

ACTIVE LEARNING IN NAVAL ARCHITECTURE

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ABSTRACT

Knowledge of naval architecture is a fundamental requirement for those working in the marine industry. The ability to design and construct marine vehicles requires the understanding of many theoretical principles. In a naval architecture course, the breadth and depth of content to be covered is very broad. There is always a danger that educators will resort to delivering every lesson in transmission mode, adopting a “tell-all” approach that focuses only on the development of theoretical knowledge. This paper describes the changes made to the learning design of a module, Naval Architecture I, offered by the School of Engineering in Ngee Ann Polytechnic to enhance learning. This module is a foundational module taken by learners without background knowledge in this area of discipline. The key change involved a shift from the traditional “tell-all” approach to one that is more constructivist and experiential. Lessons were re-designed to include activities that encouraged active engagements from learners in learning. Opportunities to develop learners in their personal and professional skills such as e-competency, teamwork and communication were also woven into the lesson. The paper will describe (1) a change in laboratory experience to support theory-to-practice progression by getting learners to physically construct a model of the hull-form, verify their computations and discuss any variations observed. (2) the use of a ship simulation tool to stimulate learners’ interest and more importantly help them visualise various parts of a marine vehicle, an important experience that brings in the context for what they are going to study in the rest of the module. (3) an activity to encourage self-directed learning and reflection through concept maps. The paper will also discuss learners’ feedback and response to the changes.

KEYWORDS

E-competency, simulation tools, concept maps, active learning

INTRODUCTION

"...the *sine qua non* of deep learning in any complex domain is the creation of such motivation for extended engagement."

Dr. James Paul Gee (Gee J.P., 2005)

Given the breadth of knowledge to be ‘covered’ in engineering education, the most-used teaching approach tends to be a lecture-based, ‘tell-all’ approach where information is transmitted and instructions are given to learners. Learners would then be expected to have the maturity and strong foundational knowledge, skills and concepts in mathematics and the

physical sciences to synthesise and transform the information, and to transfer and apply the knowledge appropriate to the various engineering situations they face.

Learning characteristics and preferences that lend themselves to this approach tend to be primarily cognitive and meta-cognitive in nature and include a high tolerance for theoretical information and for learning discrete bytes of knowledge over time, coupled with the discipline for drill and practice. Good auditory skills and the ability to imagine and visualise are also critical for effective learning. Learner motivation, discipline, and drive are expected and needed for success in this approach.

The Diploma for Marine and Offshore Technology (MOT) at Ngee Ann Polytechnic, established since 1975, also adopted a lecture-tutorial-practical approach where the curriculum was essentially content-centered and instructor-led.

However, given a changing educational landscape, many of MOT's students now have a strong visual and kinaesthetic learning preference and tend to prefer more applied approaches to learning such as undertaking projects and experiments where they can explore, do and discover rather than be told how to, what to know and how to do. Being of the digital age, many display low tolerance for 'tell-all' situations and prefer 'when-I-need-it' information. Many also may not have a strong foundation in mathematics and the physical sciences. Motivation and drive tend to be characteristics they expect the teaching approaches and the learning design to help them develop.

This paper discusses the changes made in the teaching approaches and learning experiences that have been made to Naval Architecture I to make the learning effective for this changing profile of learners.

NAVAL ARCHITECTURE I: ORIGINAL APPROACH TO TEACHING AND LEARNING

The module adopted the typical lecture-tutorial-laboratory approach to learning where lectures were events where the lecturers told all and showed how. The Tutorials offered students the opportunity to be drilled in and practice the cognitive operations necessary to work through the exercises they had been shown how to do in the lecture. The laboratory practice is an enhanced tutorial session where students get the opportunity to work on tasks such as visualising the linesplan (how the 2-D linesplan would look like as a 3-D hullform) and conducting the hydrostatic calculations by hand from the lines plan (which is a 2-D drawing of the hullform).

