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Effective Course Redesign Strategies to Integrate Collaborative PBL in Senior Computer Engineering/Computer Science Courses

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Abstract

This paper presents the accomplishments and comprehensive findings of the NSF sponsored project, entitled "Enhance Computer Network Curriculum using Remote Collaborative Project-based Learning". The focus of the project is to explore Collaborative Project-based Learning (CPBL) as a pedagogical approach to address the learning issues of under-prepared minority students, and seek effective implementation strategy to extend the pedagogy beyond the classroom through a remote learning structure. During the three-year project course, a new pedagogical model named as CPBL-beyond-Classroom was developed and its effectiveness has been thoroughly evaluated in iterative classroom implementation. In this paper, we will analyze this pedagogical model to illustrate how it can address the learning needs of minority students on a commuter campus, describe our course redesign process, and introduce effective implementation strategies to address practical challenges in the implementation process. Concrete examples of course redesign with weekly in-class and after-class instructional activities are provided in the paper and the redesign principles can be applied to other engineering/CS courses. In addition, the paper includes longitudinal study results based on 3-year assessment data to highlight the pedagogical impact on various student learning outcomes. In-depth analysis of qualitative responses also allowed us to develop a better understanding on how different pedagogical components in the CPBL-beyond-Classroom model affected the student learning process. These findings are helpful to other educators who are interested in adopting CPBL-beyond-Classroom to redesign their courses based on the learning needs of their own students.

A. Introduction

The ability to solve real-world problems and design systems or components under realistic constraints are essential to engineering and computer science graduates, as both mandated by ABET and highly valued in professional practice. To help students develop such valuable skills, project-based learning (PBL) has been considered as a useful pedagogy by many engineering/CS educators. However, it is also recognized that PBL may not always function if not designed and integrated in the curriculum appropriately [1-4]. This challenge magnifies at commuter campuses where students having difficulty coming together to work on the projects. During the past three years, California State University Los Angeles faculty team worked collaboratively to develop CPBL-beyond-Classroom pedagogy that has proved to be effective to enhance student learning on commuter campuses. As an extension to CPBL, a specific PBL model developed in the authors' previous work to address the retention issues of minority students in their freshman/sophomore year [5-7], CPBL-beyond-Classroom aims at preparing senior students for professional careers. To address the learning needs of students on commuter campuses, the new pedagogy emphasizes on virtual collaborative learning and community inquiry in a remote fashion. Iterative classroom implementation and assessment demonstrated that CPBL-beyond-Classroom model helped to create a more engaging learning experience and positively impacted the development of students' knowledge and skills.

This paper presents the CPBL-beyond-Classroom pedagogy model and describes how it can be integrated into undergraduate computer networking curriculum effectively. During the course of the NSF sponsored CCLI project, two networking courses (one in Electrical Engineering and one in Computer Science) were revised. A sequence of OPNET projects of various scopes were developed and polished to help students with diverse backgrounds achieve the target learning outcomes. While our project progresses and some preliminary findings were shared in our previous publications [8-10], this paper will provide an in-depth analysis of the unique pedagogical features, share the details of the revised curriculum using concrete examples, and discuss effective implementation strategies that have been tested in classroom repetitively. In addition, the longitudinal study based on 3-year assessment data not only highlighted the effectiveness of the pedagogical model, but also allowed us to analyze how various pedagogical components impacted the student learning process. We hope that the analysis results are useful for colleagues who are interested in adopting CPBL-beyond-Classroom to redesign their courses to better address the learning needs of their own students.

The paper is organized as follows. Section 2 presents the CPBL-beyond-Classrooms pedagogical model, analyzes its unique features, and summarizes effective implementation strategies developed throughout the project duration. Section 3 provides a concrete example to show how to incorporate CPBL beyond-classroom into networking courses at senior level. The results of longitudinal study based on multi-year assessment data are presented in Section 4, and Section 5 concludes the paper.

B. CPBL-beyond-Classroom

B.1 Unique Pedagogical Features

As mentioned above, CPBL-beyond-Classroom can be viewed as an extended pedagogic model based on CPBL. While both models utilize well-designed project sequences to build up students' knowledge and skills progressively, significant differences do exist since CPBL-beyond-Classroom model was developed to address the learning needs of senior students. Figure 1 depicts the essential components for CPBL-beyond-Classroom pedagogy [9].

