International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:8, No:3, 2014

Project and Module Based Teaching and Learning

Jingyu Hou

***Abstract*—**This paper proposes a new teaching and learning approach-project and module based teaching and learning (PMBTL). The PMBTL approach incorporates the merits of project/problem based and module based learning methods, and overcomes the limitations of these methods. The correlation between teaching, learning, practice and assessment is emphasized in this approach, and new methods have been proposed accordingly. The distinct features of these new methods differentiate the PMBTL approach from conventional teaching approaches. Evaluation of this approach on practical teaching and learning activities demonstrates the effectiveness and stability of the approach in improving the performance and quality of teaching and learning. The approach proposed in this paper is also intuitive to the design of other teaching units.

***Keywords*—**Computer science education, project and module based, software engineering.

I. Introduction

EDUCATIONAL institutions around the world aim to improve the quality of teaching and learning by adapting new methods and technologies. It is obvious that new technologies provide powerful and convenient tools to assist in improving teaching and learning. Whatever changes new technologies bring to education, the core education value remains the same, i.e., education is to integrate learning into larger intellectual frameworks that will serve the learner in immediate and generative contexts. In other words, "while technical tools can replace some of the routine tasks of delivering information at the moment of need, this work should not be confused with designing a 'course' of intellectual development, providing intellectual guidance and monitoring intellectual understandings" [1]. Therefore, developing better methods for course design in teaching and learning still remains a challenge.

In order to improve teaching and learning effectiveness, some learning theories have been proposed. Among them, the constructivism is well accepted. Constructivism views learning as a process of assimilating and accommodation new experiences that if a new learning experience or knowledge does not contradict the brain's framework of understanding, then the experience or knowledge is assimilated into the framework, otherwise the framework is altered to accommodate the experience or knowledge [2]. The representative methods of the constructivism are module-based, problem-based and project-based learning methods. The module-based method [3] is to divide the content of a teaching unit into a sequence of unit components. Each component, also known as a module, consists of integrated theories, concepts, notations and problems to solve. The teaching and practical classes are then designed to follow the content of the modules.

The problem-based method, at its most fundamental level, is an instructional method characterized by the use of real problems as a context for students to learn problem-solving skills and acquire knowledge [4], [5]. In problem-based learning, ill-structured and complex problems are first presented before students have learned the basic knowledge of the unit. The problems are typically organized into basic knowledge blocks. One advantage of this method is that students have an opportunity to be actively involved in problem-solving and are motivated in their learning. The role of the lecturer is to facilitate the problem-solving process, to guide, probe and support the students' initiatives, rather than lecture, direct or provide solutions [6]. Therefore, problem-based learning is student-centered using coach/facilitator instructors. When the problem is larger, more complex, more applied, and process-oriented, the problem-based learning could be called project-based learning [7].

The project-based learning, similar to problem-based learning, is also student-centered and based on problem solving. However, the project-based learning requires and covers more content and is different from the problem-based learning in many ways. In project-based learning, students usually work in groups to solve challenging problems. Project problems are not designed for a specific topic to learn but are authentic, curriculum-based and often interdisciplinary. "Learners decide how to approach a problem and what activities to pursue. They gather information from a variety of sources and synthesize, analyze, and derive knowledge from it" [8]. In addition, project-based learning also requires a commitment and clear understanding of the problem, a broad restructuring of policy decisions, leadership, and professional development. The student achievement is judged by how much they've learned and how well they communicate it. The lecturer's role in project-based learning is to guide and advise, rather than to direct and manage student work. This role is similar to the lecturer's role in problem-based learning.

Project based learning is more suitable to those units offered for senior students (i.e., capstone courses). How to effectively incorporate projects into learning becomes an active education research area, especially for the information technology discipline [2]. Some methods and principles have been proposed to deal with this issue, such as the redesigned basic lecture/project course model that uses the active learning theory [9], studio-based learning [10], ten principles and five practices for capstone courses [11], and the open ended group projects (OEGPs) [12]. Meanwhile, project design is also a focus of project-based learning. Dugan [2] divided projects into five main types, while Fincher et al. [13] described an

J. Hou is with the School of Information Technology, Deakin University, Burwood, VIC 3125 Australia (e-mail: jingyu@deakin.edu.au).

alternative project taxonomy across the computer science curriculum, based on which projects are classified into nine types.