Teaching and Learning materials were continuously made more visual and interactive with the use of short computer animations, illustrations and interactive calculation exercises. However, these changes and modifications have tended to focus on the medium and presentation of the content while the approach still remained largely content-focused and instructor-led.

NAVAL ARCHITECTURE I: KEY CHANGES NEEDED

Changes to the module in the last two years have focussed on re-thinking the design for learning – how the students learn - rather than on the content and on the medium and presentation of the content. 3 key needs were identified:

- a) The need to gain attention and interest in the module as many of the students expected that the learning design and activities should motivate and engage them.

- b) The need to bring the 'feeling' dimension into the learning experience as many students lacked the sailing experience and were therefore unable to imagine the ship's behaviour while in motion when learning about ship construction.
- c) The need to use more active, experiential and collaborative learning strategies to cater to students who were more visual, kinaesthetic, and social in their learning preferences.

In CDIO terms, these needs are synonymous with what is articulated in Standard 8 - **Active Learning**

“Teaching and learning based on active experiential learning methods”

Active learning methods engage students directly in thinking and problem solving activities. There is less emphasis on passive transmission of information, and more on engaging students in manipulating, applying, analyzing, and evaluating ideas. Active learning in lecture-based courses can include such methods as partner and small-group discussions, demonstrations, debates, concept questions, and feedback from students about what they are learning. Active learning is considered *experiential* when students take on roles that simulate professional engineering practice, for example, design-build projects, simulations, and case studies.”

NAVAL ARCHITECTURE I: EXAMPLES OF CHANGES

This section details 3 key examples of the changes made.

The use of ship simulation tools

Ship Simulation tools were introduced in the module to provide students with the opportunity to see and 'feel' ship behaviour. Without the luxury of time and resources of going aboard a marine vessel, the learner would be brought into this marine world through this simulation software - Ship Simulator 2008 (<http://www.shipsim.com/home.php>).

Introduced right at the start of the module, the highly graphical and interactive tools and the hands-on nature of the learning activities using the ship simulation tools were able to engage students in a way that an introductory lecture on naval architecture was not able to do.

The strategy for infusing the use of this simulation software in T&L is:

1. grabbing the attention of the learner at the start of the module
2. introducing the various types of platforms (Figure 1)
3. showing the various parts of the marine platforms (Figure 2)
4. introducing dynamics of marine vehicles through the actual playing of the game itself. The platform and mission selected should be high-speed and exciting to create maximum positive impact on the learners.



