. When the subject content is mathematical, the engagement is probably easier as after going through with some theories and examples, the learners could be asked to apply the techniques to specific problem sets and learners get busy with problem-solving. In the case of a descriptive subject, the scenario in class usually ends up in a deductive lecture, where the minds of the passive learners could stray easily past the droning tones of the lecturer and even the colours of the PowerPoint slides fail to make much *meaning* in absence of any *engagement of the learners with the content*.

The author had this dilemma of selecting a suitable engaging strategy when a subject was taught recently in two terms of a semester, where the first term was dealing with ship resistance calculations, which was purely mathematical, posing no problems and the second term dealt with the ship constructional details, which dealt with description, typical subject-specific terminology, drawings and sketches of details of ship structure.

The paper describes how an initial inquiry-based learning strategy was selected in the second term when the descriptive part was covered. This strategy led to the development of resources for the topic and later in the following semester, the approach was changed to a strategy of concept mapping to continue student engagement. A computer-based concept mapping program CmapTools from Institute for Human and Machine Cognition (IHMC), USA, was used to capture these classroom processes.

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The details of these student processes in the classroom situations are included in the paper and it is argued that these constructivist strategies together with computer-mediation with the appropriate tools could generate knowledge systems, which, on one hand, promote learner engagement, thereby improving student learning and on the other hand may lead to the development of *advance organisers* for learning and problem-solving, which could be iterated for refinement during every semester.

A detailed description of the use of CmapTools for developing searchable knowledgebase in a subject domain through classroom processes is also included.

It is suggested that in similar classroom situations, lectures in the present form, could perhaps be replaced with these strategies to improve student engagement of content. The classrooms could then be named as *knowledge-labs* as each session would refine the existing knowledge system with *cognitive commitment* of the learners.

The paper is organised in three sections. Section 1 attempts to define the *knowledge* in the context of *learning*. Section 2 describes the learning environments and classroom processes, which led to this paper and the Section 3 relates the techniques of knowledge capture from the classroom processes using CmapTools.

SECTION 1 – KNOWLEDGE IN THE CONTEXT OF LEARNING

***From Wikipedia**: **Knowledge** is information of which someone is aware. Knowledge is also used to **mean** the **confident understanding of a subject**, potentially with the **ability to use it for a specific purpose**.*

For a learner, the knowledge content to be presented for learning must be suitable to his or her stage of development. In other words, the learner's readiness to receive this knowledge is related to the learner's *stage of intellectual development* (Brainerd, 1978).

Additionally, from the point of view of learning and the present emphasis of the need of constructivism associated with the act of learning, the knowledge content to be learnt should be an *individually constructed experience* (Siemens, 2005).

Siemens (2005) also raised the notion of *networks* as a representation of knowledge system for learning. Networks, he claimed has its inherent simplicity of *at least* two elements (more in a complex domain) of *nodes* and a *connection*. Nodes could be *concepts* in a subject domain and the connection is the *relationship* between these nodes or concepts. Hence, the two nodes represent the subject domain to the learner *at this top-level*, and the relationship between the nodes helps in *meaning-making* of this knowledge representation.

The discussion above makes the case for visual knowledge representation (Jonassen & Grabowski, 1993, p.433), which could allow the learner to have a visual overview of the knowledge domain. The Figure 1 shows a top-level of knowledge domain consisting of 4 nodes and one connector with the *meaning-making* connecting phrase.

