A Nifty Inter-Class Peer Learning Model for Enhancing Student-Centered Computing Education, and for Generating Student Interests in Co-Curricular Professional Development

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***Abstract* - This Work-In-Progress paper in the Innovative Practice Category presents an innovative model of inter-class peer collaboration that enhances student learning in computing education, and addresses student conceptual gaps. It expands the scope of traditional peer learning beyond the usual classroom setting and motivates student creativity leading to interests in co-curricular professional development. This nifty peer learning model connects computing students from an upper level class with students of a lower level class, so that they can aid each other in a mentor-mentee relationship to address conceptual learning gaps. Existing literature on computing educational research show that several peer learning models have been used in a typical classroom setting for reinforcing learning. However, very few peer learning models have been used in an inter-class setting, and none have been driven by student conceptual gaps in order to create an enhanced learning environment. Our model focuses on developing student interests in further co-curricular professional development opportunities in the form of peer mentoring, tutoring and instruction. Currently, student retention is a significant challenge for computing educators, given the demand of the computing disciplines for an all-round solid knowledge base, including grasping of complex technical concepts. Our approach of inter-class peer collaboration strengthens the learning environment of both lower level and upper level computing courses, and provides much needed support to students, whose knowledge base is still underdeveloped and conceptual understanding is undercooked. This unique form of inter-class peer learning provides upper level students with an exclusive opportunity to reinforce their conceptual grasps by mentoring lower level students. It also enables the lower level students to receive peer guidance for addressing their conceptual gaps. Our improvised peer networking model adds a different dimension to the practice of intra-class peer learning and extends peer learning beyond the traditional bounds. It promotes a new kind of service learning project in classes by encouraging peer mentoring that leads to peer connections across classes. It aids student retention by helping lower level student mentees get over their knowledge limitations. Our work-in-progress research case study indicates that this model inspires peer mentors to engage in out-of-box thinking by challenging them to find creative ways for overcoming conceptual shortcomings of mentees. This, in turn, generates student interests in enhanced co-curricular professional development. Additionally, our ongoing experimental study results show that this model can help in producing a sustainable pool of peer mentors, tutors and teaching assistants, who can become resources plus role-models for other students, and for helping student retention. As part of our in-progress experiments, this model has been deployed within our computer programming classes, where CS2 students have been paired with CS1 students based upon conceptual gaps and knowledge shortcomings. As we conduct these teaching experiments, we analyze the performance of our model through data obtained by conducting student surveys. We discuss these initial collected data and cite them as preliminary evidence in the process of evaluating our model in terms of the improved learning, and generated student interests plus engagement in professional development.**

Keywords - nifty; inter-class; peer learning; co-curricular professional development; student-centered; computing education; interests; engagement; conceptual gaps

I. Introduction

Computing students, who are new learners with no prior experience in technology, can find technical concepts to be difficult and challenging to comprehend. Additionally, teaching practices and styles in computing education are not always student-centered. They may vary and are not tailor-made to fit the student's way of learning or level of ability [2]. Since there is a lack of consistency in teaching methodology within computing education, students may find applying the concepts difficult, which could lead to a lack of knowledge retention and motivation [2]. Furthermore, the highly desirable and in demand skill sets of computer programming [1] have varied abstraction levels, which demand accuracy in coding syntax [2]. Such obstacles, which cannot be overcome easily, may eventually lead to student retention issues [10]. Thus, overcoming the conceptual obstacles or gaps, and technical professional development hurdles can be vital to a student's desire to continue their computing education. Prior research [5] has been conducted on the analysis of conceptual gaps and how to improve attrition rates by identifying student conceptual

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gaps and addressing those. This work demonstrates that computing educators can apply a successful learning model based upon identifying student conceptual and addressing those weaknesses. In this paper, we discuss a student-centered design of our inter-class peer mentoring model, which is structured around conceptual weaknesses.

II. Previously Researched Peer Mentor Models

To create a consistent method to educating students in computing education, it has been shown that various peer mentoring models can be used to enhance student learning [3, 4, 6, 7, 8, 9]. Some of these peer learning models are discussed next, and then we introduce our exclusive peer mentoring model, which is both a culmination and expansion of all the models that will be discussed herein.

