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MODELING A KNOWLEDGE DOMAIN FOR A MARITIME COURSE

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Abstract. Leveraging concept-mapping in a maritime course can lead to knowledge modeling and has the potential to change the traditional ways of teaching and learning with many constructivist components. The resulting knowledge model can maintain an updated knowledge-base system (KBS), which can benefit the learners. In the long run, the KBS can produce a dynamically enriching information repository, which has the potential to support the learners as well as practitioners in the subject domain. The paper relates the experience gained in a case study at the Singapore Maritime Academy (SMA), spanning a period of almost three years, and describes the processes followed for developing this knowledge model. The results so far have been successful in establishing a knowledge model, which is structured with classificatory (*object*-based) as well as explanatory (*event*-based) components. The paper further describes the plans for capturing the dynamic procedural knowledge from ships at sea, which is expected to enrich the present knowledge model incrementally.

1 Introduction

Keeping the content in-line with the competences required for operating engineers at sea is a challenge, which is ill-served by today's maritime training institutes (Chatterjea, 2008). The rate of change of technology at sea and the operational procedures for various ship types are taking place at an accelerating pace. It becomes difficult to incorporate these changes in the course structure of a maritime training institute when the content is based on published literature, which is out-of-phase due to the present rapid changes in technology and shipboard practices. In a case study at the Singapore Maritime Academy, a new course model is being used, which is based on concept mapping and proposes social constructivist methods of involving learners in developing and updating course structure. The learners develop concept maps from existing literature as well as from shipboard practices, which are captured, when the learners are on attachment at sea. Replacing lectures with active learning was made possible through the use of CmapTools and a classroom infrastructure, which is very different from traditional classrooms, where teaching and learning are mainly dependent on transmission mode. The paper describes the development of this course model, which incorporates content, assessment as well as course administration as part of the core knowledgebase all managed through the *Views* of a CmapTools project.

2 Knowledge Model for a Maritime Domain

The case study relates our experience at the Singapore Maritime Academy (SMA) with a group of senior engineers from ships. They are qualified to operate ships with diesel propulsion and are presently doing a conversion course at SMA for gaining proficiency in running of LNG carriers with steam propulsion. Presently, we just finished our 4th Cohort of trainees, who participated actively while going through this course and thereby contributed in improving the system. Over a period of almost three years we have been developing a CmapTools-based dynamic knowledge model to run and administer all aspects of this conversion course. The knowledge model includes learning content, formative assessment, knowledge creation and capture, summative assessment, feedback and general course administration, all stored in the *Views* of CmapTools. Thus CmapTools *Views* served as an information repository for the developing KBS.

In *Views* we created folders of (1) Core Knowledgebase, (2) Steam COC Course and (3) Cohort Assessment sections. Over this period of nearly three years, this repository has become a fairly large data source and it is virtually impossible to extract the desired information without some navigational interface. However, using Novakian concept maps, accessing through this digital information repository and exploring various concepts with embedded details (texts, graphics, movie clips etc) have been made relatively simple (see Figure 2). This method of graphical information lay-out and navigation is referred to as polyscopic modeling by Karabeg, (2004). Karabeg suggested "*mountain top view*" information design to handle information overload in a complex subject domain. Polyscopic Modeling is best illustrated by Polyscopic Information ideogram (Figure 1). The triangle in the ideogram represents a mountain, on which every point is a scope or a viewpoint. Polyscopic information (represented by the "i" inscribed in the triangle) consists of the high-level information (represented by the circle) and the low-level information (represented by the square). The high-level information provides the large picture of the subject domain, while the low-level information provides the supporting details, the foundation and the necessary rationale (Karabeg, 2004).

