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Title: Inter-Class Collaboration Project to Enhance Learning in Computer Science

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Collaborative Inter-Class Project to Enhance Learning in Computer Science

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Abstract: Engineers in general and computer scientists in particular are required to work in collaborative, interdisciplinary environments. Communication skills and the ability to work in groups within different departments inside a company are often required for jobs in the industry. To expose students to this collaborative experience most engineering programs require a senior design project in the last year of courses, however, these capstone type projects risk creating a feeling of disconnect as opposed to an integrated experience with the prior curriculum. To further improve our students' collaboration skills and expose students to the pedagogical benefits of collaborative learning, we designed and implemented a collaboration between two different computer science classes (CS). Our collaborative inter-class project has the immediate intention of mutual learning across related but distinct topics, but also to increase student retention of knowledge by providing them with a similar experience to what they will encounter in industry. To evaluate the collaborative experience, we use the student lab reports and the results of an anonymous student survey. The survey shows very positive comments about the experience. Based on using inter-class collaboration for two quarters, we have decided to continue with the practice this year and we will gather more information in a more detailed survey and aim to make this collaboration a permanent feature in both classes. We also plan to explore how to integrate this kind of inter-class collaboration in additional upper division computing classes and senior projects.

Introduction

Collaborative learning is an educational approach to teaching and learning that involves groups of learners working together to solve a problem, complete a task or create a product [1]. Research shows very clear benefits on implementing group activities and group projects [1,2,3] for learning, including in higher education. In addition, hands-on applied team work exercises have been shown to have benefits for all students and for female students in particular [6]. Collaborative environments also prepare students for work in the industry, where companies expect employees to work well with others and to communicate with other members of their professional teams and teams within other departments. We, as educators, sought to design an authentic cross class group experience to help students practice working in teams and experience the relationship of two closely connected but distinct fields of computer science. In this paper we describe an experiment we are conducting at the Computer Science and Software Engineering department. Our collaboration involves two distinct but related courses in Computer Science, Parallel Programming (PP) and Computer Graphics (CG). While both class contents are essentially unique, in reality most computer graphics problems are executed on Graphical Processing Units (GPUs) which are heavily studied and used in PP; and many of the very interesting problems in PP are CG related. We felt an inter-class experience would allow students to practice working on a hands on project as a team similar to what they may experience in industry.

In general, the collaboration was structured with the two instructors jointly leading the inter-class collaboration over a two-week period, including both a theoretical and hands-on lab experience. For the first week the individual classes come together in the same classroom and on one day they receive a focused introduction to Parallel Programming and another day they receive a focused introduction to Computer Graphics. In the second week the students work in groups of mixed CG and PP students and work on a lab together that consists in two parts, one with a more graphics related focus while the other with a more parallel focused implementation but both closely related in terms of general task.

In our experience as educators we have had students express mixed feelings about group projects; some students enjoy them but some other dislike them. The main reasons many students express a dislike for group projects is the unbalanced work that the group members do, leaving some students with the feeling of doing all the work themselves while the rest of the group members do very little. Similarly, students that do not contributed to the group ultimately learn very little. There is a good deal of research about group projects and how to make group projects a better experience for students. In [4,5] a role separation is introduced and students are given specific task/roles to better adapt for different personalities. To improve the team work experience of our students, we did create teams of students but with two main roles (leader/teacher, learners) but the role assigned to the students are swapped during the experience with some of the students being the leaders/teachers for one lab and then this role will be reversed on the second lab assignment. This way students are forced to take different roles during the collaboration diminishing the probabilities of any of them doing significant less than the rest of the group; and increasing the chances to encourage the participation of students and their different preferences. The goal is for each group of mixed student teams, CG and PP, to trade-off the leadership and learner role and communicate their expertise to the other group.

In this article, we present a detailed description of the implementation of the inter-class collaboration, the results of the collaboration via lab results and student surveys and our conclusions and ongoing work related to this collaboration.

Section 1. Implementation

The two classes which participated in this inter-class collaboration are both upper division computer science technical electives and each have approximately 40 students enrolled. For the collaboration, the class rosters are combined for one week, with assigned small 3-4 student teams, each containing at least one student from each class. The collaboration occurred during the term of the class on week seven of a ten-week quarter system class. We did choose week seven so students have enough expertise on their own fields of study.

Collaboration components :

1. Theoretical. For one week the two classes meet together, where one day they receive a focused introduction to Parallel Programming and another day they receive a focused introduction to Computer Graphics. The material covered is related to the use of the GPU, but from the two perspectives of the sub-fields, with the faculty noting shared and divergent goals, perspectives and vocabulary. The purpose of these combined lectures is to give students a shared background related to the main concepts of each field. The expectation is that specific details will emerge and be tackled in the labs (ideally by the explanations of the student leader for that specific lab.