Figure 1. Various Types of Marine Platforms

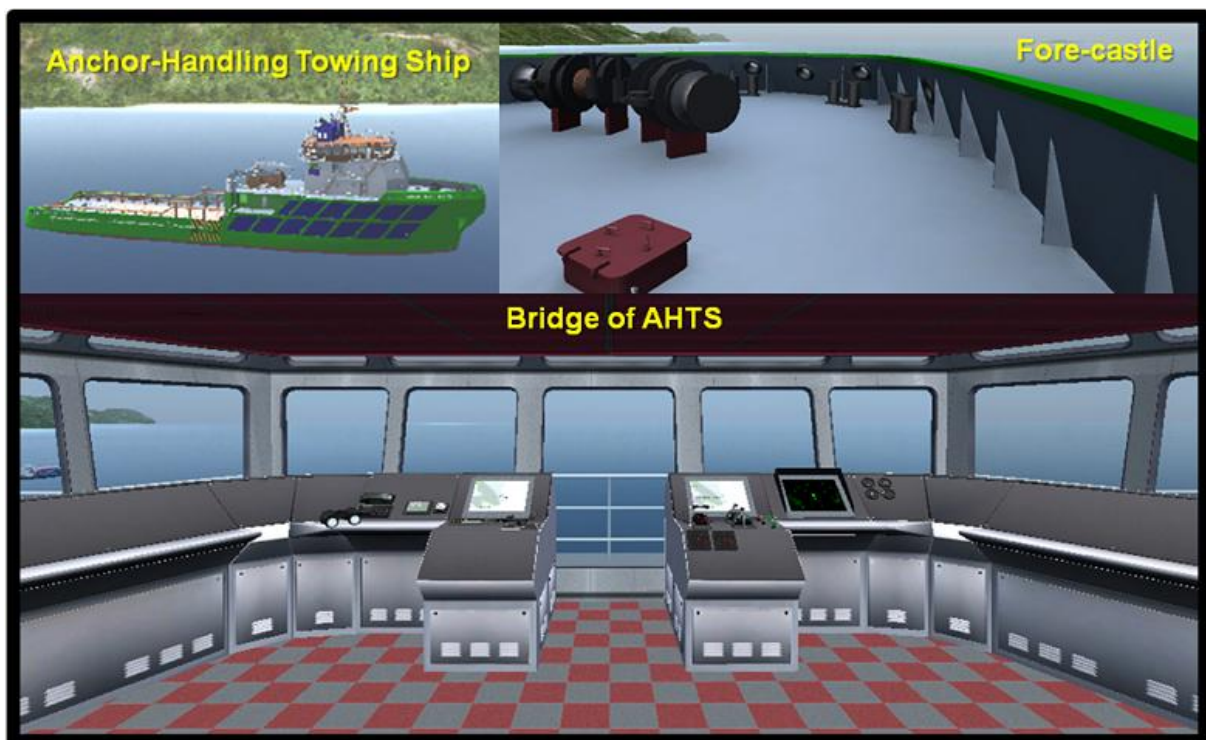


Figure 2. Various Parts of the Platform

The change in Laboratory Practice

In the new laboratory practices, an experiential learning approach is adopted that engages the learner in model construction and analysis/evaluation of the model data instead of the previous arrangement where learners looked at 2 linesplans and calculate the hydrostatics data (that basically exemplifies a prolonged tutorial session). The change enables the learners to have a hands-on collaborative learning session which also enhances the learner's e-competencies through the use of software such as Delftship (a freeware: <http://www.delftship.net/>) for hydrostatics purpose as shown in Figure 3 and Microsoft Excel spreadsheet (to replace laborious hand computations).

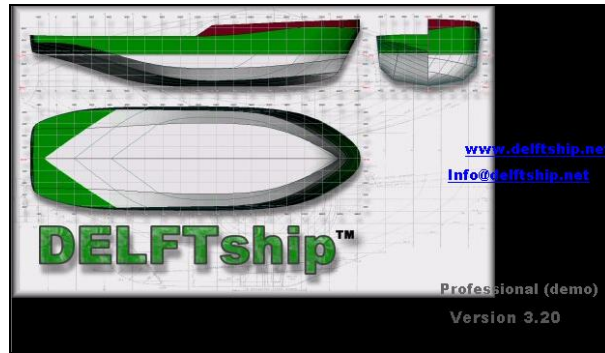


Figure 3. Delftship Software

The laboratory practice still consists of two sequential sessions (of 2 hours) for this topic (the first lab experience must come before the second). Prior to these experiential sessions, the lectures and tutorials would introduce and build up prior knowledge of the concepts needed. Table 1 shows the sequence of introducing the topics.

Table 1
Sequence of Topics

S/N	Topics	Remarks
1	Lecture & Lab - Linesplan & mini-lab	To introduce the learners the concept and the use of the linesplan
2	Lecture/Tutorial - Ship Geometry	To familiarise the learners with the hullform and ship terminology
3	Lecture/Tutorial - Ship Floatation (Archimedes Principle)	
4	Lab 1 – Visualising Linesplan through team learning 1	To appreciate the hullform generation from the linesplan – learner teams would construct a polyform hull model Learners would conduct a Archimedes Principle experiment to determine the underwater volume of the hull and displacement of the vessel model
5	Lecture/Tutorial - Ship Hydrostatics	Learners learn the application of linesplan in calculating the underwater volume of the hull and other Hydrostatics parameters
6	Lab 2 – Visualising Linesplan through team learning 2	Learners would be given the model's linesplan to calculate the model's underwater volume through Simpson's rules in Excel (instead of hand calculation) The calculated volume is then compared with that obtained from Lab 1(Archimedes Principle) to derive lessons learnt

Conduct of Lab 1

The first session enables them to recap and experience the constructed 3-D hullform on their own. During the first session, the learners form 3 to 4-person teams in a workshop setting. They are given the profile view of the lines plan (generated from Delftship) to build a simple

ship's hull out of Styrofoam board. Construction materials required are: styrofoam board, glue, cutter, cutting board and ruler.

