Volume 20, Number 2, 2018

Global Journal of Engineering Education

Design and implementation of teaching and learning activities in a ship resistance and propulsion classroom

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ABSTRACT: Teaching and learning ship resistance and propulsion for undergraduates in maritime engineering are a continuing challenge to students' understanding and skill development due to the many concepts and definitions needed to achieve the intended learning outcomes (ILOs). The first task of the work undertaken by the authors, in the Australian Maritime College at the University of Tasmania, was to identify the teaching content and integrate the relevant concepts and definitions for understanding and skill development. This integration was then fulfilled by design and implementation of an in-class teaching and learning activity. Based on the formative assessment of the in-class activity, it has been demonstrated that the ILOs were aligned and achieved successfully.

Keywords: Intended learning outcome (ILO), teaching and learning activity (TLA) design and implementation, assessment task (AT) design and implementation, maritime engineering teaching and learning

INTRODUCTION

One of the biggest and lasting challenges in ship resistance and propulsion teaching is students' understanding of the basic concepts in these two topics and the correlation between them, in the maritime engineering undergraduate degree programme. The unit, *Resistance and Propulsion* taught in the maritime engineering programme, normally covering naval architecture, ocean engineering, marine and offshore engineering, has many concepts and definitions [1-3]. The key to conducting teaching and learning successfully is first to categorise systematically these concepts and definitions in ship resistance, relate them to each other [4], and then have the students well prepared for the propulsion part [3].

The main teaching content in ship resistance and propulsion for undergraduate engineering in the naval architecture degree, based on the analysis of the unit outline [5], is typically inclusive of: classification of surface ship speeds, alignment of the type of dominant resistance component(s) associated with these speeds, determination of the most effective and feasible alternation to the ship hull to reduce the major resistance, prediction ship resistance for a wide range of ship types, iteratively, performance of the model to full scale extrapolation and design/optimisation of the full scale propeller for the behind-ship condition [4].

Once the teaching content was determined, the level of students' performance was determined using Bloom's taxonomy [6] to establish the intended learning outcomes (ILOs). For the JEE333 Resistance and Propulsion unit, the ILOs are as follows:

a) Classify surface ship speed based on Froude similarity, and identify its relationship with the dominant resistance component(s).
b) Modify hull parameters to optimise/reduce resistance.
c) Apply similarity theory to determine model size, speed and testing facility for ship model testing.
d) Predict full-scale hull and propeller performance by using ITTC extrapolation method.
e) Solve behind-ship propeller design problems from testing to manufacture, systematically.

Once the ILOs are established and refined, the task is to design and implement teaching and learning activities (TLAs), in alignment with the ILOs to achieve these ILOs [6][7].

The following sections described the design and implementation of a teaching and learning activity (TLA) and an assessment task (AT) in alignment with the ILOs to achieve the student's desired performance.

THE DESIGN AND IMPLEMENTATION OF THE TEACHING AND LEARNING ACTIVITY

About the Teaching and Learning Activity

The objectives of this TLA were to review the content covered in *Resistance of Ships* for a 3rd year naval architecture (NA) unit entitled *Resistance and Propulsion* and to achieve the above ILOs [8]. Throughout the TLA, constructive alignment (CA) was complied with to ensure the designated ILOs are achieved [9].

Two 50-minute class sessions were dedicated to the review of the content covered from week 1 to week 4, for 51 NA students in the Australian Maritime College at the University of Tasmania (AMC-UTAS). An in-class and team-work activity as an active [10], reflective [11][12] and interactive learning process [13] was designed and implemented. The students were divided into ten groups working in teams. The lecturer acted as a facilitator. The learning activity was conducted in a workshop style: students first actively worked together as a team, and then all worked together, interactively.

After 25 minutes of group work, each group was to provide the whole class with their solutions and answers to the questions that were posted as written instructions shown on DOCCAM (overhead projector) at the same time. Each group received immediate real-time feedback/critiques from the other nine groups and the facilitator.

As the *resistance* part of this unit has many concepts and definitions (declarative knowledge), interactive and collaborative learning with formative assessment [14], using whiteboard (as the *technology*) would encourage deeper learning and prompt students' motivation. A whiteboard along with open questions were deployed in the TLA, i.e. the solutions and answers were summarised on the whiteboard interactively and progressively, modified and amended with real-time feedback.

As most students have no idea what a tow tank looks like and how the ship resistance was conducted, video clips were compiled and used to show the tow tank locally at AMC-UTAS, at UBC Canada, and at QinetiQ in Haslar, UK, via *flipped classroom*.