Figure 1. Polyscopic Information Ideogram
[Source: Karabeg, 2004]

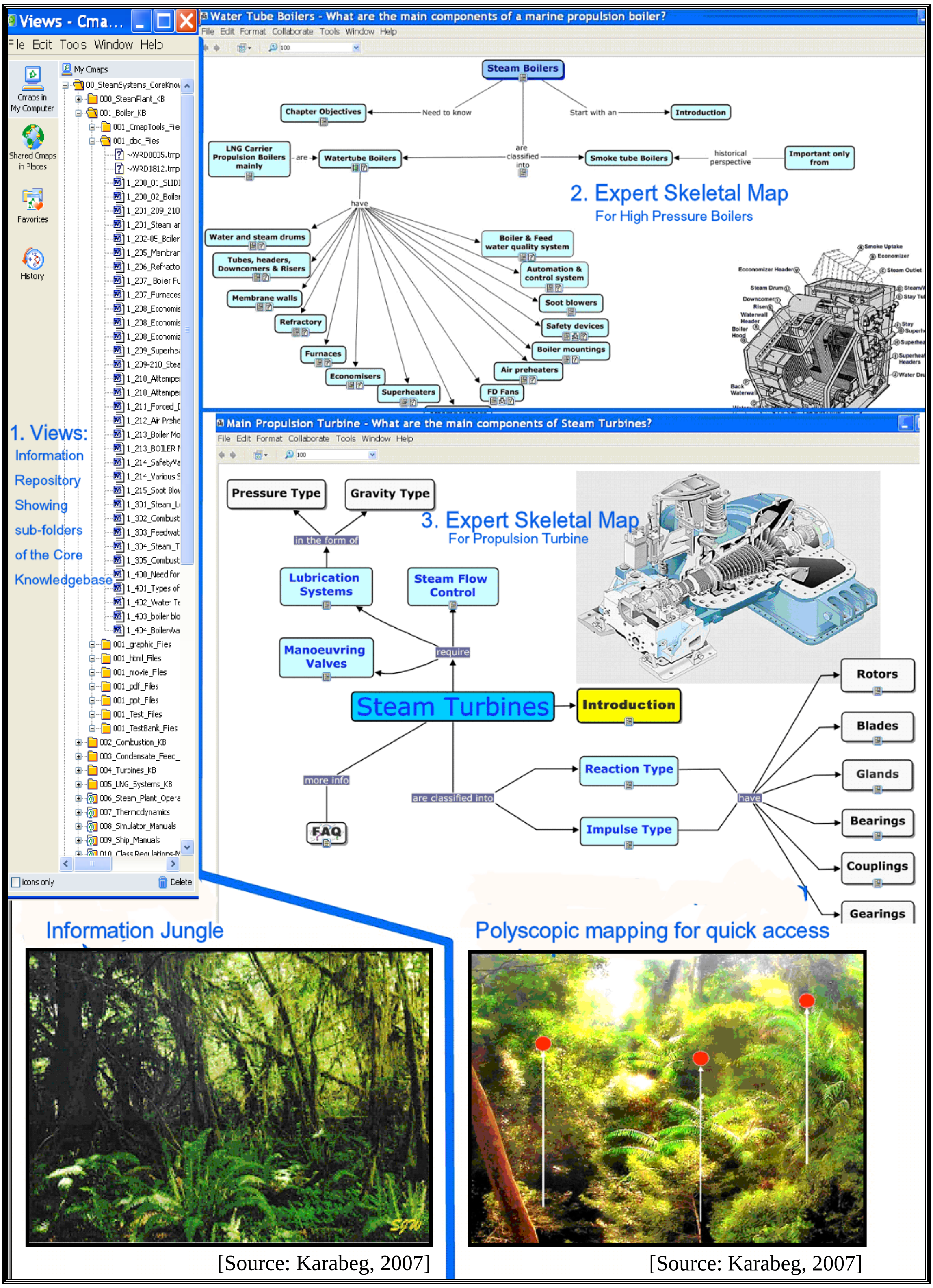

Figure 2. Information Jungle (***Views***) & polyscopic mapping (***Novakian Concept maps with resources***) providing access & relationship