Although these methods can be effective, there can also be disadvantages if they are individually used in the teaching and learning process of any subjects, because these methods focus on either problems/projects or a combination of lecture and project, rather than weaving the major aspects of learning, teaching and project. The module based learning is weak in teaching students to apply what they learn to solve real problems, even though some pre-designed problems are used with this method. The main disadvantage of the problem-based and project-based methods is that students may only focus on the knowledge and skills useful or helpful to problem solving, thus ignoring various correlating knowledge that assists in obtaining an overall picture of the knowledge structure and related facts. Furthermore, these methods mainly focus on how to enable students to learn knowledge and skills effectively, with less attention paid to how to design teaching so that teaching and learning is an integrated process in education. Therefore, there is a gap between the conventional module based learning and project based learning, for which there are few research results available.

The project and module based teaching and learning (PMBTL) method proposed in this paper aims to fill this gap by incorporating merits of the above approaches into the teaching and learning process. This method provides lecturers and students with a new approach to teaching and learning, and integrates the communication, teamwork, time management and subject-area content. We suggest the PMBTL method be used for higher level teaching (e.g., second or third year teaching units in a university) before students do real professional or practical projects. The lecture/project course model [9] and the teaching and learning principles proposed by Dubinsky and Hazzan [11] try to combine lectures and projects to improve learning outcomes. However, their focuses are still on projects, rather than the design of teaching, practice and curriculums content assessment. Like other project based learning methods, these two methods also require the project to be fully completed.

The PMBTL method has additional features that differentiate it from existing methods, such as the integration of teaching, learning, practice and assessment designs, and a curriculum-guided and project-based approach to organize teaching and learning activities. It does not require the project to be fully completed, as the PMBTL method is to bridge the module and project based learning. These new features are realized by the proposed methods presented in the following sections.

In this paper, we use a third year teaching unit Software Engineering to demonstrate the implementation of the PMBTL method. In the School of Information Technology at Deakin University, this unit is offered to third (last) year students in the first semester to teach them the theory and skills of doing a software development project professionally before they do an authentic project in the second semester (for which the School of IT offers another unit). The outcome of this unit is that students can apply what they have previously learnt with the knowledge and skills from this unit to professionally do a software development project. The practical project skills cannot be obtained from textbooks or lectures. Therefore, the PMBTL method is suitable to the teaching and learning of this unit.

The paper is organized as follows. In Section II, we present all techniques and methods of the PMBTL approach. In Section III, we provide the teaching and learning evaluation data of two teaching units to show the effectiveness of the proposed approach. In Section IV, we present the conclusions and indicate some possible applications of the approach.

II. Methods

The general principle of the PMBTL method is to use the curriculum of a teaching unit as a guide to design a genuine project for students to undertake during their period of learning, in addition to designing teaching modules based on the curriculum and the project. This method consists of new teaching and learning techniques, such as incorporating student inquiries about project methods or skills into lectures, taking into account both the study modules and the project requirements when designing tutorials and assessments. However, this method does not require students to complete the project perfectly. Instead, the project is used to establish a real problem-solving framework within which students learn knowledge and skills and be capable of using a professional approach to solving real problems. These new features make the PMBTL method different from project-based and problem-based methods. The model of the PMBTL approach is presented in Fig. 1.