A brief on the line's plan is given. After studying the lines plan, each group will have to build the model. After building the model, the learners would have to conduct an Archimedes Principle experiment to determine the underwater volume of the hullform. Figure 4 shows the conduct of the laboratory session. At the end of the session, the learners will need to log into Blackboard for a post-experience discussion and to reflect on the learning activity.



Figure 4. Conduct of Laboratory Session 1

Conduct of Lab 2

The learners would have learnt the basics of calculating the hull volume from lectures & tutorials using an approximation method i.e. Simpson's rule. In this lab session, the task is to calculate the underwater volume using Simpson's rule.

The learners are provided the linesplan to generate the table of offsets where the values would be used to approximate the volume. The learners would then need to compare the results obtained in this session and from the previous session where the volume was obtained through the Archimedes method.

Instead of traditional manual calculations, the learners are introduced the use of computational methods to approximate the volume. Excel is used in this session. A spreadsheet template shown in Figure 5 is provided to the learners and they would be guided through the use of the creating formulae for the volume approximation exercise. At the end of the lesson, the learners will need to log into Blackboard for discussion and reflection on the learning activity.

From this package of learning activities, the learner is able to Conceive-Design-Implement-Operate (CDIO) the basic concept of ship linesplan and hydrostatics in ship design and modelling.

NA1 LAB CALCULATIONS (WATERLINE AREA & SUBMERGED VOLUME)																			
Names:		Ng Xiao Tong Nursyahidah Jackie Low Siti Radiah																	
Hull Data		LPP = 36.2 cm Station Spacing (hx)= 3.6 cm DWL = 4.4 cm Waterline Spacing (hz)= 1.1 cm																	
TABLE OF OFFSETS																			
HALF-BREADTHS ARE IN CM FROM THE CENTERLINE																			
STATION NUMBERS																			
WL	AP	0	1	2	3	4	5	6	7	8	FP								
4	2.95	3.05	3.10	3.10	3.10	3.00	2.70	2.20	1.20	0.15									
3	1.90	2.80	3.00	3.00	3.00	2.90	2.50	1.90	1.00	0.10									
2	0.00	1.60	2.70	2.90	2.90	2.65	2.15	1.50	0.70	0.00									
1	0.00	0.00	0.90	2.00	2.20	2.00	1.50	0.90	0.35	0.00									
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00									
Submerged Volume																			
(Do this when complete WL areas)																			
WL	Area	SM	f(V)																
0	0	1	0																
1	70.3	4	281																
2	125	2	250																
3	153	4	612																
4	166	1	166																
		sum f	1309																
		volume	540 cm ³																
Area of Waterline 1 (Example)				Area of Waterline 2				Area of Waterline 3				Area of Waterline 4							
Stn	Nc	1/2 B	SM	f(a)	Stn	Nc	1/2 B	SM	f(a)	Stn	Nc	1/2 B	SM	f(a)	Stn	Nc	1/2 B	SM	f(a)
0	0	1	0		0	0	1	0		0	1.9	1	1.9		0	2.95	1	2.95	
1	0	3	0		1	1.8	3	4.8		1	2.8	3	8.4		1	3.05	3	9.15	
2	0.9	3	2.7		2	2.7	3	8.1		2	3	3	9		2	3.1	3	9.3	
3	2	2	4		3	2.9	2	5.8		3	3	2	6		3	3.1	2	6.2	
4	2.2	3	6.6		4	2.9	3	8.7		4	3	3	9		4	3.1	3	9.3	
5	2	3	8		5	2.85	3	7.95		5	2.9	3	8.7		5	3	3	9	
6	1.5	2	3		6	2.15	2	4.3		6	2.5	2	5		6	2.7	2	5.4	
7	0.9	3	2.7		7	1.5	3	4.5		7	1.9	3	5.7		7	2.2	3	6.8	
8	0.35	3	1.05		8	0.7	3	2.1		8	1	3	3		8	1.2	3	3.6	
9	0	1	0		9	0	1	0		9	0.1	1	0.1		9	0.15	1	0.15	
		sum fa	26.05				sum fa	46.3				sum fa	56.8				sum fa	61.7	
		area =	70.3 cm ²				area =	125 cm ²				area =	153 cm ²				area =	166 cm ²	