The work produced collaboratively in classroom during the learning process produced on the whiteboard is shown in Figure 1.

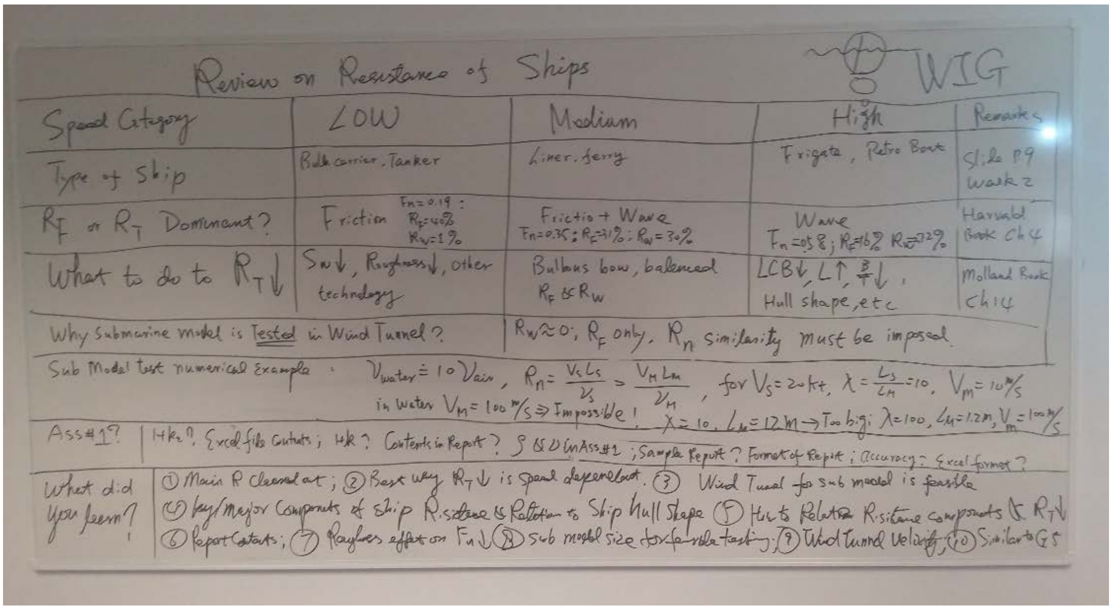

Figure 1: Whiteboard as worksheet of an active, interactive and reflective learning activity on resistance of ships in JEE333 at AMC-UTAS on 20 March 2017.

The results and outcomes in alignment with the ILOs on the whiteboard were then reorganised and are listed in Table 2.

What the Students do

The students were shown a written list in detail on DOCCAM, so the display could be switched for a laptop display for more content and materials, in the classroom. The descriptions of this activity were explained orally and clearly, while students were reading the instructions. The students were instructed to do the following:

- They were divided into 10 groups.
- They were required to nominate or flip a coin to decide on a presenter on each table.
- Students were given 20 minutes to work together, using lecture slides, textbooks, two journal articles on ship resistance, the Internet via their mobile phones and laptop computers to answer the following questions:

  1) Name one ship type for each low, medium and high-speed ranges; which resistance component(s) is important or dominant?
  2) What would you do to reduce the total resistance?
  3) What is the most important question you would like to ask for assignment #1 (one question for each group)?
  4) What did you learn today?

- The presenter of each group reported to the whole class on what the answers/solutions his/her group had come up with. In the meantime, the other nine groups in the class were asked to give feedback/comments/critiques.

Outcomes

a) Aligned with ILO A: distinguish ship's real speed and speed based on a Froude number - clarify a common confusion. Give one exemplary ship type for low, medium and high-speed ranges, in terms of the Froude number. For each ship type corresponding to a ship speed range, make students understand and identify one/two dominant resistance component(s) corresponding to its Froude number.
b) Aligned with ILO B: list main ship hull form/shape parameters and identify their effects on ship resistance. For each type of ship that corresponds to each speed range, develop students' understanding on how to modify hull form parameters/shapes to reduce the dominant resistance, and hence the total resistance.
c) Aligned with ILO C: understand the proper use of similarity theory and its practical application, by asking an open question, *why is the submarine resistance model test conducted in the wind tunnel, not in a tow tank in water?* Through practical example equations, make students develop an understanding, gain skills in selecting a test facility, and determine the model size and required travel speed.

Resources

Resources used in the learning activity provided by the facilitator are as follows:

1. Molland et al textbook, chapter 14;
2. Harvald textbook, chapter 4;
3. Lecture slides;
4. Journal articles by Holtrop and Mennen (1982) and Holtrop (1984).