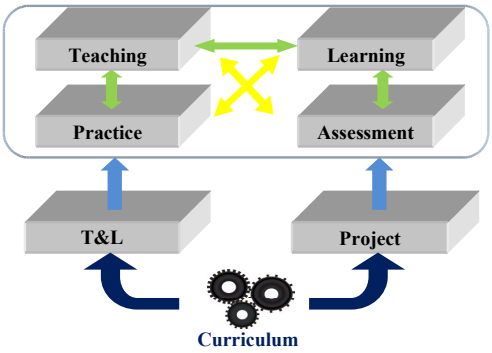

Fig. 1 The PMBTL model

A. Teaching and Learning (T&L) Module Design

The teaching and learning modules of a unit are designed to include the knowledge, methods and skills students should receive from delivery of the unit. The module design is based on the unit curriculum, and from this we target the purposes and graduation attributes of the unit, and organize the unit content in an effective way to achieve these targets. The design method is the same as conventional module based learning as in Yakhno et al. [3].

In our Software Engineering teaching and learning, the objective is to let students know and understand that software

development is an engineering activity that can be managed and executed in an efficient manner. Students are required to draw together many skills learned previously, work in groups to complete a software development project, and learn methods and skills for conducting a project, including project management, system analysis and design, development and deployment. Accordingly, the teaching and learning modules of Software Engineering are designed as

- Module One: Project Management, including process models, requirement engineering, system size and project effort estimation, project planning and scheduling, risk management, and software specification.
- Module Two: System Analysis and Design, including use cases, object-oriented modelling, dynamic modelling, and system design.
- Module Three: Software Quality and Reuse, including software testing, software configuration management, software quality and maintenance, and software reuse.

The curriculum of Software Engineering unit in our school states the following targets should be achieved after students complete the unit: discipline-specific knowledge and capabilities, communication, digital literacy, critical thinking, problem solving, self-management, and teamwork.

It can be seen that the teaching and learning modules of this unit mainly address the first target of this unit, and partially address the third and fourth targets. Therefore, integrating a project into the teaching and learning of this unit becomes necessary.

B. Project Design

For a teaching unit that combines multi-discipline skills from previous units with further content to learn, designing a practical project for teaching and learning is necessary. The project is to be used as a guide for students to apply what they have learnt and what they are going to learn to solve real problems, and also as a framework for assessing the outcomes of student learning. Meanwhile, combined with the teaching and learning modules, the project is also used for teaching, practice and assessment designs for achieving better teaching and learning outcomes.

Although there are various types of projects [2], [13] such as industry, simulated and research, each type of project has its own advantages and disadvantages [2]. In the PMBTL method, the design of a project combines industry and simulated types with the unit modules. Specifically, a project is basically a simulated one based on the unit modules. However, the simulated project comes from industry projects with some modifications in requirements. Therefore, a project in the PMBTL method incorporates major advantages of both simulated and industry project types, such as allowing instructor to control project milestones and management policies [14], providing consistent experience across groups [15], motivating students [16] [17], and providing students with real world experience [18] [19]. With the PMBTL method, the basic principle of project design is that a project must be challenging, aligns with the teaching and learning objectives defined in the unit curriculum, and covers major content in the teaching and learning modules.

The project should be larger than a single assignment in terms of time and workload, but smaller than a real project, to comply with the purposes of project in the PMBTL method. Accordingly, the project design takes the following two factors into consideration:

i. Coverage. The project should cover the major content of the teaching and learning modules and the required skills of the unit.
ii. Orientation. Depending on the unit content, some parts of the project are compulsory and require students to do these parts as best as they can, while other parts require students to demonstrate they can apply the skills or knowledge previously learnt to solve the problem.

As a policy, a project must be done by a group of students.

Time to release the project is critical to the overall success of the project and module based teaching and learning. The project, once finalized, should be released to students before commencement of the semester. The reason for this is because the project frames the assessment outcomes for student learning, so students will be motivated by the project from the start of their learning, and in turn will pay more attention to the content in teaching and learning modules.

The project design for our Software Engineering unit follows the above design principles and methods. We have designed various projects for this unit, such as the Teaching Allocation System (TAS) and the Conference Paper Review System (CPRS). Each project covers the three modules of this unit.