Figure 5: Spreadsheet Template for Laboratory Session 2

The use of concept maps

The use of concept maps for T&L is applied on the Ship Construction topics. The learners would have some basic understanding of forces and stresses on hull structure and also, seen the ship structure models in the marine workshop. The subsequent Ship Construction topics require the learners to go a little more in depth to discover the construction and detailing of various parts of the ship.

CMap, (<http://cmap.ihmc.us/>) from the Institute for Human and Machine Cognition (IHMC), USA is used as a reflective tool in a constructivist approach. The exercise is done as a group mini-project which requires students to build knowledge, connect concepts, and construct new understanding which they are required to represent graphically as a concept map rather than in text or PowerPoint presentations. In this active learning experience, no lecture is given on the topic (which is a part of the ship detail and construction) and the learners are required to research online and at the workshop. At this point in the module, the learners are equipped with some basic ship construction knowledge to scaffold them in this assignment. Through the exercise, the learners are able to build on their prior basic knowledge of ship construction and construct new knowledge and understanding for themselves. They use the CMap tool to construct and present a graphical representation of their new concepts, connections and knowledge. In addition to the group exercise, each learner is required to do an individual reflection on what they have done by summarising it in a separate concept map. A sample of the concept map is shown in Figure 7.

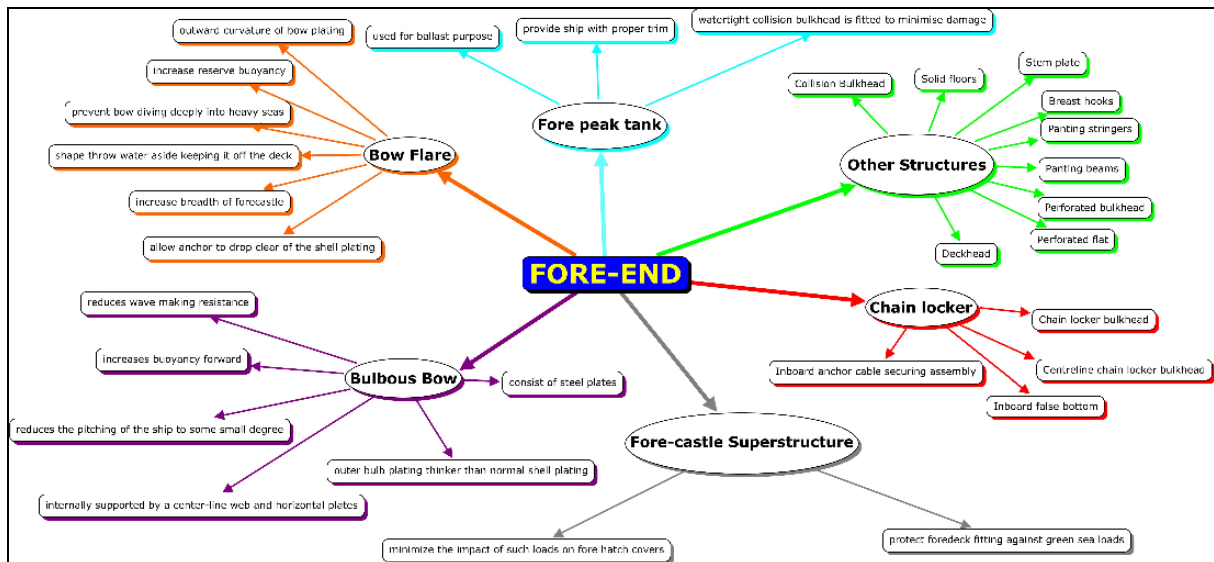


Figure 7. Sample Concept Map

NAVAL ARCHITECTURE 1: STUDENT FEEDBACK

After these changes were implemented, student feedback was obtained in November 08.

Table 2 shows the results for the module survey conducted for 69 learners (55 responses) in Nov 08. Feedback by learners on the module is detailed in Table 3. From the module survey results, the learners had a good learning experience in the module as compared with student feedback on modules with a more traditional approach to teaching.

Table 2
Module Survey Results

Dimension	Rating
The module helped me to develop useful skills and knowledge	5.25
This module stretches my thinking	5.16
The teaching and learning approaches are appropriate for this module/project	4.95
I received timely and useful feedback in a group/individually on my progress in this module/project	4.53
The module materials including online resources were useful	4.85
The module activities enhanced my overall learning	5
Overall, this module provided a good learning experience	5.29

Scale: 1-Strongly Disagree, 2-Disagree, 3-Disagree somewhat, 4-Agree somewhat, 5-Agree, 6-Strongly Agree. Rating above indicates students who have selected "Agree somewhat", "Agree" and "Strongly Agree".

Table 3
Module Survey - Student Comments

S/N	Feedback
1.	This module is an essential module if you are planning to work in marine industry.
2.	very interesting module.you get to know about ships,measurements and many more.is a really good module to be prepared in this industry