A. Generating Interest in Computer Security Using Peers

In the computing security field, previous work [4] consists of a group peer mentoring model using peers that were matched from an upper level class to a lower level class. The aim of this research was to generate interests in security careers, and the results over a two year period proved to be successful with survey scores seeing as high as 100% in terms building confidence about security related computing. In this study, female students responded 100% positive, with absolutely no negative survey scores. This shows that even in a field of study that is traditionally male dominated, a peer mentoring model is effective regardless of gender. The research is just one of many case studies that show the effectiveness of peer mentoring.

B. Near Peer Mentoring in Middle School

Even in at an early stage of education, peer mentoring can be effective in increasing participation. In a prior near peer mentoring study [6], high-school students were paired with middle-school students as role models and teachers for a summer camp, where students learnt computer programming. The goal of this work was to find "role models, who are relatable and who resonate with the middle-school student identities. This theory was based on Bandura's social cognitive theory [6], which implies that self-efficacy of students can increase if they align themselves with their role model, who are more competent and can be treated as an expert. Results from this study show that mentees, who were able to closely relate to their mentors, had more interest and self-efficacy gains, which provided motivation as well as a positive learning environment. This research is another variation of the peer mentoring model that has proven to be successful.

C. Peer Assistantship in Lab and Lectures

Another notable case study from previous work [7] created a mentorship model, where older students would help sophomores with lecture and lab sessions in introductory computing courses. The older students acted similarly to a teaching assistant. The main idea of this study was to create a pool of assistants by offering to train the assistants as volunteers first, and then moving the assistants into a classroom setting to help with labs and lectures. The intent was to create an ongoing cycle of assistantship with students moving up to become assistants. Although this research was preliminary, some results of this research demonstrated that over a few years, a higher percentage of students elected a computing major after going through this mentorship model. It also indicated a long-term path towards creating a cohort of assistants as part of the model.

D. Peer Instruction and Problem Based Learning

Two prior studies [8, 9] focus on peer instruction [PI] in a flipped classroom setting. The first study [8] focused on the downfalls of the traditional classroom, and on providing guided practices, which allowed students to have a more thorough practice on the learning material before coming to class. This allowed students to have more complete and fruitful discussions when they were put into peer groups [8]. The other study [9] conducted research on comparing different active learning approaches, which included both peer instruction (PI) and a problem-based learning (PBL) approach. In this study, students found that both the PBL and PI approaches made learning easier than a traditional lecture for computer programming, which further proves the merit of peer mentoring models and their variations.

III. Proposed Inter-Class Peer Learning Model

Our nifty inter-class collaborative peer learning model, which is driven by matching conceptual gaps across courses between upper level and lower level computing students, is the focus of this paper. This student conceptual gap [5] based inter-class peer mentoring model is aimed at intermingling peers from across different classes. This helps in generating a lot of unique exchanges, including creative thinking, personalized peer collaboration, addressing of conceptual gaps, as well as generation of student interests in co-curricular development. Our model focuses on pairing upper level student mentors with a lower level student mentees across different courses.

The potential benefits of this inter-class peer model are:-

- Mentors are encouraged to think outside-the-box when creating teaching materials for the corresponding mentee. This leads to a much more effective learning environment because it is different than what the mentee is accustomed to.
- Mentees gain a vastly different perspective when the learning materials are presented by a peer in an exclusive form. It is no longer a traditional lecture, it is the self-designed teaching system that the mentor develops, which improves conceptual reinforcement.
- Peer pairs are allowed to collaborate and work with each other in a way that works for them individually, and are given space. Whether it is discussing concepts or practicing programming, the personalized collaboration strengthens learning engagement and makes our model student-centered.
- Mentees benefit from mentors creating customized learning material that addresses their specific

conceptual gaps and weaknesses. This gives more focus and attention to identify individual conceptual gaps and improve the grasp of the corresponding concepts.