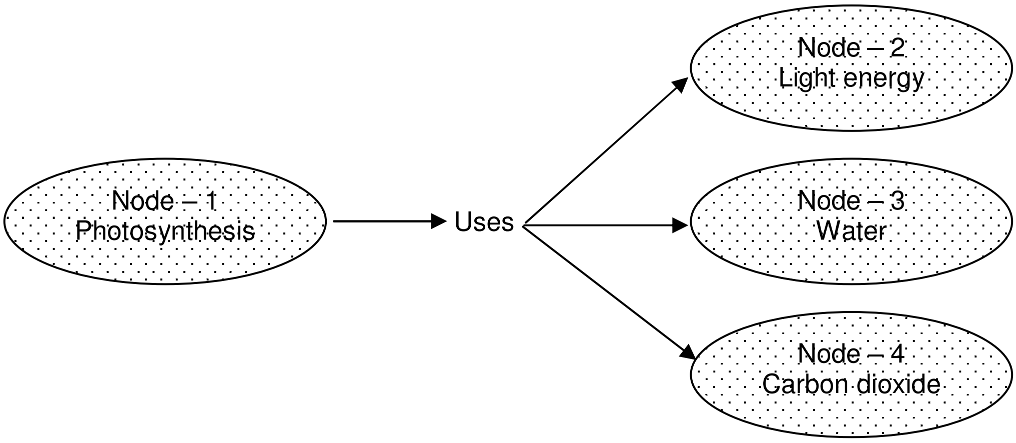

Figure 1 – A knowledge representation network in context of learning

To represent a real world domain, the number of nodes in the knowledge representation network would need to increase. As number of nodes increases to represent a more realistic view of the subject domain, the learner is faced with a visual representation, which is difficult to grasp. A cencept-map made during the classroom experiment conducted by the author is shown in the Figure 2, which may represent the knowledge domain in more detail and yet it may not be the right representation of knowledge for learning at the beginner-level.

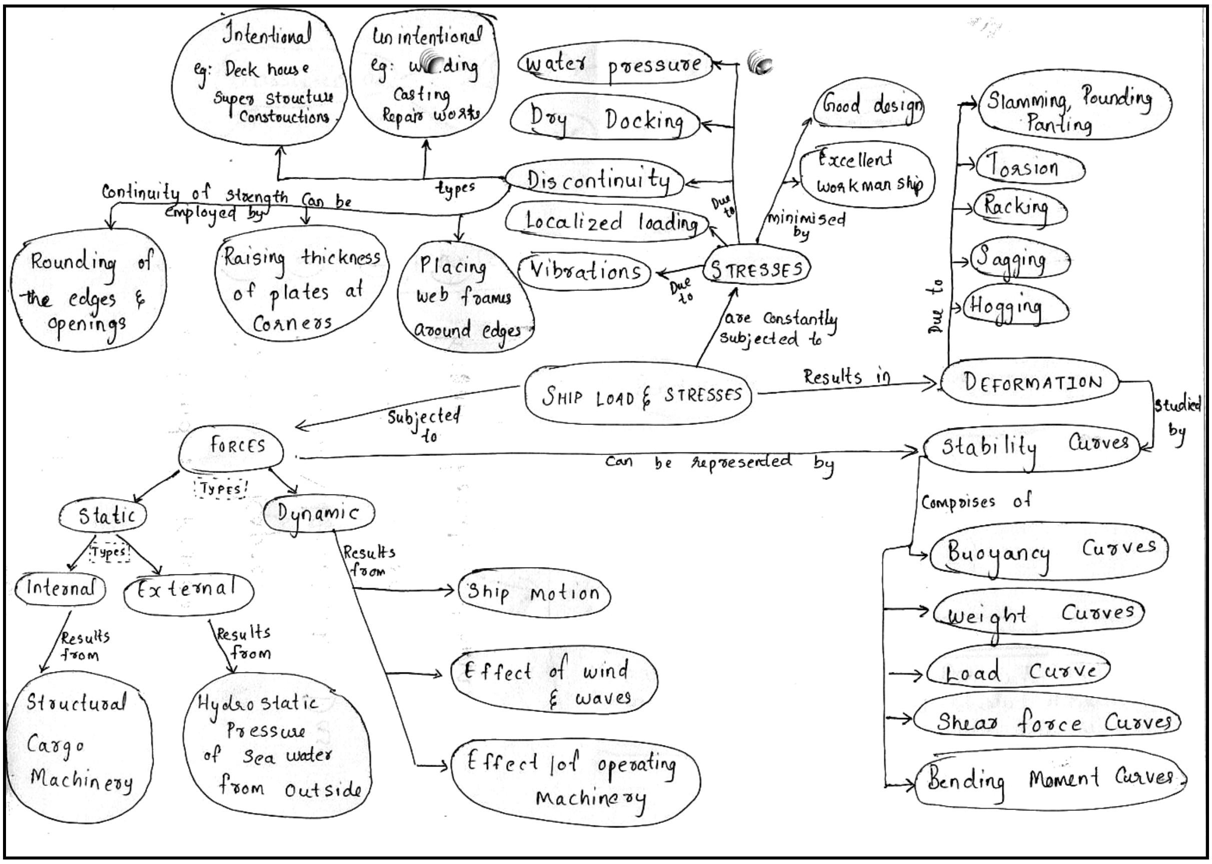

Figure 2 – Somewhat detailed representation but not easy for a learner to grasp quickly