Static knowledge is sometimes referred to as declarative and classificatory (Ferguson-Hessler and de Jong, 1990; Cañas and Novak, 2006). It is usually arranged hierarchically. On the other hand, the dynamic or evolving knowledge is referred to as procedural, cyclic or sequential knowledge (Safayeni, et al., 2005). This classification conforms to maritime practice, where we differentiate between knowledge (e.g. knowledge of thermodynamics) and skill (e.g. skill/ proficiency of operating a steam boiler). Hence, we organized the knowledgebase (see Figure 3), in our case study into two distinct areas. We called them (1) knowledge, which is meant to be classificatory and (2) proficiency which is explanatory and more dynamic in nature. The knowledge could be referred to as being *object*-based and proficiency to be *event*-based (Cañas and Novak, 2006). The *object*-based knowledge-section represents the accepted ontological structure of the subject domain, which is elicited from texts and existing literature and usually presented in an expert skeletal (Novak and Cañas, 2004) Novakian concept map. From our experience, we found these expert skeletal maps are more useful to the learners, when they had lesser number of concepts (say not more than 10 to 15). Otherwise, the learners, encountering so many of theses new concepts get overwhelmed with information overload.

So, we arranged the knowledge domain with a number of layers of expert skeletal maps and they were cross-linked for integration. As stated by Novak & Cañas (2008), cross-links facilitate seamless integration of concepts from one map to another in a large knowledge domain. Each skeletal map represents a set of byte-size information, which can be easily handled by the learners in a domain, where they are not familiar. Focus questions for the object-based concept maps shown in Figure 2 (e.g. *what are the main components of steam turbines?*), may appear trivial but to keep the self-directed learners engaged in these graphical exploratory interfaces, simplified expert skeletal maps were found to be more useful in introducing the basic ontological structure of the subject domain. It must be added that these structural arrangement of the knowledgebase was iteratively arrived at by the authors, who could be considered as domain experts. Further fine-tuning of the structure is done as we demonstrate the system to domain experts from various shipping companies. With our close association with the industry, we will be able to keep the KBS relevant to the present-day shipboard practices.