Comparing to the original CPBL, the new model has a number of unique features:

1) Scalability: Unlike the original CPBL that mainly involves in-class projects, CPBL-beyond-Classroom offers project experience with different scopes and complexity. Particularly, after-class projects and term projects provide students opportunities to work on complicated problems that require creative thinking and integration of knowledge learned in classes.
2) Open-Structured Design: The original CPBL model was centered on the design of well-structured project sequence, each with a clear design goal along with step-by-step instructions. While this well-structured design makes it easier for students with limited knowledge/skills to succeed, it cannot meet the learning needs for senior students. In CPBL-beyond-Classroom model, the projects are either semi-structured (in-class projects) or open-ended (after-class or term projects) that are similar to real-world cases in professional practice. This open-structured design of project sequence is useful to

prepare students with essential knowledge and skills and challenge them to learn and grow as professionals.

3) Collaboration and Community Inquiry: CPBL-beyond-Classroom features various degrees of peer collaboration and makes collaboration a key in student learning process. Due to the complexity of after-class and term projects, students need to work in teams of three or more to accomplish the design task. Also, many learning activities require group discussion or community inquiry. This feature leads to more social interaction and allows the students to learn from multiple perspectives and construct knowledge collaboratively. Our assessment results indicated that students recognized the importance of social interaction in their learning and gained better team skills in the process.

Table 1 summarizes the major difference between CPBL and CPBL-beyond-Classroom.

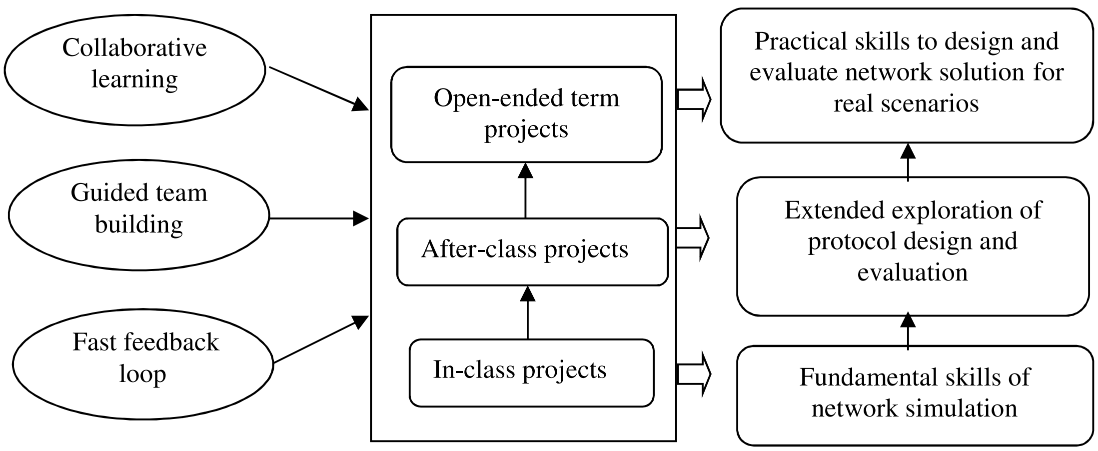

Figure 1. Essential components for CPBL-beyond-Classroom.

Table 1. Major differences between CPBL and CPBL-beyond-Classroom.

	Original CPBL	**CPBL-beyond-Classroom**
Project Scope	In-class project only	*Projects of various scopes*: • In-class project sequence to build up students' knowledge and skills; • After-class projects to challenge students with more complex and ill-defined problems; • Term project to provide real-world design experience similar to professional practice
Project Structure	Well-structured: projects are well defined and step-by-step guidance is provided in project handouts	*Open-structured*: • Partial guidance is provided as needed to get students prepared; • Many after-class and term projects are unstructured such that students may need to identify design goals by themselves, conduct research, formulate problems, select methods for design and testing, etc.
Collaboration Style	Think-pair-share	*Larger scope of collaboration required*: • Team effort is essential to complete after-class and term projects; • Many learning activities are designed to allow collaborative construction of knowledge;

		• Community inquiries are enabled in a much larger scale via social networks and online learning community.