The key to manage this problem is perhaps to split the domain into smaller manageable logical segments of knowledge, just suitable for the level of learners and for quick *meaning-making*. These knowledge-segments should have logical interconnections between them to represent the complete domain knowledge. The Figure 3 shows the knowledge representations at split levels and their logical interconnection. Concepts are shown as knowledge nodes and connectors [C] depict the interconnection. The connectors represent the relationships between concepts. Three split levels are shown with their logical connectors.

This splitting of the domain into levels of knowledge provides the possibility of extending the depth of the subject in any particular area by creating deeper levels. If we extrapolate this manner of knowledge representation for learning, it becomes evident that a large body of a structured knowledgebase could contain knowledge levels necessary for the beginner's level, advanced level and even at practitioners' level by increasing the level depths. Then, a beginners' course could include only, say, the first 5 levels. An advance learners' course could cover these first five levels quickly as refresher and then cover in detail the next five levels, which are more appropriate to the advanced learners. Similarly, if the knowledge nodes have been captured for the practitioners' level, similar strategies could be practiced. As an example, in Singapore Polytechnic, this approach could be taken for a particular subject at Diploma level, followed it up at the Advanced Diploma and extend it further to a Specialist Diploma – all using the same structured knowledgebase.

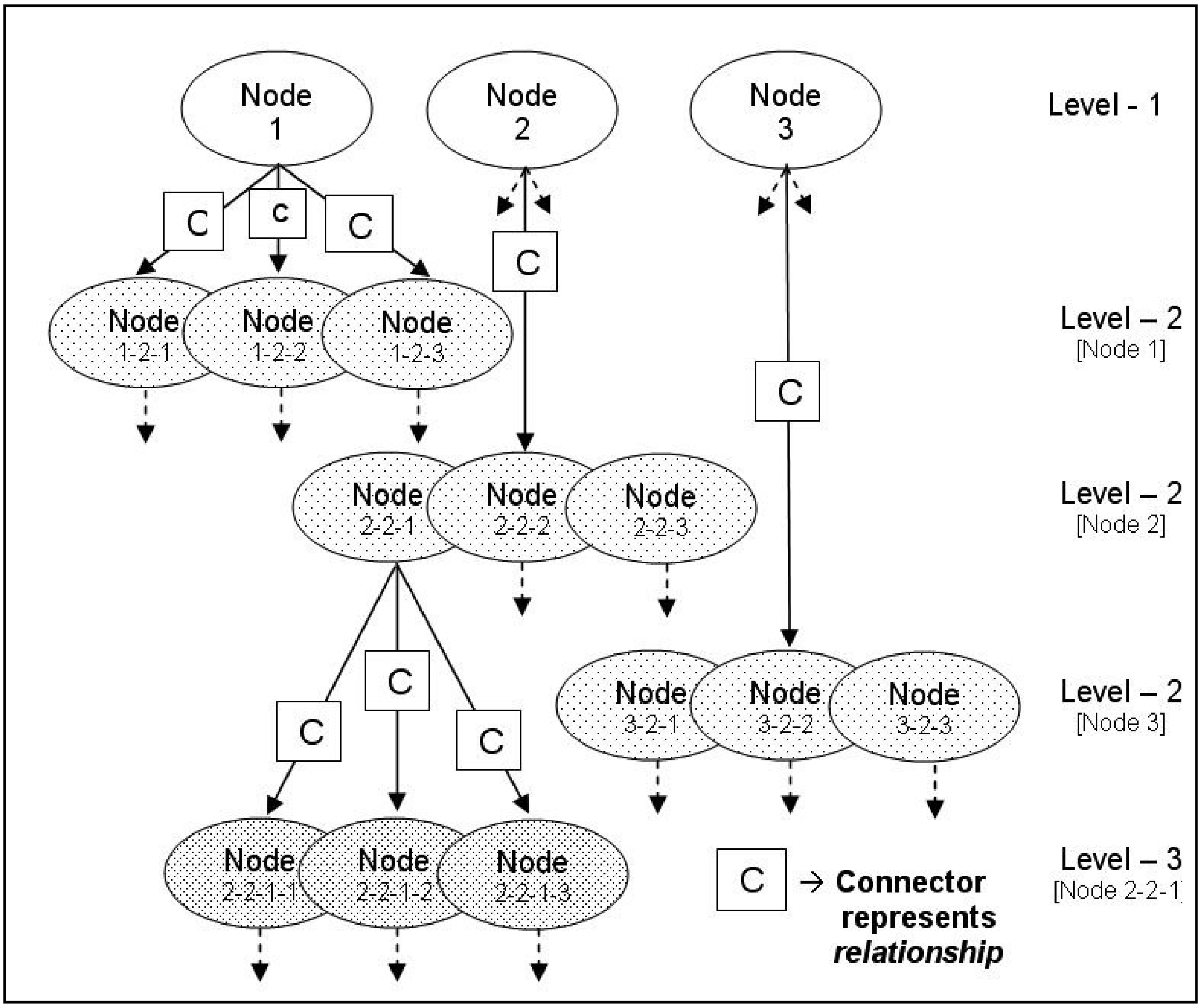

Figure 3 Subject domain split into manageable knowledge levels for easy learning

The Institute for Human and Machine Cognition (IHMC) of University of West Florida developed a software suite called CmapTools, which is the resulted outcome of many years of research by Professor Joseph D. Novak (presently the Emeritus professor of Biology & Education, Cornell University, USA and Senior Research Scientist at IHMC). CmapTools allows users to construct concept maps to represent large bodies of knowledge. CmapTools supports splitting of large subject domains to be divided into levels of concept maps and relationships.

IHMC researchers receive funding from a wide range of government and private sources. IHMC research partners have included: **DARPA, NSF, NASA, Army, Navy, Air Force, NIMA, NIH, DOT, IDEO, Nokia, Sun Microsystems, Fujitsu, Procter & Gamble, Boeing, SAIC, and IBM** among others.