Our projects focus on the entire engineering process of developing a software system, and the required knowledge and skills to effectively and efficiently implement this process, i.e., communication, planning, designing, construction and deployment. In regards to project orientation, the communication, planning and design of the entire engineering process are compulsory. The construction and deployment components require students to demonstrate their capability of applying programming skills to implement a system. Due to the project design orientation, our projects only require students to implement major parts/functions of the software system.

C. Class Teaching Method

The class teaching is based on both the unit modules and the designed project. Since the project is designed from the unit teaching and learning modules, important modules have been mapped into the corresponding parts of the project. Class teaching method is therefore implemented in several ways. When starting a new teaching module, the lecturer indicates to students the relationship between the module and the corresponding part(s) of the project. So that students understand teaching content better in the context of the project.

When teaching theory, principles and methods of each module, the lecturer uses corresponding part(s) of the project as examples to demonstrate how teaching contents can be applied to the project. This method keeps all teaching

demonstrations consistent across all modules.

With the project, it is easier to design and organize discussions in a class as discussion questions can be based on the requirements of the project, which will further attract the attention of students.

Feedback and student inquires about the project are another good resource for improving teaching and learning outcomes. Different from the direct feedback or inquiries from class discussions which focus on specific teaching content, the feedback and inquiries about the project come from students who are concerned about the entire project. These inquiries might refer to skills, principles and methods covered in many related modules. By analyzing student feedback and inquiries, the lecturer can identify some possible confusion and misunderstanding in the teaching and learning, and take corresponding actions, such as emphasizing the relationships between content when preparing teaching materials, or guiding students to the contents or modules to be introduced.

As a case study in our teaching of Software Engineering, the project we designed has a component that requires students to estimate the project effort before planning the project. This part refers to the size estimation of a software system in terms of function points (FP) or lines of code (LOC), effort estimation in terms of person-month, project cost estimation, reconciliation of estimation results and project planning. Common feedback and inquiries from students about this were mainly about how to convert the FP or LOC estimates of a software system into the person-months, whether some common senses can be used directly to estimate a project cost instead of using system size estimates, and how to deal with different estimation results from different team members for the same project. The feedback and related inquiries were incorporated into our teaching, and the student project work was on the right track as we expected.

D. Practice Class Teaching

The key to the effectiveness and success of practice classes is the practice materials provided to students. Traditional module based teaching designs practice materials on the basis of learning module content, and providing exercises to help students understand the lecture content or solve some problems relevant to the lecture content. One drawback of this practice is that practice materials mainly address individual modules and pay less attention to systematically combining and applying the learnt skills to solve a real problem. This issue can be well addressed with the PMBTL method.

To this end, practice material design combines the content of learning modules and the techniques needed to solve the *key problems* of a project. In other words, the practice materials are designed in the context of the project and teaching modules (see Fig. 2).

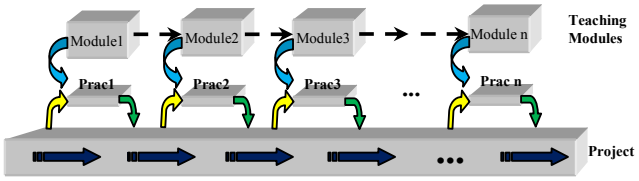

Fig. 2 The context of practical material design

To achieve the best outcomes of using the designed practice materials in practice classes, it is necessary for a lecturer to introduce practice materials when delivering the module content in lectures, and for the practice class tutor to address the project context of the practice materials at the beginning of each practice class.

In Software Engineering practice class teaching, we design practice materials to cover the main content of teaching modules and the key techniques for software system development, including the project operation conceptual document template, the software requirement specification template, the software system size estimation in terms of FP, the software for project planning, the object-oriented modeling of a software system, the dynamic modeling of a software system, and the testing case design etc. At different stages of a project, students significantly improve their project quality by using the techniques they learned from practice classes.

E. Assignment and Assessment Design

Since the project design has already taken into account the major content of the teaching and learning modules, the assignment design is therefore based on the project..