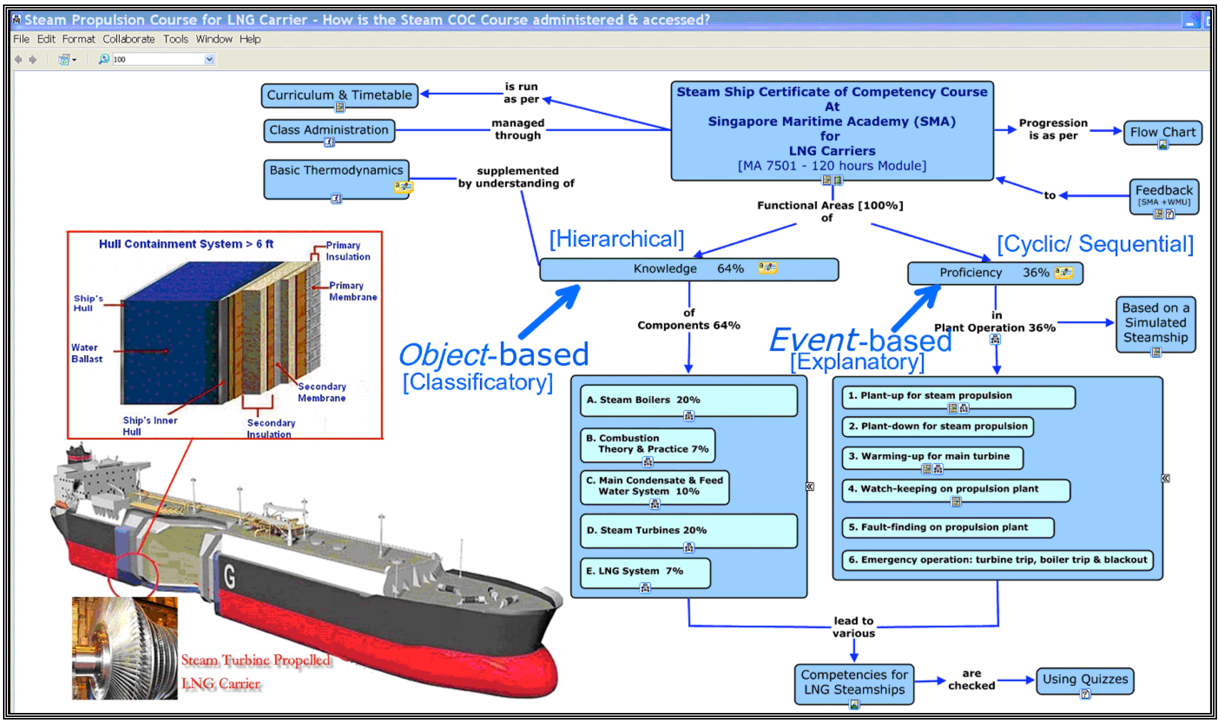

Figure 3 Object-based and Event-based division of the knowledgebase

2.1 Development of Expert Skeletal Maps

The idea of the expert skeletal concept maps, mentioned earlier, is to represent the established ontological structure of the subject domain, which should lead the learners towards practitioners' pathways to the knowledge segment. In our case study, these maps were developed by the learners themselves under the guidance of the course facilitator. Once a topic sub-folder is populated with digital files of texts, graphics, etc from the available literature, the learners, who were paired for collaborative work, were asked to develop these maps. The maps were iterated for improvement and finally socially validated for acceptance by the group under the guidance of the facilitator.

The process followed the recommended guidelines suggested by Novak & Cañas (2008) of parking of the concepts. Given the existing literature in the knowledge segment, the learners were asked to pick up the important issues or concepts after going through the information repository in the CmapTools *Views*. The concepts were then kept aside in a parking bay on one side of the Cmap. Critical issues missed by the learners are appended to the list by the facilitator.

Subsequently the learners drew the Cmap, taking the concepts from the parking bay and by choosing the appropriate connecting phrases as they saw fit. The resulting Cmap is not merely a reflection of the existing literature but a combination of the existing literature as viewed by the participants, who have diverse exposure in the field of engineering. Once they were finalized after a number of iterations by the group, the Cmaps were presented to the whole class for social validation. Hence, sometimes the existing literatures were partly disagreed with by a certain group and if the suggested Cmap could be accepted by the class and the facilitator, the created Cmap was put inside the core knowledgebase.

Some of the groups also worked on knowledge extension on the expert skeletal maps, digging out further information from the Internet and books from the library. Thus, each cohort will substantially improve the core knowledgebase and as we dealt with mature students with substantial industrial exposure, significant contributions were received from a number of participants in each cohort.

2.2 Development of the Skill/ Proficiency Path of the Knowledge Model

Based on suggestions by Safayeni et al. (2005) and Cañas & Novak (2006), we based our proficiency path of the knowledgebase on sequential concept maps (see Figure 4), which became a *learning organizer* for the simulation exercises.