B.2 Effective Implementation Strategies

Converting an innovative pedagogy to successful practice is never an easy task. During our implementation process, we have encountered significant challenges related to virtual collaboration and diverse students' backgrounds. The following strategies were useful to address these challenges and help to achieve a smooth course re-design process.

First of all, to redesign the curriculum with CPBL-beyond-Classroom requires a comprehensive evaluation of the course contents and relevant instructional methods. During the evaluation process, the following questions shall be considered:

1) What are the fundamental topics that need to be taught explicitly via direct instruction?
2) What are the topics/learning outcomes that can be more effectively achieved by project-based learning?
3) What are the topics that can be implicitly covered by class activities (including projects, discussions, inquiry-based activities, homework)?
4) Which topics shall be reinforced by extra scaffolding tools such as video tutorials, video lectures, online learning tools?

The answers to the above questions allow the instructor to better arrange the teaching schedule and plan for essential instructional activities to achieve the learning outcomes.

With proper layout of curricular structure, the instructor will have a clear idea about what types of project activities shall be developed and what shall be their associated learning outcomes. To ensure a successful experience for each project, the following strategies are proved useful in the project design and implementation phases:

- Strategy #1: Link the projects with reality.

Do provide an authentic context to your projects; Don't just build the project based on theories.

- Strategy #2: Prepare and motivate the students in advance!

Do use pre-project activities to ensure that students are well prepared for the projects; Don't assume they can do it on the spot.

- Strategy #3: Structured or Unstructured?

Do design the project sequence to build up student skills, but leave room for exploration and invention; Don't underestimate the students' ability and creativity.

- Strategy #4: Focus on Learning Process, not the Results!

Do incorporate as many key learning factors in project design; Don't set the goal to be just completing the project.

- Strategy #5: Provide guidelines to foster collaboration

Do use team-building activities and provide guidelines; Don't assume students can work well in teams naturally.

- Strategy #6: Build an online community to provide scaffolding

Do build a learning community to provide support; Don't assume that students will come to Professor to ask questions.

Our previous publication described several examples of how to use the above strategies, and interested readers can refer to [10] for details.

C. **Integrating CPBL-beyond-Classroom into Curricular Structure**

A successful curriculum should offer a rich and balanced learning experience with various instructional strategies including lecturing, CPBL activities, and other active learning components. In this section, the curricular structure of EE440 is described as an example to illustrate how to integrate CPBL-beyond-Classroom model in teaching practice. We hope this classroom-tested curricular structure can serve as a reference for other colleagues in similar institutions to redesign their courses with CPBL-beyond-Classroom model.

To better visualize the curricular structure of EE440, its weekly in-class instructional activities are listed in Table 2, while the schedule of after-class projects is described in Table 3. The instructional strategies utilized in EE440 can be classified as 1) explicit instruction (***black***); 2) hands-on in-class projects (in CPBL-beyond-Classroom) (***blue***); 3) other active learning activities including group discussion, team building activities, interactive exercises, etc. (***red***). The schedule shows how the class projects are integrated "just-in-time" to achieve the specified learning outcomes.

Table 2. Schedule of in-class instructional activities in revised EE440 (in 10-week quarter system).

Lecture #	Learning Outcomes	Instructional Activities
1 (week 1)	1) Understand communication model, hardware structure of computer networks; 2) Be able to describe what are LAN/MAN/WAN, and the corresponding key technologies 3) Get to know each other to initiate team building process	• Explicit Instruction • Team building activity (Build a LAN): each student acts as a node on the network, and in group they create LANs with various topology to send message.
2(week 1)	1) Understand layered Network Architecture and data encapsulation process; 2) Be able to describe OSI model, TCP/IP model, and their difference; 3) Know the concept of protocol and protocol stack	• Explicit Instruction • Group activity (design your 1st protocol): students work in team to propose "protocol" to deliver a diamond safely via a unreliable channel
3(week 2)	1) Understand communication theory including Nyquist's law and Shannon's law. Noise calculation; 2) Able to apply the theory to calculate channel capacity, data rate, attenuation and noise power in practical scenarios.	• Explicit Instruction
4(week 2)	1) Understand basics about network design process 2) Reinforce the understanding of layered architecture 3) Explore the impact of physical layer parameters on	**In-class project 1: Introduction to OPNET.** Learn to create a basic network