Assignments for a unit is designed in such a way that they guide students to do the project step by step (module by module), and in the meantime enable students to master the content of the unit. To do this, a project is “chopped” into related but relatively independent parts, each of which is for one assignment. Meanwhile, this design should guarantee the outcomes of assignment 1 be the basis of assignment 2, and so on. The unit lecturer or teaching team needs to synchronize the delivery of the module content, practice materials and assignment due dates when designing assignments.

As a case study, our Software Engineering project is divided into three major parts, and accordingly three assignments are designed. These three assignments are about the project plan and software specification, system analysis and design, and system implementation. The specification document of each assignment clearly indicates what to do, how to do it (including what skills and methods are needed, and how to use them to do the assignment), and importantly, the relationship between the assignment the teaching and learning module content.

To guide students to do the project professionally, it is better to provide students with examples, reference materials and samples in the assignment design. Our experience shows that samples, rather than individual examples, greatly help students understand the assignment requirements and ensure their assignments are on the right track.

The assignment assessment is designed not only for markers

to assess the quality of student assignment work, but also for students to get a guidance of doing the project properly and professionally. To achieve these targets, in addition to listing all required assessment items, the assessment criteria should also indicate the relationship between assessment items if applicable, the expected results, as well as examples of incorrect avenues students should avoid. Because of the roles the assessment plays in guiding students to do the project, the PMBTL method requires the assignment assessment criteria be released to students with the assignment specification document.

The following is a part of our assignment 1 assessment criteria designed to assess the work on identifying preconditions of a system function in the software requirement specification document. We provide detailed comments and examples to guide students what they should/shouldn't do.

Preconditions (25 marks)
Pre-allocated marks *25*
If select this one, the others will not be assessed
✖*No preconditions provided for all capabilities/requirements.* *-25*
Select any of these which are appropriate including the following mark
✖*Very few of the preconditions written are assertions. Preconditions must always be assertions. Assertions are either True or False. For example, "the file is open" is either True or False and, therefore, is an assertion. But "the file must be open" and "open file" are not.* *-4*
[Other criteria with comments/examples]
……

The comments and examples designed in the assessment criteria are also used to generate an assessment report for the student assignment by keeping those that apply to the assignment work. As a result, the assessment is formalized within a framework. The assignment and assessment designs are complementary to each other to concretize the requirements in teaching and learning modules.

III. Evaluation Results

We evaluated the effectiveness of the PMBTL method on the teaching and learning outcomes of two Software Engineering units the author has been teaching for several years. One unit is Software Engineering (SE) for undergraduate students (the third-year students), another is Advanced Software Engineering (ASE) for postgraduate students. The evaluation was based on the statistic data provided by the Student Evaluation of Teaching and Units (SETU) conducted by Deakin University at the end of each semester. The SETU is a comprehensive teaching and learning evaluation system that enables students to evaluate the effectiveness of a unit teaching from different angles, including teaching materials, lecturer's teaching performance, help provided, clearance of assessment tasks, working load, teaching tools used in teaching and learning. With this system, students can also provide comments on and suggestions to the units they studied. Therefore, the SETU incorporates merits of some commonly used course evaluation methods such as the survey with Likert scale questions [20] and the student reflection [21], and the SETU results reasonably reflect the students' satisfaction level in their learning, as well as the effectiveness of a unit teaching.

Since there are many evaluation items in the SETU, our evaluation was not based on these individual items. Instead, the evaluation was based on the overall evaluation result of teaching and learning performance. The overall evaluation result provided by the SETU combines all individual evaluation results and their weights. The rationale for adopting this evaluation method was that the PMBTL method incorporates different methods in different teaching and learning aspects. Therefore, simply evaluating each individual aspect could not properly reflect the overall effectiveness of incorporating these methods in the PMBTL method. The SETU results of these two units were also compared with the average SETU results in our School, Faculty and Deakin University. The SETU results were normalized into values within the range of 0 to 5, where the higher the value, the better the teaching and learning performance. The comparisons of the SETU results of these two units with the average SETU results of the School, Faculty and Deakin University are presented in Figs. 3 and 4 respectively (for the years from 2009 to 2012).