> ***The CmapTools client is free for use by anybody****, whether its use is commercial or non-commercial. In particular, schools and universities are encouraged to download it and install it in as many computers as desired, and students and teachers may make copies of it and install it at home. (Commercial companies that install their own CmapServer do need to get a separate license for a CmapTools client that will talk to the commercial version of the CmapServer). [From http://cmap.ihmc.us/]*

Based on the learning psychology of David Ausubel (1963; 1968; Ausubel et al., 1978), CmapTools is designed on the principle that learning takes place by the assimilation of new concepts and propositions into existing concept and propositional frameworks held by the learner (Novak & Cañas, 2006).

CmapTools creates a domain of knowledge referred to as *Knowledge Model*, which consists of series of concept maps. A concept map has *concepts* and their *inter-relationships.* The concepts are populated with *resources* e.g. media files, texts, URLs, slides as well as concept maps at other levels (Cañas et. al., 2003). Each concept could be well defined through the use of these resources. Then keywords or phrases are used to inter-relate these concepts, which are known as *meaning-making* in the knowledge domain. Cmap*Tools* could also be used for collaborative learning and could be uploaded to the server for worldwide sharing.

These knowledge models could also serve as *learning objects* and a combination of them would make a bigger knowledge model. Each concept map could be made just the right size for learning – making them manageable for various target groups of learners.

In this classroom-based research project at the Singapore Maritime Academy, the CmapTools was used in two semesters to develop a knowledgebase at beginner's levels for this experiment at the Singapore Maritime Academy. The outcome of this project is now resident on CmapTools Public Server and the knowledge model is called "*Ship Construction for Beginners*". Being in the public domain, anyone with the CmapTools software suit could access the captured classroom processes through Internet and even annotate with comments.

The next section presents details of the classroom processes, which provided the necessary interaction of the learners with the content and also relates how CmapTools software suit was used to capture the results of these interactive processes, which could be reused as *advance organisers for learning* in the subject domain.

SECTION 2 – LEARNING ENVIRONMENTS & CLASSROOM PROCESSES

> *When we were students, content area classes, such as social studies and science, focussed on memorization of specific facts and concepts. We listened to lecturers, read textbooks, filled out worksheets, gave "right" answers in class discussions, and took tests about facts, dates and events that we forgot as soon as the test was over (Short, 1996).*

With the urge to get away from the familiar model, so well described by Short (1996) above, and to put an emphasis to content interaction, an inquiry-based strategy was chosen.