	end-to-end network performance 4) Develop basic skills to use OPNET and run simulations	scenario and how to analyze the network performance.
5(week 3)	1) Understand transmission media (twisted pair, coaxial cable and optical fiber) 2) Be able to describe the pros and cons of the transmission media 3) Be able to identify applications supported by various transmission media	• Explicit Instruction • Group discussion on pros and cons of transmission media used in everyday life
6(week 3)	1) Understand why data encoding is important and what is the design challenges 2) Be able to use bi-level and multi-level encoding methods to convert data to electrical signals 3) Understand the characteristics of bi-level and multi-level coding and be able to demonstrate how the characteristics affects the performance of data transmission	• Explicit Instruction • In-class exercise: convert data to signal using various encoding methods; • Community inquiry: discuss and propose ways to improve the data encoding methods
7(week 4)	1) Understand bi-phase coding (Manchester, Differential Manchester etc.) 2) Be able to solve problems using bi-phase coding; 3) Learn how to use scrambling to achieve synchronization 4) Understand B8ZS and HD3B coding	• Explicit Instruction • In-class exercise: convert data to signal using various encoding methods.
8(week 4)	1) Be able to describe what are asynchronous and synchronous protocols. 2) Understand the working mechanism of RS-232 3) Be able to identify applications using RS-232	• Explicit Instruction
9(week 5)	1) Understand what is flow control and why it is necessary 2) Be able to explain the working mechanism of Stop-and-Wait and Sliding Window flow control 3) Be able to analyze the performance and calculate the Link utility	• Explicit Instruction Community inquiry: discuss and propose ways to make flow control more efficient.
11 (week 5)	Midterm Exam	Periodic Assessment
12 (week 6)	1) Understand what is error detection and why it is important 2) Be able to explain different types of error detection methods (Parity, CRC) 3) Be able to apply CRC to generate frame checking sequence and use it to detect errors in real transmission scenarios	• Explicit Instruction In-class exercise: Can you detect errors in the received packets?
13 (week 7)	1) Understand what is error correction 2) Understand the operation of ARQ 3) Explore the performance of ARQ in various transmission scenarios 4) Be able to identify factors that affect link layer performance. 5) Be able to use OPNET to do performance analysis	**In-class project 2: Effect of link error and ARQ** Through hands-on experiments, students observe the performance of ARQ, identify factors affecting the performance and propose ways to improve it.
14 (week 7)	1) Understand the design issues of link layer protocols 2) Be able to explain widely used protocols (HDLC, LLC) 3) Understand the operation procedure of link-layer protocols	• Explicit Instruction
15 (week 8)	1) Understand what is media access control, the design issues of MAC 2) Be able to identify different types of MAC approach and explain their differences 3) Understand the working machismo of ALOHA and	• Explicit Instruction Community inquiry: discuss and propose ways to make MAC more efficient (reduce collision).

	CSMA	
16 (week 8)	1) Be able to analyze the performance of MAC protocol 2) Identify factors that affect the design of MAC through experiments 3) Explore ways to improve the performance of MAC protocol 4) Be able to generate characteristic curve in OPNET to measure the network performance	**In-class Project 3: ALOHA vs. CSMA** Through hands-on experiments, students compare the performance of ALOHA and CSMA, identify factors affecting the performance and propose ways to improve it.
17 (week 9)	1) Understand the working mechanism of CSMA/CD 2) Be able to explain the main features in Ethernet 3) Understand the design issues of MAC in Wireless LAN 4) Understand why CSMA/CD cannot by employed in Wi-Fi, and be able to describe the features of CSMA/CA	• Explicit Instruction Group discussion: analyze the performance of CSMA/CD in Wi-Fi and identify problems.
18 (week 9)	1) Deepen the understanding of MAC design in Wireless LAN; 2) Be able to articulate the performance difference b/w Ethernet and Wi-Fi and explain the reasons 3) Exploring potential areas to improve the efficiency of CSMA/CA 4) Be able to use wireless modeler in OPNET	**In-class Project 4: Go Wireless** Through various simulations, students compare the performance of Ethernet and CSMA/CA under different network situations, discuss the issues of MAC in Wi-Fi and propose ways to improve it.
19 (week 10)	1) Be able to describe features of representative hi-speed networks 2) Understand the needs and challenges to extend LAN 3) Understand the concept of Bridge and how it works	• Explicit Instruction
20 (week 10)	1) Be able to apply spanning-tree algorithm to perform routing using bridges 2) Be able to analyze the performance of bridges 3) Develop ability to extend LAN using bridges	• Explicit Instruction Interactive exercise: analyze the performance of spanning-tree algorithm in a given scenario.