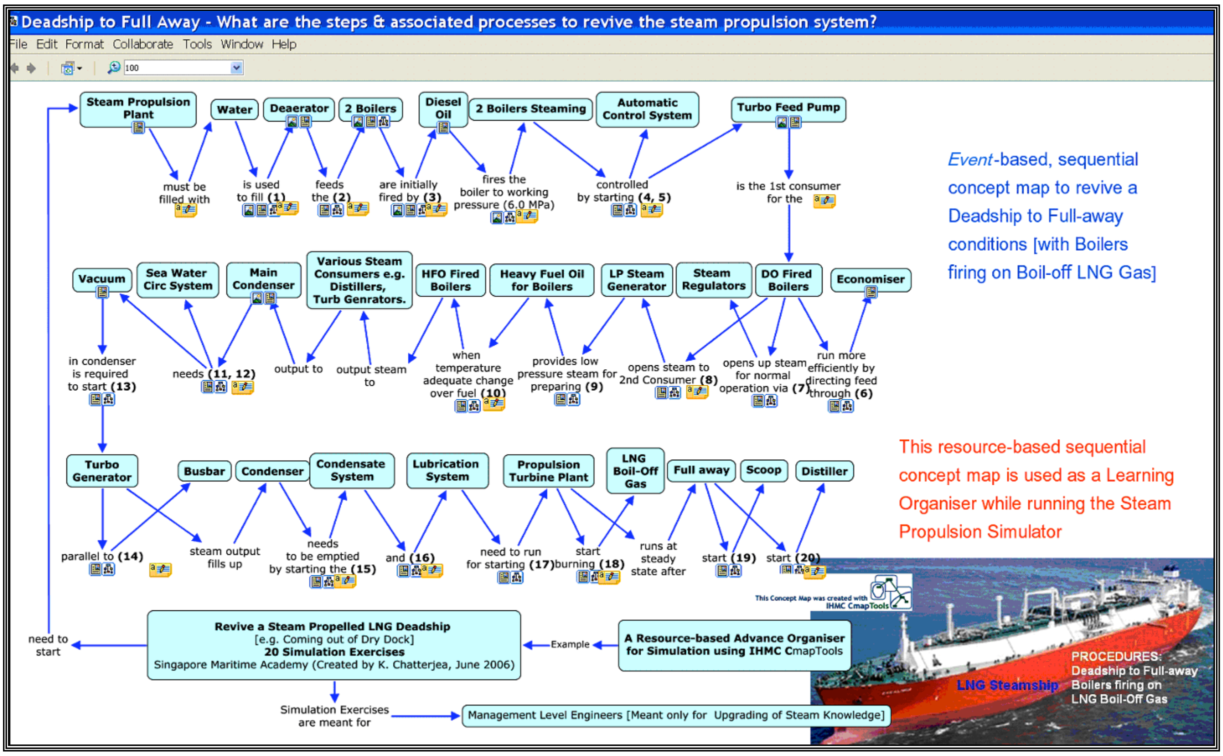

Figure 4 A Learning Organizer: *Event*-based sequential concept map to assist learners while running the Steam Propulsion Simulator

The concept map traces the steps required to revive a LNG carrier with steam propulsion from the deadship conditions (plant in *dead state* as opposed *running state*) to full-away conditions at sea (running at full *sea-speed*) with the propulsion boilers firing on LNG boil-off gas. These *event*-based procedures of 20 simulation exercises (represented by the numbers in Figure 4 above) are well depicted in the sequential concept maps. For each exercise, embedded resources provide the knowledge support. The maps serve the purpose of a *learning* *organizer* (Ausubel, 1960; Willerman & Mac Harg, 1991) and it provides spatially distributed context-base resources to support individual knowledge management. This *learning organizer* provides support while running the steam propulsion simulator, which forms the main instrument for gaining proficiency in operating the steam propulsion machinery of an LNG carrier.

2.3 Infrastructure for the Knowledge Lab

We had to device a new arrangement in our knowledge lab as the traditional classroom arrangement with predominantly transmission mode of learning (see Figure 4.) was considered unsuitable for learning tasks of knowledge creation, knowledge sharing, cooperative learning, social validation of knowledge and finally knowledge capture and additionally, online assessment. We based on a collaborative arrangement with two students per station. This arrangement allows for teamwork and peer level support. Support from one's capable peers or adult guidance could lead to higher levels of achievement in learning (Vygotsky, 1978) as compared to learning through independent efforts. Additionally, the arrangement as shown in Figure 6, led to the development of self-directed learners, who enjoyed learning without much intervention from the facilitator.