3.	INTERESTING!!!!!!!!!!!!!!!!!!!!
4.	interesting module. enhance my knowledge on ships and stuffs.
5.	Great module, very interesting.
6.	tough but interesting. whole new learning.
7.	created a more pleasant practical workshop

Table 4 shows the survey results for the Laboratory sessions conducted for 50 (25 responses) learners in Apr 08. Comments from the 3 questions were also obtained as detailed in Table 5. The qualitative feedback was very encouraging.

The feedback also indicated more time may be provided for certain aspects of the laboratory session, in particular, the learning of the use of EXCEL might be conducted separately and prior the laboratory session 2 so that there is sufficient time for the learners to consolidate the learning then.

Table 4
Survey Result for Laboratory Session

S/N	Question	Yes	No
1	Have you benefitted from the Labs?	25	0
2	Are you able to visualise and understand the lines plan, table of offsets and its application on calculating waterplane area and underwater volume better?	24	1
3	Overall, was it a good and engaging learning experience within your group?	25	0

Table 5
Laboratory Session Survey Feedback

Q/n	Comments
1	<p>Overall it was a fun experience to get hands on activity rather than sticking to the books. We get to work in teams and got to know each other better. We also got to learn while having fun, I believed that the labs session made the understanding of details (eg. calculation of waterplane area) much easier.</p> <p>Learn some very interesting stuff thro. practical instead of theory.</p> <p>Yes. I guess it was pretty enriching as its something not from the textbook. as in we get to do a hands on kinda thing.</p> <p>through this i can visualise and understand more about the offset table.</p>
2	<p>It was clearly explained by you :) and furthurmore with the activities carried out. It was fairly easy to understand and visualise the information.</p> <p>Constructing a ship hull enables us to visualise better</p> <p>it makes me understand it more with the models.</p> <p>The practical helps as its something that is verbally explain and some ship objects to help us understand and visualise.</p>
3	<p>It was a fun and enjoyable time at lab sessions and not to forget that it was a good learning experience. We each had our flaws and niche areas. Therefore, when my group worked together, we each get to point out each other's mistakes and also get to learn from each other. One example was that my team mates' handwriting and organisation of details were very neat. I believed that i have improved on my presentation of work after working with him in the lab. In overall, i think that working in groups is definitely a good and engaging learning experience.</p> <p>it has helped me to understand my team mates better. From this i have learned on how they complete the assignments which will help me to work better with them in the future.</p> <p>we had fun as well as achieved learning at the same time.</p> <p>greaT learning experience...!</p>

CONCLUSION

Student feedback indicates that the move to rework the learning design of the module Naval Architecture I is a move in the appropriate direction.