It will be pertinent to quote Paulo Freire in an interview with Aurora (Gismondi, 1999).

> *It is impossible that a person, not being the subject of his own curiosity, can truly grasp the object of his knowledge.*

As Freire stressed the need for *knowledge* to be *grasped* should come from the queries generated by the learners themselves and NOT the teacher, the student group was asked to generate relevant questions as they thought fit after interacting with the content in a classroom process. This classroom process is described below under *Inquiry-based Learning* and was undertaken with a student group in the first semester, when this project was initiated. The learner groups generated their own queries and developed resources in PowerPoint slides and the entire process was then captured in CmapTools.

In the next semester the author worked with another group of students for the same subject. The earlier queries generated by the last group were re-looked by this new group of learners in classroom situations to find relationships between those issues from the queries.

These classroom processes are described below under *Meaning-making in Classrooms.* It is realised that the concepts and issues generated in the last semester do not exist in isolation. Concepts are related to make meaning in the subject domain. To find this clarity of meaning, the learners are challenged. The learners need to think in various directions to establish the true relationship between the concepts. It is probable that learning takes place when the learners indulge in deep thinking to seek inter-relationships between the concepts. Concepts and these inter-relationships make a small entity of a knowledge node.

A knowledge node (also called *semantic units* or *units of meaning*) of concept map is referred to as a Proposition (Novak & Cañas, 2006), where it is defined as follows:

> *Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement.*

The details of these two semesters of classroom practices are presented in the following two subsections.

Inquiry-Based Learning

This approach was taken in the last semester for a 3rd year Diploma in Maritime Studies Module on Ship Construction. This is a sandwich course where the students spend their 2nd year at sea. As these students had already sailed on ships, it was decided to tap their experience by allowing them to develop their inquiring attitudes, which is essential in analysis and examination of knowledge.

The subject was divided into various topics and each topic was handled in two consecutive classes (Tuesday & Thursday of each week of the term). The students were grouped with four students per group. Each student group was given two sets of hard copies of the topic on day one. During the entire lesson, they were asked to go through the topic and develop a suitable question per group for the topic, which would make meaning to them. The idea was to sieve out the main issues in the topic, which they thought were important. As there were six groups working, there were possibilities of six view points of the subject area in hand. The students were told that we were working towards multiple perspectives from the core topic given in text format as hand outs by the facilitator. They were to submit the questions by the end of the one and half hour lesson and were graded on the quality of the questions generated.

As there were two classes per week, one on Tuesday and the next one on Thursday, the students were asked to prepare suitable answers to the queries raised by them earlier in the week and present them on Thursdays. The submissions were to be in PowerPoint presentations. The presentations were critically viewed, evaluated and graded by both the peers as well as the facilitator.

The next step was to organize this work into a knowledgebase, which could provide a multiple platform for easier access and understanding. The tool used was IHMC CmapTools. The CmapTools knowledge model created for the project is shown in Figure 4 below. This was then put on an autorun CD for distribution.