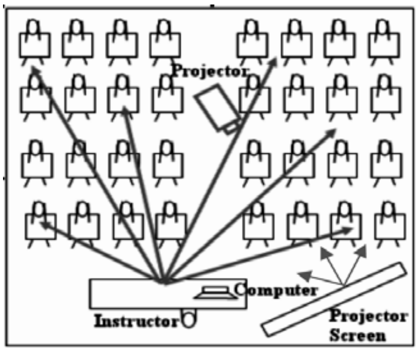

Figure 5 Traditional Classroom with Transmission Mode of Learning

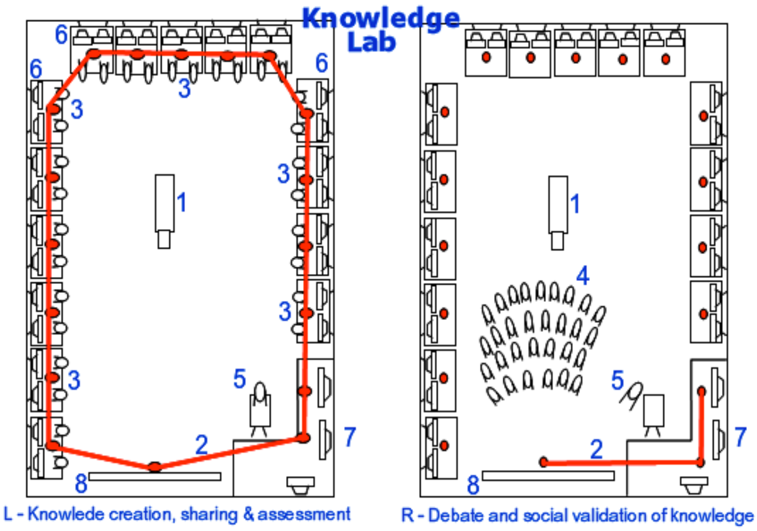

Figure 6. Two scenarios of Knowledge Lab arrangement [L – for facilitating knowledge creation, knowledge sharing and online assessment; R – for debating and social validation]

Legend: 1 – Projector, 2 – LAN with knowledge nodes, 3 – Students (in pair) connected to KBS, assessment & simulation servers, 4 – Students debating to validate shipboard procedures, 5 – Facilitator, 6 – Student computers on LAN, 7 –Knowledge, simulation & assessment servers, 8 – Cambridge-Hitachi knowledge-capture screen (FX77).

Each learning station has a pair of learners and there is connection to the knowledgebase, simulation and assessment servers. A Cambridge-Hitachi interactive knowledge-capture board (Starboard FX77 – Item 8 in Figure 6.) is used for presentation, for running of the simulator and social validation of the newly created knowledge. Figure 7 shows the classroom discussion captured on the FX77 board and the formalized Cmap using equipment images as concepts. This approach of including background graphics, makes the concepts in concept map more in context and for the novice user it becomes easier to relate to the actual system flow.

FX77 is an active board, which supports projection as well as touch-screen activity. Hence, the propulsion simulator can also be operated directly from this board. While running the simulator, comments and remarks from the learners are also captured on a simulator page and the same is then converted into an image file. These captured image files are subsequently embedded on the learning organizer (see Figure 4) to enhance performance support to the learners as they operate the simulator.

Once a Cmap is finalized by a group, it is then presented to the whole class for debate and social validation (see Figure 6). This is the crucial stage of the knowledge creation, where final changes are made to the concept map after a debate. With the FX77 board, we could capture all the discussions when the Cmap is presented by a group. Based on these discussions, Cmap is modified and stored at the appropriate folder of the core knowledgebase (in *Views*).