Table 3. Schedule of after-class projects in revised EE440 (in 10-week quarter system).

Projects	Learning Outcomes	Timeline
Hub vs. Switch: Study the performance of hub and switch on networks of various traffic condition and discuss when to use which device to achieve cost-effective design	1) Understand the difference between hub and switch 2) Be able to describe the functions of hub and switch 3) Be able to use rapid configuration to create network scenarios in OPNET 4) Be able to generate traffic with target data rate in OPNET configuration 5) Be able to analyze the network performance under different traffic conditions 6) Develop team skills to collaborate remotely	Week 3-week 5
Term Project- Design a company network with optimal performance: An open-ended design project that requires the student teams to define their design goals, do research on various network components, consider practical needs and constraints, present their design plan, do simulations and select the best design with optimal performance under cost constraints.	1) Ability to set design goal under realistic constraints 2) Be able to reflect the knowledge and apply skills acquired thru the previous projects to develop design plan 3) Develop ability to find and evaluate available technical information from various sources 4) Be able to present the design clearly in both oral and written format 5) Be able to use OPNET to evaluate the performance and validate the design 6) Enhance team skills to collaborate effectively to solve real-world design challenges	Week 8 – Week 10

From the above tables, it is clear that the in-class projects are tightly related to the course contents, and some of them are even designed to replace regular lectures (explicit instruction) to achieve the same learning outcomes. Moreover, the learning outcomes of the in-class projects show that these guided, semi-structured hands-on experiences provide fundamental knowledge and skills for students to accomplish after-class and term projects; while the after-class and term projects offer more authentic design experience that develop critical skills required in the professional practice.

In addition to the class projects, the instruction is enhanced significantly by embedding various small active learning components. As shown in the above tables, these active learning components include:

1) Team building activities: these are small group activity designed for students to better learn from each other while exploring basic networking concepts. For example, in the first section of EE440, students were divided into groups and each group formed a "Local Area Network" where each student was a node. They needed to introduce their own names to each other in the fastest way (transmit messages over the LAN). Classroom implementation showed that students really enjoyed this activity and were creative to construct different topologies and explore ways of packet propagation. The follow-up discussion also prompted them to think about the performance issues and the cost of adding new nodes in LAN of different topologies.
2) Group discussion/Community inquiry: During the redesign process of the course, we started to embed more group discussions as an effective way to allow students reflect on what they learned in both their projects and lectures, and to foster their critical/creative thinking skills.
3) Interactive exercises: These activities were used to reinforce students' understanding of key concepts and develop their problem solving skills. The use of Tablet PC platform along with DyKnow [11] made it easy for Professor to post questions, collect answers, highlight common misconception and make clarification.

D. Impact on Student Learning: A Longitudinal Study

Throughout the three-year project duration, the effectiveness of the CPBL-beyond-Classroom pedagogy and its implementation has been constantly measured by both formative and summative assessment. This section present a comprehensive analysis of the pedagogical impact on various aspects in student learning process based on our longitudinal study.

D.1 Impact of CPBL-beyond-Classroom on Student Knowledge and Skill Development

Integration of CPBL-beyond-Classroom changes the way that students acquire knowledge on networking concepts and offer new opportunities for them to gain design and experiment skills. To gauge the growth of students' knowledge and skills under the new pedagogical model, pre and post surveys were conducted at the beginning and the end of each quarter in the revised courses. Along with classroom observation of students' performance and focus group, the pre and post survey results sketched a clear picture to show how well students achieved the knowledge and skill outcomes.