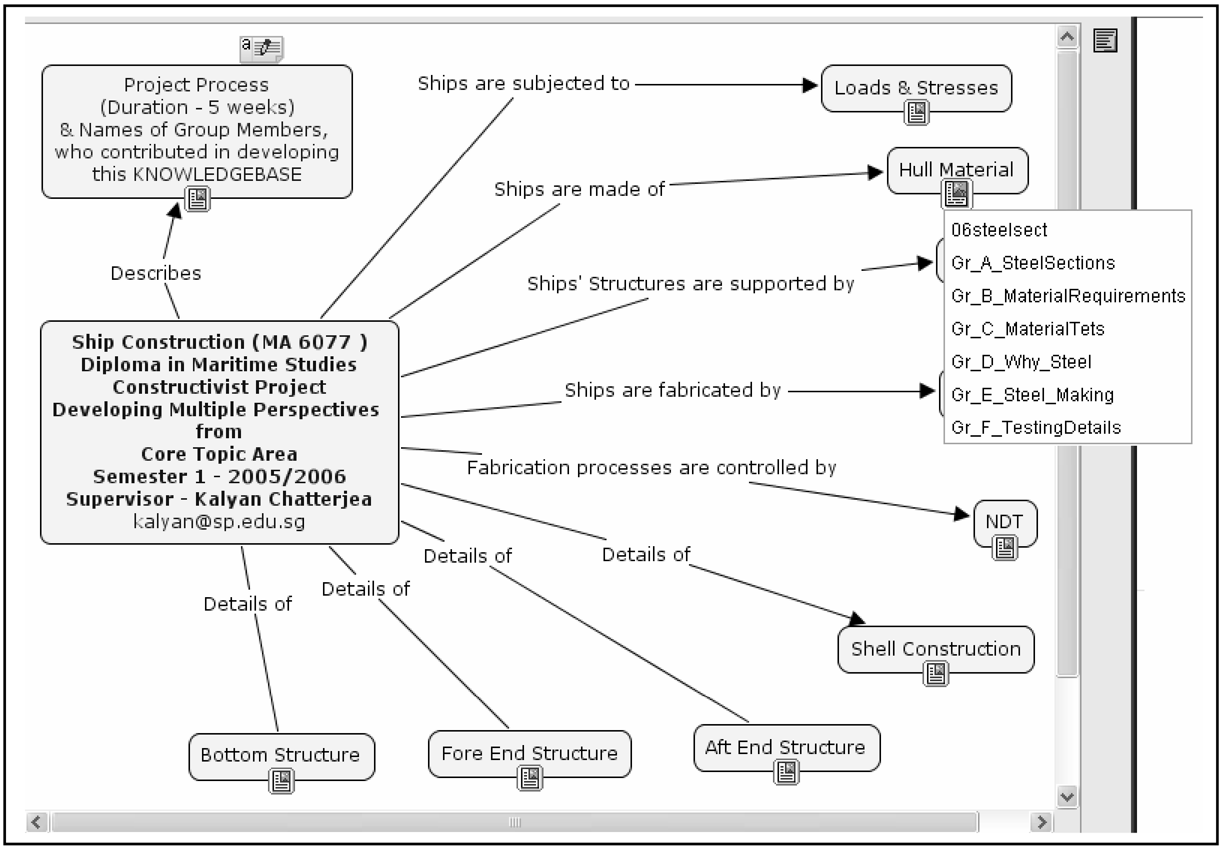

Figure 4 The Initial Concept map generated after one semester.

Each student was given this *autorun CDs*, which could be used to access the resources for future use. It was realized that in the next run, the knowledge model could be refined further by producing more resources and more Cmaps, which could define the scope at a lower level.

Referring to inquiry-based learning Joe Exline (2004) stated the following with respect to traditional delivery of education:

> *Unfortunately, our traditional educational system has worked in a way that discourages the natural process of inquiry. Students become less prone to ask questions as they move through the grade levels. In traditional schools, students learn not to ask too many questions, instead to listen and repeat the expected answers.*

Some of the discouragement of our natural inquiry process may come from a lack of understanding about the deeper nature of inquiry-based learning. Effective inquiry is more than just asking questions. A complex process is involved when individuals attempt to convert information and data into useful knowledge. Useful application of inquiry learning involves several factors: a context for questions, a framework for questions, a focus for questions, and different levels of questions. Well-designed inquiry learning produces knowledge formation that can be widely applied.

Thus, at the end of the module one could claim that some additional knowledge formation was made possible by the process. Quoting Joe Exline again, he said,

> *Inquiry implies involvement that leads to understanding. Furthermore, involvement in learning implies possessing skills and attitudes that permit you to seek resolutions to questions and issues while you construct new knowledge.*

This methodology of teaching is different from traditional classroom-based teaching, where all the answers come from the teacher and the students remain passive recipients of knowledge from a single viewpoint. The inquiry-based learning attempts to engage the learners in active learning and basic course material could be dynamically improved with each run of the module.

Meaning-making in Classrooms

A second group of 3rd year Diploma students in Maritime Studies Module on Ship Construction was targeted in the next semester. Similar to the first group, these students also spent their 2nd year at sea.

The students were briefed about the work done by the last cohort and they were given an option to either continue a similar experiment in the class or learn through traditional classroom lectures. It was encouraging to note that all of them were eager to contribute and ready to support this classroom-based research.

The reason for their enthusiasm could also be the novelty of this process, as they were expected to provide inputs as opposed to receiving passive 'knowledge'

Again the students were divided into groups and they were given one topic in each class. The main issues in these topics were identified by the earlier groups. These new groups had the task of finding the relationships between these issues (or *concepts*) to make the so-called *meaningful knowledge node*, giving a visual overview of the subject domain.