While the more active, experiential and collaborative T&L strategies have been well received by students, further review is needed to build in sufficient time and proper sequencing of learning activities to ensure that students have sufficient opportunity to synthesise the knowledge and skills and reflect on and evaluate their learning.

Problem-based learning is one approach that is being considered in the next stage of enhancement for the laboratory sessions.

A more immersive ship simulation laboratory experience is also being designed for the next stage of enhancements.

REFERENCES

- [1] Bloom B.S., Englehart M. D., Furst E. J., Hill W. H., & Krathwohl D. R., The Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I : Cognitive Domain, David McKay , 1956.
- [2] Chanda S., "Facilitating Effective Learning using Learning Triangle Approach", Proceedings of the International Conference on Education, 2005.
- [3] Chanda S., "Revisiting Teaching and Learning through Learning Triangle", Proceedings of the Hawaii International Conference on Education, 2007.
- [4] Chatterjea K., "New Technologies & Teaching Methodologies to meet the future needs of the 21st Century Seafarers", International Conference on "The Ship's Command – Preparing & Supporting the Master and His Team for the Challenges of the Future", 2005.
- [5] Dewey J., How We Think: A restatement of the relation of reflective thinking to the educative process, Boston: D.C. Heath, 1933.
- [6] Gardner H., Frames of Mind: The theory of multiple intelligences. New York: Basic Books, 1983.
- [7] Gee J.P., Shaffer D.W., Squire K.R. & Halverson R., Video Games and the Future of Learning, WCER Working Paper No. 2005-4, 2005.
- [8] Kolb D., Experiential learning: Experience as the source of learning and development, Englewood Cliffs, NJ: Prentice-Hall, 1984.
- [9] McManus H.L., Rebentisch E., Murman E.M. & Stanke A., "Teaching Lean Thinking Principles through Hands-on Simulations", Proceedings of the Third International CDIO Conference, 2005.
- [10] Mitchell A. & Savill-Smith C., The use of computer and video games for learning (A review of the literature), Learning and Skills Development Agency, UK, 2004.
- [11] Novak J. D., Learning, creating, and using knowledge: Concept Maps(R) as facilitative tools in schools and corporations, Mahweh, NJ, Lawrence Erlbaum Associates, 1998.
- [12] Novak J. D. & Cañas A. J., "The Theory Underlying Concept Maps and How to Construct and Use Them", Technical Report IHMC CmapTools 2006-01 Rev 01-2008, 2008.
- [13] Smith R.M., Learning How To Learn, Englewood Cliffs, NJ: Cambridge, 1982.
- [14] Stringer E., Action Research in Education 2nd Edition, Pearson Education, 2008.
- [15] Tan O.S., Parsons R.D., Hinson S.L. & Sardo-Brown D., Educational Psychology. A Practitioner-Researcher Approach (An Asian Edition), Thomson, 2003.
- [16] Tan O.S., Problem-based Learning Innovation: Using Problems To Power Learning In The 21st Century, CENGAGE Learning Int'l Row, 2003.
- [17] Weck O.L., Kim I.Y. & Hassan R., "Active Learning Games", Proceedings of the First International CDIO Conference, 2005.
- [18] <http://www.shipsim.com/home.php>
- [19] <http://www.delftship.net/> (previously, <http://www.freeship.org>)

[20] <http://cmap.ihmc.us/>

[21] The New Paper, [Article on the fun image of Ngee Ann Polytechnic](#), 26 Mar 2009

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