Table 4 lists the knowledge and skill outcomes evaluated via pre and post surveys in CS470, one of the pilot courses that were revised to incorporate CPBL-beyond-Classroom. In the table, outcomes with * are directly reinforced by in-class or after-class projects.

Table 4. Knowledge sets evaluated via pre and post surveys in CS470 and EE440.

Index	*Knowledge Outcomes in CS470*	*Skill Outcomes in CS470*
1	Knowledge of network simulation*	Computer network design skills*
2	Knowledge of network performance analysis*	Ability to design and implement a network scenario in OPNET*
3	Knowledge of ARQ and TCP error control*	Ability to analyze the network performance using simulations*
4	Knowledge of TCP flow control and congestion control*	Ability to choose an optimal design based on realistic constraint *
5	Knowledge of OPNET Software*	Ability to use OPNET to explore and learn new network protocols*
6	Knowledge of network design process	General computing skills
7	Knowledge of layered network architecture	Communication skills
8	Knowledge of network topology (bus, star, etc.)	Math skills
9	Knowledge of IP addressing and subnetting	General design skills
10	Knowledge of Internet routing	
11	Knowledge of DNS, SMTP	
12	Knowledge of HTTP and FTP	

In the pre and post surveys, students rated their knowledge and skills using the sets listed in Table 4 (1- "None", 2- "poor", 3- "Fair", 4- "Good", 5-"Excellent"). Please note that the absolute growth values may differ from quarter to quarter, due to the different background of students in different class sessions. To rule out the influence of students' diverse background, we conducted a comparison study by ranking the relative growths of the knowledge/skill outcomes and comparing the ranks of those that are relevant to class projects against the rest. Yearly comparison results clearly indicated that *CPBL-beyond-Classroom had a positive impact on student learning and helped them to achieve bigger knowledge growth*.

For example, in CS470 offered in Winter 2012, the biggest increments of the rating occur on the following outcomes, and ***all of them are directly addressed by in-class or after-class projects***.

- #1 Growth: Knowledge of ARQ (Pre=1.58, Post=4.44, growth=2.86)
- #2 Growth: Knowledge of TCP flow control and congestion control (Pre=1.35, Post=4.11, growth=2.76)
- #3 Growth: Knowledge of network simulations (pre=1.65, Post=4.33, growth=2.68)

Figure 2 plots the longitudinal results on knowledge outcome growth in CS470. From the figure, we can compare the growths between outcomes related to CPBL-beyond-Classroom and those that are not related (control group). Although the results are mixed, overall more knowledge outcomes related to CPBL-beyond-Classroom are associated with bigger growth (higher ranking).

Similarly, Figure 3 depicts the growth difference between skills outcomes related to CPBL model and those that are not related. It is clear that for skills outcomes, CPBL model has more significant impact on student learning, thus leading to a much larger growth in CPBL-related outcomes.