It can be seen from the figures that the overall performance of the units Software Engineering and Advanced Software Engineering, which adapted the PMBTL method, consistently and significantly outperformed the average performance of the School, Faculty and University over several years. The evaluation results demonstrated the effectiveness and stability of the PMBTL method in improving the quality of teaching and learning.

IV. Conclusions

The project and module based teaching and learning (PMBTL) approach enables students to learn unit content in a completed project context. As a result, students are motivated to study and apply their knowledge and skills comprehensively and professionally. With this teaching and learning method, students can get an overall picture of the teaching unit rather than individual facts, understand the teaching and learning content better, know how to apply what they are learning, and learn how to solve real problems. Adapting the PMBTL approach to improve teaching and learning requires lecturers to combine the teaching, learning, practice and assessment together using the methods proposed in this paper. These proposed methods are supplementary to each other to realize the PMBTL approach.

The PMBTL approach is also intuitive to the design of other kinds of teaching units. Specifically, the PMBTL approach is more suitable to master degree courses that require students to do more research oriented work and projects during their study.

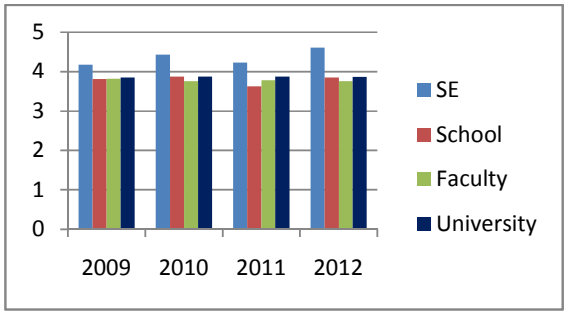

Fig. 3 Comparison of SETU results of the unit Software Engineering (SE) with the average SETU results of the School, Faculty and University. The values on X-axis are the years; the values on Y-axis are the SETU results

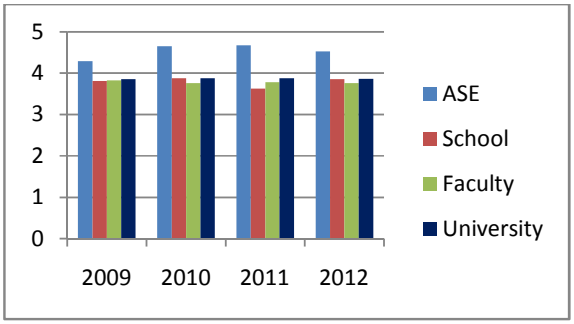

Fig. 4 Comparison of SETU results of the unit Advanced Software Engineering (ASE) with the average SETU results of the School, Faculty and University. The values on X-axis are the years; the values on Y-axis are the SETU results

REFERENCES

[1] M. Riel, "Education in the 21st Century: Just-in-Time Learning or Learning Communities," in *The Fourth Annual Conference of the Emirates Center for Strategic Studies and Research*, Abu Dhabi, May 24-26, 1998. Available: *http://faculty.pepperdine.edu/mriel/office/papers/jit-learning/*

[2] R.F. Dugan, "A survey of computer science capstone course literature," *Computer Science Education*, vol. 21, no. 3, pp. 201–267, Sep. 2011.

[3] T. Yakhno, E. Ekin and T. Aktuglu, "Work in Progress – Module-Based Active Learning Approach for Introductory Level of Computer Engineering Curriculum," in *The 39th ASEE/IEEE Frontiers in Education Conference*, San Antonio, TX, Oct. 18 – 21, 2009.

[4] P. Brazier, A. Garcia and A. Vaca, "A software engineering senior design project inherited from a partially implemented software engineering class project," in *FIE '07: Proceedings of the 37th annual frontiers in education conference*, New York, NY: ASEE, 2007, pp. F4D–7–F4D–12.