Resources used in the learning activity by students sourced by themselves are as follows:

5. Lecture notes;
6. Any related materials accessible on the Internet, such as data, videos, images, discussion forums, articles and essays.

DISCUSSION

Constructive Alignment of the Active, Interactive and Reflective Learning Activity

A unit content based constructive alignment was developed for the in-class, instructor facilitated activity, using the theory by Biggs [15]. Table 1 shows the details of this TLA. In Table 1, each learning activity task is aimed to address one ILO. At the end of each activity task, students report their answers/solutions to the class, so it gives them the opportunity for self-assessment/correction and reflection for deeper learning and achievement of the ILO. The students' real-time report gives the lecturer, the author, a chance to know their level of understanding and performance, so the author could improve his teaching and making proper adjustment.

Table 1: The details of constructive alignment (CA) for the TLA.

ILOs	TLA to align with the ILOs	SOLO (structure of observed learning outcomes) level-knowledge type [16]	Formative assessment [17]
A	1) Work collaboratively to answer an open question about ship speed classification to address ILO A. 2) Identify the relationship between dominant resistance type and ship speed to addresses ILO A.	Multi-structural-declarative	Learning goals and criterion are clearly identified - important content is emphasised for job competency and unit's key assessments (class test and final examination);

B	1) Identify how to modify hull parameters/hull-shape to reduce the dominant resistance and hence the total resistance to address ILO B.	Relational-declarative	Self- and pear-assessment - rest of the nine groups and the teacher evaluate each group's answers/solutions; Collaboration - teacher facilitated the TLA in collaboration with the students as partners to learn together using the resources and establish the answer keys and solutions on the whiteboard; Descriptive feedback - teacher summarised and gave the correct answers that link to each ILO, respectively.
C	1) Determine the model size, facility and test speed that gives students the chance to practise and develop skills to address ILO C.	Relational-functioning	
A, B and C	1) Ask one most important question for assignment 1 to reflect on what they have learned previously and strengthen deeper learning and understanding.	Mult-istructural-declarative; Relational-declarative Relational-functioning	

Justification of the Active, Interactive and Reflective Learning Activity

The TLA as mentioned above was based on the theory by Biggs [8]. Throughout the TLA, the CA [9] between the teaching content and the ILOs were strictly aligned to ensure the designated ILOs are achieved. For this TLA, as indicated in Table 1, formative assessment was employed. UTAS encourages this type of assessment [18], because it *prompts student learning*. This kind of activity gives students the chance to make mistakes, and get self-assessment and correction instantly. It also gives the instructor the chance to know how the students performed and the students' level of understanding, and hence, the direction and measurements to take for the instructor to improve the teaching.

The design of this TLA also has the following features:

- The teaching content and tasks in the TLA were tightly aligned with the ILOs. Therefore, this TLA has achieved the following benefits [19]: 1) students' focus; 2) clear what really counts; 3) teacher's use of ILOs for planning; 4) teacher's design assessment criterion and engagement; and 5) clarify the graduation standards.
- This TLA was designed to provide an active learning environment, thus this work created the following benefits [12]: 1) more student involvement (to give students something to do interactively rather than lectures only); 2) student are engaged (a few students, especially some international students, lost concentration during the lectures); 3) greater emphasis on skill development (provide some hands-on skill development in the classroom); 4) greater emphasis on exploration of attitudes and values (by the use of formative assessment to do so); 5) increased student's motivation (the instant, real-time critique and correction let them know where they were and how well they compared with the whole class); 6) students receive immediate feedback (by using formative assessment and *recasts and uptake*); and 7) students involved in higher order thinking (by leading the students from the basic concept to particular ship design technique - these are essential assets for their future career as professional naval architects).
- The design also emphasised the creation of an interactive environment [20]. This was achieved by using the following approaches: 1) asking open-end questions; 2) let students critique each other - collaborative work group of four-five, presenting answers/solutions critiqued by rest of the class; and 3) what is wrong with this example?: If the submarine model is tested in the water, the carriage speed will go up to 200 m/s which is feasibly impossible.
- The TLA was designed to reflect the knowledge and skills taught during weeks 1-4, with the main objective being to review the subjects delivered. The reflection was achieved by engaging with learning that provide an opportunity to critically analyse and evaluate the learning practice [21] - peer-peer and teacher critique on the answers/solutions from each group resulted in the correct answers/solutions posted on the whiteboard.
- Formative assessment [17] was deployed for this TLA, of which obtained benefits are listed in the most right column in Table 1 above.