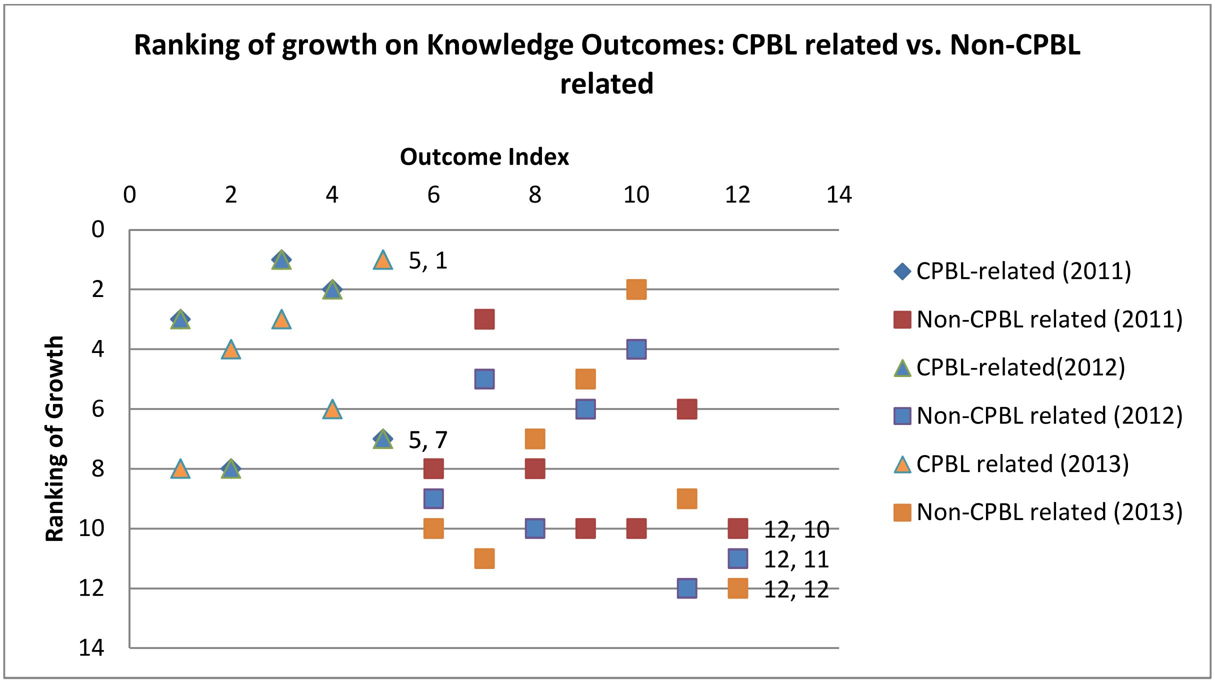

Figure 2. Multi-year comparison of growth on knowledge outcomes in CS470: CPBL related vs. non-CPBL related