2.4 Knowledge Capture at Sea & Course Assessment

While shipboard technologies and particularly procedures evolve rapidly with changing times, the changes in content at the maritime training institutions lag behind due to the content being generated, mainly from books and published literature and consequently the learners do not get the updated knowledge at the shore-based training centres. Most of the trainers at these institutes are lacking the updated shipboard operational knowledge as they leave sea early in their sea career to settle down ashore with their families and rarely get the opportunity to sail again. Perhaps, the easiest channel of capturing updated operational knowledge from the practitioners is when these engineers come to the institute for further training. In maritime practice the practitioners come regularly to the training institutes to revalidate their certificates or to get additional endorsement to their existing certificate.

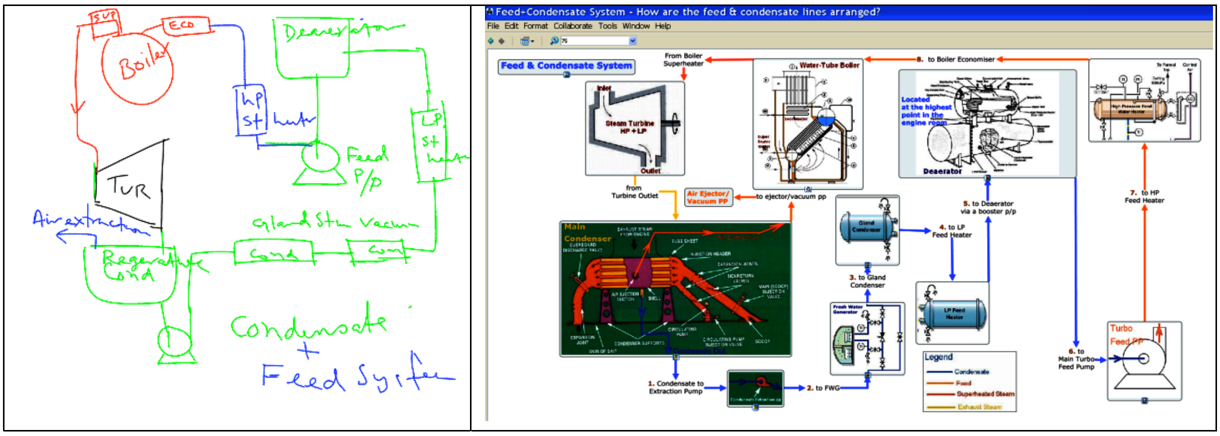

Figure 7. Left: Knowledge capture of the discussion on FX77; Right: Formalized Cmap using figures as concepts

Normally, we make no effort to capture their recently acquired rich shipboard experiential operational knowledge. The age-old institutional practices of catering unidirectional knowledge-transmission towards the learners are difficult to moderate. We had the experience of capturing such knowledge using CmapTools in a pilot project earlier (Chatterjea, 2006). In this steam conversion course, we are creating an avenue to tap this rich experiential knowledge of practitioners through shipboard assignments. The process should plough back the latest procedural knowledge into the core knowledgebase, thereby keeping the course content dynamically updated. The core knowledgebase will grow incrementally and over time has the potential to become a large source of knowledge with logical concept-map-based access points, which could be tapped by both learners and practitioners. As the learners go on board LNG carriers after completion of this course, they are urged to capture the shipboard procedural knowledge as part their course assignments (see Table 1, last row). The assignments are given on the course Blog: http://lngsteam.blogspot.com, so that these could be updated regularly and can be directly accessed by the learners when they are away from the institute. An extract from the course Blog is shown in Figure 8.

Assessment Components	Type of Assessment	When Conducted	Weightage %
1. Coursework A (*Formative*)	60 Computer-based on-line assessment	Continuous (*In-course)*	15
2. Coursework B (*Collaborative Knowledge Creation*)	12 Assignments – 2 for main areas of coverage (*Individual Portfolio*)	Continuous (*In-course)*	15
3. End of Course Assessment (*Summative*)	1 Computer-based on-line assessment	End of Course at SMA	55
4. Shipboard Assignments (*Dynamic Procedural Knowledge Capture at sea*)	6 Assignments – 1 for 6 main areas of coverage. (Appending *Individual Portfolio*)	During steam ship attachment at sea.	15

Table 1. Assessment plan for Steam Certificate of Competency Course at SMA

Table 1 shows the components of the assessment for the course and highlights the various aspects of interactive teaching and learning as well as knowledge management plan. Dynamic procedural knowledge capture will start when the 1st and the 2nd cohort students return to SMA towards end-2008/ beginning-2009.