2. Hand-on experience. The lab portion of the collaboration spans two weeks. The first week students solve a problem using a traditional CG implementation and development tools, while the second week the students solve the same problem but using only the PP development tools. The labs were carefully chosen so it makes sense to have both implementations. For this reason, we selected an image processing problem, image blur, which is relatively easy to understand and implement in both settings. We also wanted a hands-on example and blurring an image, reducing the original edge content, has many different desired uses. For example, by blurring the background of an image we highlight the object we want to focus on, also by blurring an object we can get a fluorescent effect of the object of interest. At the basic level, image blur mainly involves a series of matrix by vector multiplications and the algorithm can be efficiently implemented in computer graphics and parallel programming development settings (for example using GLSL shaders and then openCL or CUDA).

3. Reflection. A culminating document is required in the form of a laboratory report. Teams are required to work together to solve the two labs. We ensure collaboration by requiring each student to submit a lab report with students expected to be able to answer questions about any part of the lab by the TA or instructor. Students report computational timings for both implementations (CG and PP) and explanations for the differences in these timings.

Section II Results

To assess the students, experience with the inter-class collaboration we used an anonymous survey. The questions primarily focus on student experience but also include comprehension questions to provide a sample measure of learning outcomes. The experience questions are intended to provide us with feedback about the student's perspectives and also to provide students with an opportunity to reflect on their role in the experience. The following is a list of the survey questions students received at the end of the class:

i. What is something that CUDA and GLSL have in common?
ii. Did the joint teaching experience help you understand the GPU from multiple perspectives? (Yes/No/Maybe answer)
iii. What worked best for you about the cross teaching experience (e.g. lectures, teammates explaining things, office hours, or ?)
iv. Reflecting on the cross-teaching experience what did you contribute to your team?
v. For CPE 471 (CG) students: Are you more likely to want to learn more about parallel programing after this exercise? (Yes/No/Maybe answer)
vi. For CPE 419 (PP) students: Are you more likely to want to learn more about computer graphics applications after this exercise? (Yes/No/Maybe answer)
vii. Any suggestions for future exercises of this type? or other comments you would like to share with us?

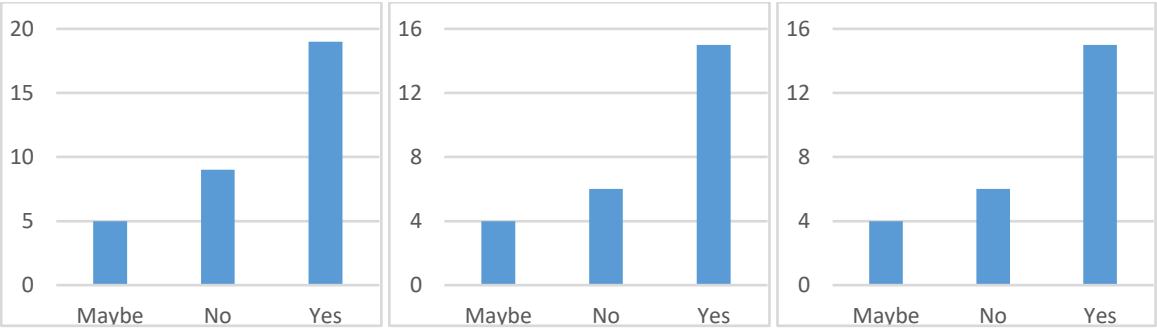

Figure 1 Results for Questions a) ii, "Did the joint teaching experience help you understand the GPU from multiple perspectives?" b) v: "For CPE 471 (CG) students: Are you more likely to want to learn more about parallel programing after this exercise?" C) vi: For CPE 419 (PP) students: Are you more likely to want to learn more about computer graphics applications after this exercise?

The results of the three types of questions on the survey show that the inter-class collaboration was overall a success:

A. Comprehension/knowledge related questions. To evaluate what students learned from the collaboration, we asked a short answer question asking students to write about what is common between the two main libraries/Programming Languages used in CG (GLSL [7]) and PP (CUDA [8]). For this question 24 out of 30 written responses include a relevant technical response, i.e. "Allow for parallel access to data and operations using the GPU" (with 5 other responses also including correct information but of very general technical value, i.e. "They use the GPU"). The survey also included a Yes/No/maybe question, "Did the joint teaching experience help you understand the GPU from multiple perspectives?" shown in Figure 1 (a). The responses clearly show that a majority the students feel they have a better understanding of the GPU after this collaborative experience

B. Enthusiasm for each class. To assess whether the collaborative experience translated into an interest in the other course, each group was asked whether they want to learn more about the other field after the collaboration. The results are shown in Figure 1 (b) and (c) and reflect that a majority of students want to or are thinking about taking the other class to learn more about the subject.

C. Reflection about the collaborative experience. We asked students to reflect on the team work experience and specifically their role when working with other students from a different class, the summary of the comments is presented in Table I and II, which are discussed in detail below.

Table I Summary of the essay questions iii, "What worked best for you about the cross teaching experience (e.g. lectures, teammates explaining things, office hours, or ?)"

Positive	Neutral or Neg
Teammates working together and explaining to each other	Still haven't figured out the parallel part.