Table 2 shows the answers from each group - each group was allowed to give only one answer to the question: *what is the most important knowledge/skills you learnt from the activity today?* All the most important things that students deemed to have learnt are well in alignment with the ILOs. Therefore, the outcomes of the TLA are achieved, which are in alignment with the ILOs [22][23].

Table 2: Students' answers to: *what is the most important knowledge/skills you learnt from the activity today?* Each group is allowed to give only one item.

Group	Students' answers	ILOs covered	Feedback from students live report
1	Main resistance component for different ship speed categories	A	Fairly performed, but went well after feedback
2	The best way to reduce ship resistance is different in each ship speed range	B	Good performance and went well after feedback

3	Understanding and use of the law of similarity - why submarine model resistance test is done in a wind tunnel and not in a water tank	A and C	Similar to group 2
4	Dominant resistance is hull shape dependant	B	Similar to group 2
5	How to relate the dominant resistance to the total resistance	A	Poor performance, but went well after feedback
6	What content should be included in the report for assignment 1	A, B and C	Very good uptake after explanation/feedback
7	Ship hull roughness relation to friction resistance	B	The best group with highest level of understanding
8	Submarine model size and facility determination/selection	A and C	Similar to group 2
9	Wind tunnel velocity to produce high Reynolds number	A and C	Similar to group 2
10	Similar to group 5	A	The poorest performance of this group, but went well after feedback

The ten answers in Table 2, i.e. what students have learnt from their feedback, show that the ILOs were achieved successfully and thoroughly. The content, the level of understanding and the skills developed are the desired outcomes of the one-month teaching and learning from weeks 1-4. This indicates that this learning activity is good practice.

Rationale and Personal Perspective to Develop a New TLA for JEE333 Ship Resistance Teaching and Learning

This TLA is the first ever the authors experienced either as a student or a lecturer in the ship resistance topic. Ship resistance contains much more declarative knowledge than propulsion. In the authors' personal experience, these many pieces of declarative knowledge are hard to facilitate students' deeper learning without relating and linking the speed categories, similitudes, model to full scale extrapolation, dominant resistance and effect of the hull form parameters, and hence finally, the propeller design considerations, altogether, systematically. It was found that at the beginning of the couple of weeks, several students had no clue about some pieces of declarative knowledge and the relationship between them that are vitally important for them to design and modify ship hull to reduce the total resistance effectively. After four weeks of teaching in ship resistance, this TLA was designed, conducted and proven to be effective in deeper understanding and skill development. After the collaborative work in classroom and formative assessment as feedback between students and the lecturer, one could be confident that the students learnt, and all the ILOs were achieved comprehensively.

The Designated Resources of Teaching and Learning:

The previous unit outline requires two software packages as mandatory and this was modified to none. Teaching and learning of a unit should not be tied to any software. The most important thing is the students' understanding and ability to solve problems. Software should be normally used as tools to help their understanding, skill development and increasing efficiency. The problem-solving ability of students should not be affected, if they do not have access to the software. The expectation after the completion of the unit, is that students can solve propeller design and optimisation problems by any means, either by using hands and pen, calculators, and any common office software, or being able to develop software to solve problems, whatever is appropriate and possible.

CONCLUSIONS

The essential content for ship resistance and propulsion for the maritime engineering undergraduate degree was analysed and determined. The intended learning outcomes (ILOs) were refined and an interactive, active and reflective learning activity was designed and implemented to enhance the teaching and learning for the resistance part of the unit. Constructive alignment of the ILOs was emphasised on both the TLA and AT conducted to ensure the ILOs were achieved.

REFERENCES

1. Molland, A.F., Turnock, S.R. and Hudson, D.A., *Ship Resistance and Propulsion: Practical Estimation of Propulsive Power*. Cambridge University Press, 537 (2011).
2. Harvald, S.A., *Resistance and Propulsion of Ships*. New York: John Wiley and Sons, 353 (1992).
3. Liu, P., Marine Propeller-Turbine Rotor Prototyping, Design and Optimization - a Hands-on Computational Approach, 297 (2017).
4. Liu, P., JEE333 Resistance and Propulsion Lecture Notes/Slides, Australian Maritime College, University of Tasmania (2017).
5. Liu, P., JEE333 Unit Outline, Australian Maritime College, University of Tasmania, 16 (2017).