- There is a natural motivation for the mentor to continually improve their methods of peer teaching, and this goal to be more effective helps the mentor enhance their own grasp of knowledge and master the concepts.
- Both mentors and mentees may develop interest in becoming a part of the cohort of resources and volunteer in the future as a peer mentor. In this way, a constant cycle and pool of peer learning resources is created within the computing program.
- The class instructors in the upper and lower level courses act as both the facilitator and evaluator of this prosed inter-class peer learning process. Firstly, the instructors help set up the mentor-mentee pairing among the interested student participants based upon the identified conceptual gap areas [5]. Once a mentor is assigned to a mentee, they both are given the space and time to connect with each other, leading to one or more mentoring sessions. The instructors are not present in person during these one-to-one mentoring sessions, but follows up with both the mentor and mentee on the overall progress and status of the peer learning process. Lastly, the instructors also play a role in evaluating the learning material, including case studies, generated by the mentor for driving the mentoring process. The instructors also get an opportunity to evaluate the learnings of the mentee through the perusal of any work produced by the mentee during this process. This allows the measurement of the effectiveness of the model, as well as creates a pool of resources for co-curricular professional development.

IV. Methodology

For our preliminary research experiments, we chose to pilot our nifty model in computer programming classes at the CS1 and CS2 levels. The data that was selected for our initial study focuses on instances where an upper level student collaborated with a lower level student to achieve our proposed model's learning goals. For instance, the CS 316 course in our computing program is an advanced level CS2 course that further extends existing knowledge of programming practices from a prerequisite CS 256 course, which is a CS 1 level class in our program. Therefore, the peer pairings that came out of these two courses were a good fit for the mentor-mentee pairing, as presented in our proposed model. We can also potentially deploy our model in other classes, where pairing between an upper level student with a lower level student is possible.

A. *Inter-Class Peer Model - Pairing Process*

As part of our preliminary experiments, the pairing of upper level peer mentors to lower level peer mentees is driven by offering the students an option to participate as volunteer cohorts of this model, as part of a class project. The unique highlight and feature of this model is that the matching of mentees with mentors are based upon existing student conceptual gaps, which is inspired by the GAHP model [6], and mutual interests to fix these common learning holes. Basic conceptual gap assessments were given out at the beginning of the semester to identify student learning opportunities. These assessments simply asked students to identify their own strengths and weaknesses. Once the gaps were identified, the mentors and mentees are connected by the instructor. The pairs are then advised to schedule regular meetings, and encouraged to meet in person on an as-needed basis. Figure 1 shows an outline diagram depicting our inter-class peer learning model using the examples of a CS1 and CS2 level computer programming course - namely CS 256 and CS 316, where inter-class mentor mentee pairs were created for our study.

B. *Preliminary Research Results and Data Collection*

Our preliminary research results are based upon the data collected over three semesters through the initial cohort of students from two CS1 and CS2 computer programming classes. Surveys have been conducted during our initial research case study with altogether sixteen students, who have participated as mentors and mentees in the multiple instances of trial experiments with our proposed model. The goal of our offered survey was to collect information regarding several comprehension indicators related to the effectiveness of our model from both mentors and mentees.

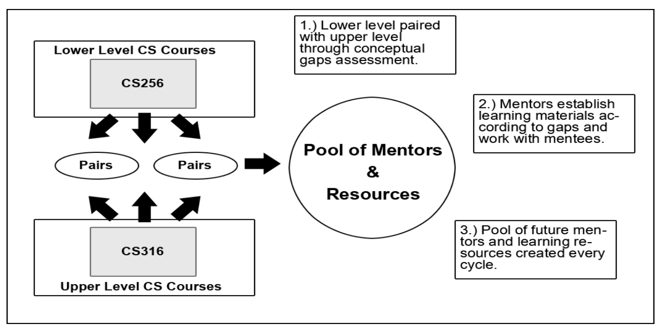

Fig. 1. Inter-Class Mentor-Mentee Pairings Based Model.

The data, which we have gathered so far from participants in the form of student mentor plus mentee survey responses, indicate improved learning and addressing of conceptual gaps. We also have seen student mentees express interests in becoming peer mentors and get motivated towards engagement in further co-curricular professional development - in the form of peer instruction, teaching assistance, tutoring, etc. This observation suggests that our model was potentially able to interest participants in exploring future teaching and mentoring opportunities. In our collected data, we notice student expressions of confidence boosting, enhanced retention of knowledge, interests in further development of technical coding skills, enjoyment and improved engagement. The survey questions, as listed in Table I, are primarily based on a numerical rating scale between 1 and 10. In order to support our participant survey data, future evaluations of this work will include qualitative data acquired through interviews with participants and inferences drawn from these conversations.

V. Results in Progress

In order to show the preliminary merit of our proposed inter-class peer learning model, some initial results, from our conducted student surveys, have been reported here in this paper, as seen in Table I as well as Figures 2 and 3.