[5] M. A. Albanese and S. Mitchell, "Problem-based learning: A review of literature on its outcomes and implementation issues," *Academic Medicine*, vol. 68, no. 1, pp. 52-81, 1993.

[6] A. Kaufman et al., "The New Mexico Experiment: Educational Innovation and Institutional Change," *Academic Medicine*, 64: pp. 285-294, 1989.

[7] R.B. Heckendorn, "Building a Beowulf: Leveraging research and department needs for student enrichment via project based learning," *Computer Science Education*, vol. 12, pp. 255-273, 2002.

[8] G. Solomon, "Project-Based Learning: A Primer," *Technology and Learning*, Jan. 2003. Available: *http://pennstate.swsd.wikispaces.net/file/view/PBL-Primer-www_techlearning_com.pdf.*

[9] S. Ludi, S. Natarajan and T. Reichlmayr, "An introductory software engineering course that facilitates active learning," in *SIGCSE'05: Proceedings of the 1986 workshop on applied computing*, New York, NY: ACM, 2005, pp. 302-306.

[10] J. Knight and T. Horton, "Evaluating a software engineering project course model based on studio presentations," in *FIE'05: Proceedings of the 35th annual frontiers in education conference*, New York, NY: ASEE, 2005, S2H-21-26.

[11] Y. Dubinsky and O. Hazzan, "A framework for teaching software development methods," *Computer Science Education*, vol. 15, pp. 275-296, 2005.

[12] A. Hauer and M. Daniels, "A learning theory perspective in running open ended group projects (OEGPS)," in *ACE'08: Proceedings of the 10th conference on Australasian computing education*, Darlinghurst, Australia: Australian Computer Society, Inc., 2008, pp. 85-91.

[13] S. Fincher, M. Petre and M. Clark (Editors), "*Computer science project work: Principles and pragmatics*," London, UK: Springer-Verlag, 2001.

[14] D. Coppit and J.M. Haddox-Schatz, "Large team projects in software engineering courses," in *SIGCSE'05: Proceedings of the 36th SIGCSE technical symposium on computer science education*, New York, NY: ACM, 2005, pp. 137-141.

[15] M. Gehrke, H. Giese, U.A. Nickel, J. Niere, M. Tichy, J.P. Wadsack and A. Zundorf, "Reporting about industrial strength software engineering courses for undergraduates," in *ICSE'02: Proceedings of the 24th international conference on software engineering*, New York, NY: ACM, 2002, pp. 395-405.

[16] S. Gorka, J.R. Miller and B.J. Howe, "Developing realistic capstone projects in conjunction with industry," in *SIGITE'07: Proceedings of the 8th ACM SIGITE conference on information technology education*, New York, NY: ACM, 2007, pp. 27-32.

[17] Z. Alzamil, "Towards an effective software engineering course project," in *ICSE'05: Proceedings of the 27th international conference on software engineering*, New York, NY: ACM, 2005, pp. 631-632.

[18] M. Buckley, H. Kershner, K. Schindler, C. Alphonce, and J. Braswell, "Benefits of using socially-relevant projects in computer science and engineering education," in *SIGCSE'04: Proceedings of the 35th SIGCSE technical symposium on computer science education*, New York, NY: ACM, 2004, pp. 482-486.

[19] H. Parkers, M. Holcombe and A. Bell, "Keeping our customers happy: Myths and management issues in client-led student software projects," *Computer Science Education*, vol. 9, pp. 230-241, 1999.

[20] L.M. Northrop, "Success with the project-intensive model for an undergraduate software engineering course," in *SIGCSE'89: Proceedings of the 20th SIGCSE technical symposium on computer science education*, New York, NY: ACM, 1989, pp. 151-155.

[21] M.C. Davis, "A student's perspective of a capstone course," *Journal of Computing Sciences in Colleges*, vol. 16, pp. 151-167, 2001.