Two classes were participating. We had 4 students in each group and there were seven groups in one class and eight groups in the other. To start off the session in the two-hour class (the class time was extended to 2 hours from 1½ hours in the last semester), I spent about fifteen to twenty minutes showing the issues and the resources generated by the earlier groups and introducing the topic to the new group of learners. Then it was up to the individual group to discuss the topic among the group-members. Usually, the making of the concept maps was done in the second hour, when concepts and relationships were finalised by the group. Each group produced one concept map for the topic. Hence, on the topic selected for the day, I had an outcome of seven or eight hand-drawn concept maps. One of the day's outcomes by a particular group is shown in the Figure 2.

Later I would look through these seven or eight concept maps and produce a single cencept-map using CmapTools. The process was to select some of the suggestions in the hand-drawn concept maps by the groups, which were similar in most of the concept maps. So, the main issues came out in a distinctive manner and therefore it was easy to create this part of the map.

In general, about 70% of the ideas were similar and deliberate decisions were required for the rest 30%. Usually, considerable cognitive involvement on part of the facilitator was called for and it must be admitted that some deeper meanings became clearer as many items produced dilemmas in these decision makings. The produced Cmap was later shown in the class for further debating and finalisation. In later sessions, while the groups struggled with the day's topic, I was working on the previous day's outcomes and struggling as well to produce a Cmap truly representative of the knowledge domain.

As there was a product being made as a classroom outcome, all involved showed a lot more seriousness than a normal class. This struck me as a positive result of this new teaching and learning strategy.

In the following final section, I discuss the steps in capturing this classroom-based knowledge generation processes using CmapTools software suite.

SECTION 3 – KNOWLEDGE CAPTURE USING CMAPTOOLS

From the Wikipedia's definition of knowledge, the thrust should be on the ***confident understanding of the subject*** and at the same time, it should be targeted towards acquiring ***the ability to apply this knowledge for a specific purpose***.

The *specific purpose* in CmapTools is called the *focus question* (Novak & Cañas, 2006). It is recommended that every concept map should address a specific problem. When saving the Cmap, one has to define this focus question as one of the properties of the Cmap generated. While making the Cmap, this *focus question* should always be borne in mind, otherwise the Cmap could cover the domain knowledge area in general but to the learners it may not be obvious why they are learning the unit. As an example, the main Cmap for this project is titled "Ship Construction for Beginners", while the focus questions is "How are ships constructed?". For another Cmap titled, "Hull Framing System", the focus question is "How are ships structurally supported?".

Concept mapping exercises could be viewed as two principal processes, identification of main issues & deciding on the interconnecting phrases between these issues.

We found that by populating a Cmap with too many concepts usually results in a complex presentation and the new learners are confused to grasp what the main issues are in the domain.

We restricted our concepts to about five in a Cmap. The domain knowledge was split into number of Cmaps to accommodate the knowledge domain. Additionally, we used nested nodes which usually hide the details and shows only when necessary.

The following sequential steps were used to make Cmaps:

- Sieve out the main concepts in the subject domain.
- Prioritise the concepts in hierarchical manner and choose the top four or five concepts.
- Start with these four or five concepts on the CmapTools.
- Work out the relationships between concepts. Iterate for the best representation of the knowledge domain.
- If the remaining concepts are to be included, these could be included through nested nodes (which could be hidden for clarity and shown only when necessary) or more Cmaps at a deeper level.
- Populate the concepts with media files, text files, slides, URLs and more Cmaps to define the concept.
- Get users and practitioners to vet the resulting Concept map.