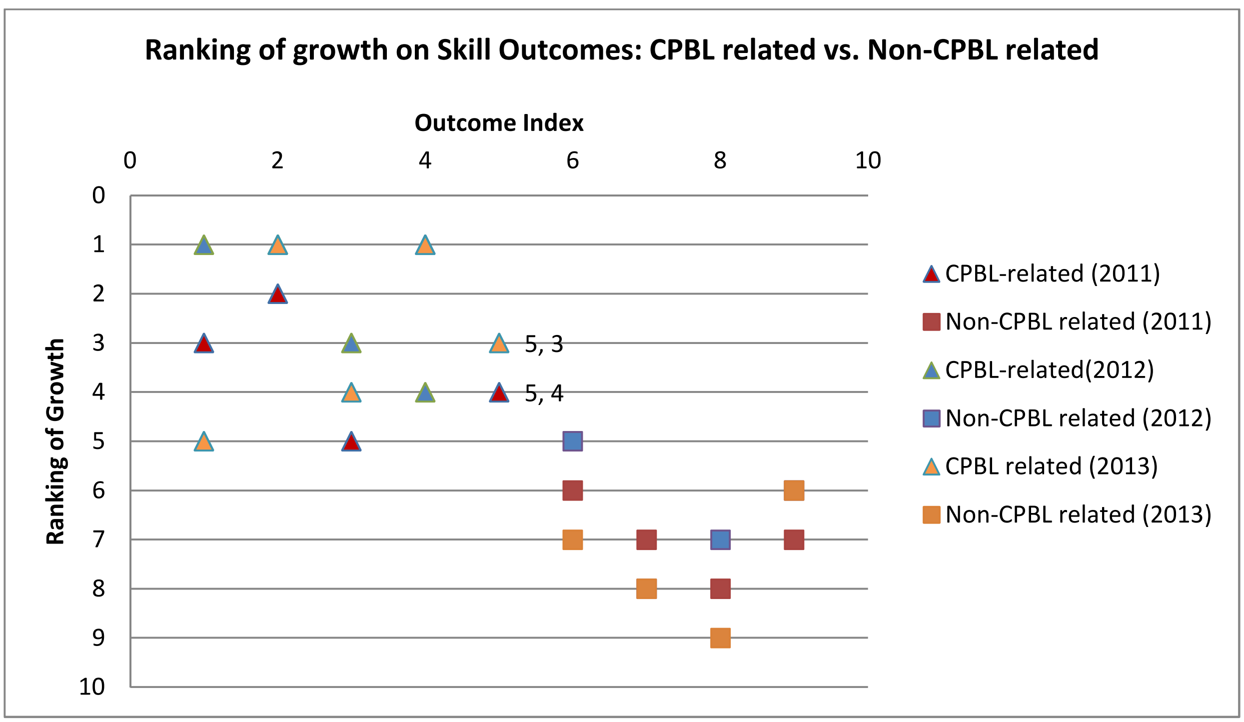

Figure 3. Multi-year comparison of growth on skill outcomes in CS470: CPBL related vs. non-CPBL related

D.2 Pedagogical Impact on Student Learning Process

Besides pre and post surveys, qualitative data (including the answers to open-ended questions in the student surveys and focus group discussion) have been collected regularly which allowed us to perform a deeper analysis on how CPBL-beyond-Classroom affects various aspect in student learning process.

One important factor in the learning process is student interest and motivation. According to our multi-year assessment data, majority of students reported that the class projects increased their interest in the computer networking area and prompted them to learn more in the subject. Students showed higher level of engagement and participation, and were able to appreciate the theoretical learning when they visualized the results through OPNET simulations.

In addition to the increased motivation to learn, qualitative findings also revealed that real-world application of theory, opportunity to explore and practice design skills, social interaction, working with people of different cultural backgrounds, and understanding multiple perspectives were some of the most valuable aspects of their learning experience with CPBL. Examples of student comments include:

- *"I think in engineering classes when you learn an engineering concept you don't really know what it can be used for, or even though you know what it can be used for you don't know what it actually looks like so I think it's a very good practice for you to actually experiment with it and see how it works out."*
- *"I think you get to see the design that you build and see how effective it can be so you can actually see the application of the materials you learned, so it's not just theories, you can actually test and simulate and see how well the results are or how bad they are."*
- *"…in a more realistic way…It's like theory-based; it's also where you can see what type of networks are being used like at home or office, the things that we learned in class while other engineering classes are very theoretical you don't see the applications in the real world."*
- *"Well, I enjoyed working with my team for several reasons. First reason is that we actually ate together, lunch, and in other classes you don't really do this. You don't really sit down and get to know each other. I think I can learn each other's strengths and weaknesses and in other class, we don't really do that. "*

Peer collaboration is an important feature in CPBL-beyond-Classroom pedagogy. Through the project experience, many students recognized the importance of social skills, as indicated in the following quotes:

> *The most important thing is working in a group. You have to have really good people skills and communication skills…because [in] engineering you have to have a lot of people skills. If you cannot cooperate with others to accomplish a goal or an objective then you're not going to be successful in engineering.*

Nevertheless, team work also introduced a challenge to many students in their project experience. As indicated in our findings in the past year, it is important to include the team-building components in CPBL implementation; and the instructor shall provide guidance to develop the students' team skills.

Overall, the qualitative assessment results showed that with CPBL-beyond-Classroom model, the learning process are more interesting and enjoyable for most students regardless of their ethnical backgrounds or social economic status. Comparing to traditional engineering classroom where lecturing dominates, the revised course with CPBL created a more interactive, collaborative, authentic and engaging learning environment with group projects, real-world practice, along with adequate supporting/scaffolding tools. The qualitative findings supplement the findings from the longitudinal study and explained why our developed pedagogy worked well for our student population.

E. Conclusions

In this paper, a newly developed pedagogical model, CPBL-beyond-Classroom, is analyzed and evaluated through both quantitative and qualitative analysis. The findings demonstrated that the scalable and open-structured project design provided an excellent match to the learning needs of senior students. Among the pedagogical components of CPBL-beyond-Classroom, social interaction, collaborative construction of knowledge, and opportunity to work on real-world cases are considered as most valuable features by students. Our implementation experience showed that it is important to offer a balance between theoretical learning and hands-on practice when redesigning the curriculum using CPBL-beyond-Classroom. Active learning activities such as team building and group discussion are very useful to enhance the pedagogical effectiveness.

Acknowledgment

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