3 Conclusion

The paper described the development process of a knowledge model in a maritime subject domain. It was shown how a CmapTools-supported knowledgebase could be developed involving students through social constructivism. The four cohorts of students (a total of 37 participants) developed a course structure with guidance from the course facilitator. Even though the learners came with limited IT exposure, they learned to use CmapTools within a period of few days using mainly the *Help* files provided with the CmapTools program. It was surprising how quickly the learners accepted the use of CmapTools as the vehicle for learning and started contributing in the development of the knowledgebase. However, in general, the younger learners were more productive than their senior counterparts, who needed a lot more support and encouragement from the facilitator.

According to Novak and Cañas (2008), knowledge creation by individuals facilitates the process of learning for the learners. It is expected that this new course model will impart a more *meaningful* learning for the learners and they will practice knowledge management using CmapTools in their own workplace. A longitudinal study is required to establish the true usefulness of this approach of constructivist learning.

1.1 Sunday, 6 January 2008

1.1.1 Assignments at Sea

Shipboard Assignments:

++ These are meant for those of you at sea doing steam-time now!
++ You need to complete six assignments at sea.
++ Either do six assignments from the suggested list below -- one from each topic -- or you may suggest your own assignments (in that case you need to check with me first...just send me a mail at Kalyan@sp.edu.sg).
++ Table below lists the suggested assignments. Please note the submission should be based on your shipboard plant and NOT reproduction of information from books.

Assignments for STEAM BOILERS
a) Boiler shut down and start up procedures followed on board.
b) Safety valves on drum, superheater and desuperheater: construction, setting and operation.
c) Line drawing of the steam distribution system and rationale for the same.
. . . .
Assignments for COMBUSTION THEORY & PRACTICE
e) Boiler combustion control and management: Faults encountered in practice and actions taken.
f) Fuel oil to gas and gas to fuel oil change over: precautions and practices on board.
. . . .

Figure 8. Extract from the course Blog showing the items for procedural knowledge capture

4 Summary

The paper describes the development of a CmapTools-based knowledge model, which includes learning content, formative assessment, knowledge creation and capture, summative assessment, feedback and general course administration for a maritime course titled "Steam Certificate of Competency for LNG Carriers". A knowledge-based system was created in the CmapTools *Views*, which served as an information repository for this course. In *Views* we created folders of (1) Core Knowledgebase, (2) Steam COC Course and (3) Cohort Assessment sections. Over a nearly 3-year period, this repository has become a large data source for this course. Using Novakian concept maps, accessing through this digital information repository and exploring various concepts with embedded details (texts, graphics, movie clips etc) have been made relatively simple. In the case study, these maps were developed by the learners themselves with the guidance of the course facilitator. Once a topic sub-folder is populated with digital files of texts, graphics, etc from the available literature, the learners, who were paired for collaborative work, were asked to develop these concept maps. The developed knowledgebase was split in to two sections: (1) *object*-based, which is classificatory and (2) *event*-based, which is explanatory. The *object*-based section covered the knowledge from the existing literature, while the *event*-based section covered the proficiency or the skill aspects of the knowledgebase and created learning organizers. A learning organizer provides support while running the steam propulsion simulator, which forms the main instrument for gaining proficiency in operating the steam propulsion machinery of an LNG carrier. There is also plan for dynamic knowledge capture using student assignments, when the learners are sent for industrial attachment at sea after completion of the course. The paper also describes the class infrastructure used to develop concepts map and for social validation of the new knowledge, generated by the learners.

5 Acknowledgements

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