6. Anderson, L.W., Krathwohl, D.R., Airasian, P., Cruikshank, K., Mayer, R., Pintrich, P., Raths, J. and Wittrock, M., *A Taxonomy for Learning, Teaching and Assessing: a Revision of Bloom's Taxonomy*. New York, 154-159 (2001).
7. Biggs, J., Enhancing teaching through constructive alignment. *Higher Educ*., 32, **3**, 347-364 (1996).
8. Biggs, J., Constructive alignment in university teaching. *HERDSA Review of Higher Educ.*, 1, **1**, 5-22 (2014).
9. Bonwell, C.C. and Eison, J.A., Active Learning: Creating Excitement in the Classroom. ASHE-ERIC Higher Education Reports. ERIC Clearinghouse on Higher Education, the George Washington University (1991).
10. Study.com. Reflective Learning: Definition, Style & Theory (2017), 20 March 2018, http://study.com/academy/lesson/reflective-learning-definition-style-theory.html
11. Dewey, J., *How we think: a Restatement of the Relation of Reflective Thinking to the Educative Process*. Boston: D.C. Heath and Company (1933).
12. Merlo, C., 4 Interactive Classroom Activities for College Students (2017), 20 March 2018, https://blog.tophat.com/interactive-classroom-activities
13. Moss, C.M. and Brookhart, S.M., *Advancing Formative Assessment in Every Classroom: a Guide for Instructional Leaders*. ASCD (2010).
14. Biggs, J., What the student does: teaching for enhanced learning. *Higher Educ. Research & Develop*., 18, **1**, 57-75 (1999).
15. Biggs, J., *Teaching for Quality Learning at University: what tthe Student does*. UK: McGraw-Hill Education (2011).
16. McManus, S., *Attributes of Effective Formative Assessment*. Washington DC: CCSSO (2008).
17. Pretorius, L., Bailey, C. and Miles, M., Constructive alignment and the research skills development framework: using theory to practically align graduate attributes, learning experiences, and assessment tasks in undergraduate midwifery. *Inter. J. of Teaching and Learning in Higher Educ.*, 25, **3**, 378-387 (2013).
18. The University of New South Wales, Aligning Assessment with Outcomes (2017), 13 April 2017, https://www.unsw.edu.au/about-us
19. Bonwell, C.C. and Eison, J.A., Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports. ERIC Clearinghouse on Higher Education, George Washington University, Washington, DC (1991).
20. Black, P.E. and Plowright, D., A multi-dimensional model of reflective learning for professional development. *Reflective Practice*, 11, **2**, 245-258 (2010).
21. Engineers Australia, National Engineers Register - Areas of Practice Descriptions (2017), 16 April 2017, https://www.engineersaustralia.org.au/sites/default/files/content-files/2017-02/areas_of_practice_descriptions_updated.pdf
22. UTAS, Assessment Policy, (2016), 17 April 2017, http://www.utas.edu.au/__data/assets/pdf_file/0019/29341/Assessment-Policy-July-2012-minor-amendments-December-2016.pdf
23. Tasmanian Institute of Learning and Teaching. *Guidelines for Good Assessment Practice.* (3rd Edn), 31 (2016).

BIOGRAPHIES

Pengfei Liu received his BEng degree from Wuhan University of Technology (WUT), China, in 1982, and his MEng and PhD in Naval Architecture at Memorial University of Newfoundland (MUN), Canada, in 1991 and 1996, respectively. Dr Liu worked as a Senior Research Officer at the National Research Council Canada from July 1999 to January 2016. He is currently an Associate Professor in the Australian Maritime College at the University of Tasmania (UTAS), Australia. He served as an adjunct professor/researcher at MUN since 2000, China Ocean University (2002-2005), the Institute of Mechanics, Chinese Academy of Sciences (2005-2008), Herbin Ship Engineering University, China (2008-2010) and UTAS (2013-2016). Dr Liu has worked intensively for over two decades in the development of speciality engineering software, teaching undergraduate and supervision of higher degrees by research. He is an Associate Fellow of the UK Higher Education Academy, a professional engineer of APEGBC, Canada, and a member of various international academic committees, including the Board of Directors of Computational Fluid Dynamics Society of Canada (2001-2007). Dr Liu has co-authored over 120 refereed journal articles and conference papers in engineering software development for hydrodynamic/ aerodynamic applications of rotary and oscillatory wings for propulsion and turbine renewable energy.

In 2003, Yiyi Xu received her BA from Hunan University of Science and Technology in China, and in 2006 received her Master's degree from Huazhong University of Science and Technology, China. Yiyi has taught computer networks and computational thinking for more than 10 years at Guangxi University of Science and Technology, China. Her research focuses on computer education from a computational thinking perspective. She has jointly published ten articles in this field and obtained two province-level teaching awards. Yiyi is currently studying in the Australian Maritime College at the University of Tasmania, as a PhD student. Prior to her study at the University of Tasmania, she was an Associate Professor at Guangxi University of Science and Technology, China.