Seeing the Graphics students explain GLSL as they were working on it helped me understand it more My teammate did an excellent job explaining things, especially after I was unable to attend the CUDA Lecture.	I found the lectures overall to be a little chaotic and confusing. Sitting down with the teammates and discussing topics was very helpful. Also coming to office hours also helped to clear confusion.
Teammates explaining things	Nothing. Requiring attendance of lecture and lab that is so far outside of students' normal class times is unfair for students with conflicting schedules

The most frequent comment for question iii, about what worked best was teammates explaining things. We are pleased to see this result as it was one of the main purpose of this work (to allow students to experience both a leadership and learner role in a team). The main complaints (not surprisingly) center around the scheduling chaos created by trying to merge two different courses. This was avoided in one iteration of this experiment when both course sections ran at the same time, but survey data was gathered for the second iteration, when the two courses met at distinct times, causing scheduling challenges.

Table I Summary of the essay questions iv, "Reflecting on the cross-teaching experience what did you contribute to your team?"

Positive	Neutral or Neg
I was able to contribute to both lab parts effectively. I feel I could explain the code reasonably well.	Very little. I helped a bit with debugging the GLSL program but could not contribute to the CUDA program in any capacity.
helped the team understand tasks and work through bug fixes	
I provided ideas on the algorithms we should use to do the labs and participated in documentation	

We received very few negative comments on question iv. Students in general seems to have worked out how to organize themselves by different levels of expertise.

Finally, in question vii we ask students how the experience could be improved and again, the main recurring comment is about scheduling. Group meeting times are always difficult since students have very busy and packed schedules. Ideally for this type of collaboration, lab times for the two courses can overlap, but we still feel the gains outweigh the difficulties overall.

Conclusion

Overall, we feel the collaboration provided students with a meaningful way to work on a team with varied expertise. This kind of experience simulates not only the teamwork found in industry but also the challenge in industry of collaborating with others who may not be an expert in the specific tasks but can bring relevant technical information to the table. We feel there was value in giving the students the chance to step into a 'teacher'/expert role and then trade off that role in addition to seeing the project they are working on from multi technical perspectives. Aside from the survey, we heard informally from students about how much they did enjoy the collaboration, and that they made friends and for example some are planning on working on senior design together. In addition, some students did enroll in the respective "other" class in a later quarter since they wanted to know more about it.

Given our experience, we decided to continue the collaboration again this year and are considering the collaboration as a permanent part of both classes. A new faculty member in computer graphics is now working on the collaboration and finding different projects that can be useful for both classes and at the same time simple enough that can be implemented in two weeks. For example, the most recent iteration of this collaboration used a simple n-body simulation instead of image blurring. This expanded new collaboration is providing positive team work experiences not only for the students but also for the participating faculty members, making the class more interesting and building support among colleagues.

A personal observation is that we did notice that many of the students in one class register for the other class, and Computer Graphics students almost at their totality take the parallel programming class and this didn't happen so strongly before the collaboration. Which indicates to us that the collaboration is the right approach

Future Work

In this paper we concentrated mainly in the student survey as a measurement for the success of the collaborative experience, but in future implementations we will evaluate the influence of the collaborative project on the learning outcomes compared to previous years. The survey was volunteer and we had some of the students not feeling the survey online, we are aware that for future implementations of the collaborations and analysis of data we need to increase the response by making students fill the survey during class. We did not collect any demographics information from the students to investigate if different groups reacted differently to the group project but we plan to add this aspect to future analysis.

Bibliography :

1. M. LaalSeyed, and M. Ghodsi “Benefits of collaborative learning” Elsevier Procedia - Social and Behavioral Sciences,Volume 31, 2012, Pages 486-490.

2. Barkley, E.F., Cross, K.P., and Major, C.H. (2005). *Collaborative learning techniques: A handbook for college faculty.* San Francisco: Jossey-Bass.

3. Johnson, D.W., Johnson, R., & Smith, K. (1998). *Active learning: Cooperation in the college classroom.* Edina, MN: Interaction Book Company.

4. D. Kantor, Four-Player Model of Communication. Kantor’s Institute.

   http://www.yacavone.com/pdf/KantorFourPlayerSummaryV2.pdf
5. Kivunja, Charles. (2015). Using De Bono's Six Thinking Hats Model to Teach Critical Thinking and Problem-Solving Skills Essential for Success in the 21st Century Economy. Creative Education. 6. 380-391. 10.4236/ce.2015.63037.
6. Hammar Chiriac Eva “Group work as an incentive for learning – students’ experiences of group work”. Frontiers in Psychology v.5 pp.558 2014.

7. GLSL. “OpenGL Shading Language” Chronos Group
   https://www.khronos.org/opengl/wiki/OpenGL_Shading_Language
8. John Nickolls, Ian Buck, Michael Garland, Kevin Skadron “Scalable Parallel Programming with CUDA”, ACM Queue, vol. 6 no. 2, March/April 2008, pp. 40.