Survey Question	***As a mentor, how successful was this peer mentoring session in strengthening your concepts and knowledge?***			
	Minimum	***Maximum***	***Mean***	***Count***
Rating Scores	6	10	8.16	6

Fig.2. Question to mentors on enhancing of conceptual knowledge.

Survey Question	***How effective were the case studies of this peer mentoring session in addressing your conceptual gaps?***			
	Minimum	***Maximum***	***Mean***	***Count***
Rating Scores	6	8	7.2	10

Fig.3. Question to mentees on addressing of conceptual gaps.

TABLE I. Survey Ratings And Responses Obtained

Survey Question	**Overall Participant Ratings Of Proposed Model:** ***How would you rate this peer mentoring experience?***				
Rating Scores	***6***	***7***	***8***	***9***	***10***
Count	3	3	5	4	1
Survey Question	**Mentor Ratings On Success In Aiding Concepts:** ***As a mentor, how successful was this peer mentoring session in strengthening your concepts and knowledge?***				
Rating Scores	**6**	**7**	**8**	**9**	**10**
Count	1	1	1	2	1
Survey Question	**Mentee Ratings Of Mentoring Sessions:** ***How effective were the case studies of this peer mentoring session in addressing your conceptual gaps?***				
Rating Scores	**6**	**7**	**8**	**9**	
Count	1	4	3	2	
Survey Question	**Mentee Ratings Of Interests In Becoming A Mentor:** ***After participating in this peer mentoring session, are you interested in further participation, including the opportunity of becoming a peer mentor in the future?***				
Answers	**Yes**	9	**No**	1	

Although limited data has been collected, current results show positive correlation to the potential of our model. In our survey, which was given out to both the student mentees and mentors, the participant responses show that there were student interests generated and benefits served towards the participants. For instance, Figures 2 and 3 display stats from the survey responses of the 16 participants, and indicate how the mentors and mentees rated our learning model in terms of knowledge enhancement and addressing of their conceptual gaps. The obtained results, as seen in the Table I, also show that majority of the mentees (90%) were interested in future participation, including playing the mentor role. This implies how our model can potentially contribute towards the creation of a prospective pool of peer mentors and teaching assistance related resources.

VI. Conclusion, Future Work and Scope

Given that this preliminary research case study is based on a limited number of participants, future work would focus on expanding on our initial experiments. The scope of future work involves further data collection from an increased number of student cohorts or participants in an extended effort to determine the overall professional development prospects of the students as well as gauge the summative effectiveness of the mentor-mentee learning model. More time and inputs are needed to further validate our contribution towards the creation of a pool of student mentors, tutors and teaching assistants, which is directly related to the long-term sustainability of our model. Another possible future direction of this research would be to reassess the scope of greater student professional development via our model, and to conduct a study for determining if our approach can make undergrad students drive their own computing educational research projects [3].

Therefore, much of our future work will be focused on gathering more data in both quantitative and qualitative forms through further experiments with our inter-class peer learning model in order to verify its potential. In summary, the main contributions of this work-in-progress paper are to present our nifty inter-class peer learning framework, and show its impact through the preliminary set of data collected in our initial experimental studies. Our current research work also indicates the merit of our model in achieving the desired learning goals, including overcoming of conceptual shortcomings, assisting student retention and building of a sustainable pool of peer mentoring resources, which in turn leads to co-curricular professional development.

There are some scope of improvement in terms of enhancing the implementation process, particularly the careful handling of the mentor-mentee pairing process and structuring the inter-class connections. This involves fine collaboration between upper level and lower level class instructors. Another challenge is recruiting students as cohorts for these experiments. We offered credits to students, who chose to participate in these experimental trials as a way of fulfilling a project assignment. Finally, we summarize the potential contributions of this work:-

- A novel medium to motivate peer mentors and mentees by challenging themselves to think out-of-the-box and create handy peer case studies that provide different methods of enhanced learning and knowledge reinforcement beyond the traditional class lecture
- A unique avenue to address student conceptual gaps in an innovative way by pairing a more experienced upper level student with a less experienced lower level mentee
- A creative way of extending the traditional intra-class peer learning model beyond the classroom by fostering teamwork and collaborative learning through an inter-class connection of peers to spark new avenues of enhanced learning and exploration of conceptual gap

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