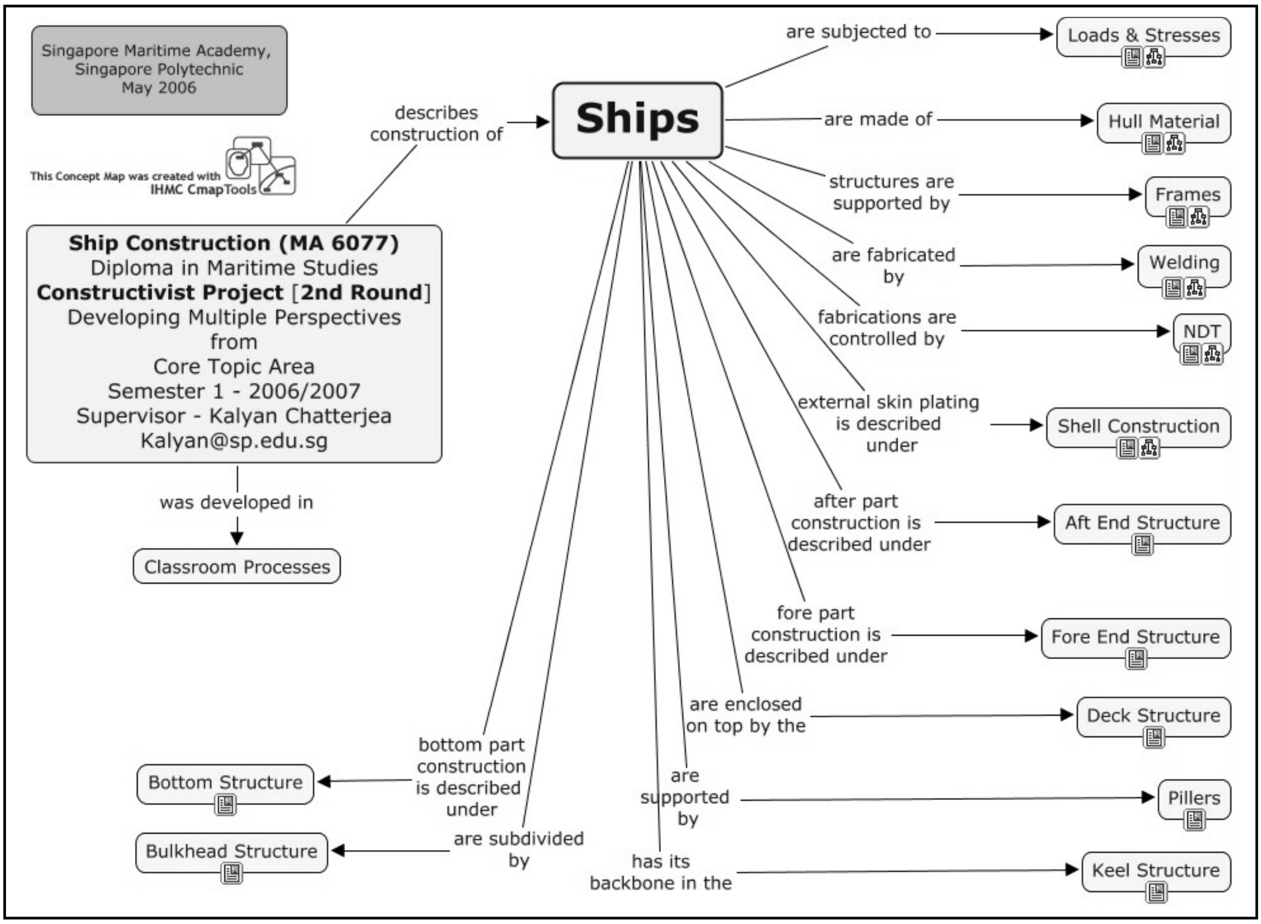

Figure 5 Improved Cmap after 2nd Round of Classroom Processes

The resultant Cmap from the present semester is shown (Cmap is still under construction) in Figure 5, which is an improved version from the one created after the first semester. The completed Cmap will be handed over to all the participants at the end of the semester. This will serve as an *Advance Organiser for Learning*.

This Cmap on "Basic Ship Construction for Beginners" are now uploaded to the Public Server at the IHMC, USA. Anyone with CmapTools could view the same and annotate comments for vetting and critical evaluation.

CONCLUSION

The paper described the classroom processes of student engagement with the content through use of inquiry-based learning and concept map development. These replaced the passive classroom process of lectures with 3rd year Diploma students at the Singapore Maritime Academy. The experiments conducted over two semesters produced concept maps, which could be used by future cohorts of students to learn and further improve this product as a classroom-based outcome. According to Novak (1993), knowledge creation by individuals facilitates the process of learning for them. Normal lecture classes were converted to knowledge laboratories to develop and refine knowledge-base artefacts. The student responses were positive.

Further studies are required to measure the improvement of learning in students through longitudinal classroom-based research projects.

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