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Peer Assessment Methodologies for a Laboratory-Based Course

Abstract

Advances in technology and the explosive growth of the Internet have called for new ways of learning environment. The content delivery is no longer the passive approach of lecture emanating from the teacher to the student. It is imperative that computer networking courses taught at the undergraduate level contain adequate hands-on implementation based projects and experiments in order to better train students. The computing curricula 2001 (CC2001) emphasizes this by stating that "students must 'do science' not just 'read about science'". The CC2001 also lays out the importance of working in teams and encourages the computer science programs to provide such opportunities early in the curriculum. The hardest part of the team-based projects is to find a procedure to evaluate the students individually when the outcome is a net result of the group work. In this paper we discuss the methodology that was used in assessing team-based projects for a computer networks course and report the feedback from students on the effectiveness of this approach.

Introduction

Computer networking is an area that has grown dramatically in the recent years and has been fueled by the Internet age. As a result computer communications has become a critical part of the global infrastructure. In Academia, a course in computer networks is widely taught as part of various Computer Science and Computer Engineering undergraduate and graduate curricula, as either an elective or a required course. The need for networking expertise with hands-on experience is addressed by the computing curricula 2001 (CC2001) [1], developed by the Joint IEEE Computer Society/ACM Task Force, that a net-centric computing is included as a key area in the Computer Science body of knowledge and that all programs include networking topics. The networking field has grown so vast and continues to mature that creative ways of introducing the content and engaging the students are needed to enhance the learning experience.

The traditional formal mode of lecture is thus no longer fulfilling the needs of teaching techniques. Innovative teaching methods, lab materials, and technologies that appeal students with a broad range of learning styles and background are needed [2]. The pedagogy is changing to a more hands-on approach in a number of computer science courses. In recent years active learning strategies has received a lot of attention in implementing effective teaching techniques. Students tend to be more involved and motivated when they can see and feel the concepts they learn in class. They also seem to remember the cause and effects of the hands-on experiences longer than

the traditional teaching techniques. Hands-on experiences are more effective in a peer learning environment when compared to individual efforts. Instead of single mode of input for learning, hands-on approach in a group setting provides a multi-faceted mode for learning. In this paper we discuss the assessment techniques for a hands-on learning process provided in a hybrid group environment for a course in computer networking taught at the department of computer science at Central Connecticut State University.

Motivation

Effective teaching has always been the underlying phenomenon for educators and innovative techniques have been applied irrespective of the field of study. The traditional mode of lecture is no longer the only mode of teaching. Effectiveness is brought by engaging the students in academically challenging activities. As a means of improving the delivery of the subject matter instructors have sought to visuals and video to bring higher quality of in-class learning experience. This approach still means a single mode of delivery passed from instructor to student. Although this method of delivery is certainly an improvement over the traditional lectures, students of the digital age seem to respond better when they are involved.

As a means of involving students, the traditional mode of delivery is enhanced by involving the students in projects, presentations, and papers. This method calls for more elaborate and deeper learning strategies. In this mode the learning works better for students who are independent and self-regulated learners [6]. This approach widens the gap of learners who can read and interpret from learners who can do and understand. Educators are always looking for ways to improve this situation and narrow the gap. Active learning approaches that include team efforts can turn around this gap to enhance interaction and promote higher order thinking. This is particularly true with a diverse group of students with varied backgrounds and skill levels.

Interactive hands-on techniques are therefore a requirement in the computer science and engineering disciplines to put the concepts learned into practice. In the evolutionary process to find an effective teaching methodology, an approach that is commonly followed to narrow this gap is to involve students directly in the form of discussions and group work. It has been reported that student engagement rates are higher in a group setting than during independent seatwork. Engagement rates are higher when students receive more monitoring or help from an instructor [6]. Lectures are therefore substantiated with laboratories and group work. The impact of learning, however, is enhanced by structuring opportunities for reflection and peer consultation [3]. Although these pedagogical techniques stimulate the students to use the course concepts in thinking and problem-solving and is aimed at developing communication and interpersonal skills, the biggest hurdle here is the assessment. When performed in a group, how can the individual student be assessed and graded? Our approach for this question involves a hybrid setting where students work together in various groups and while working individually for the projects. The details of this method, applied to a computer networking course, is discussed in this paper.

Peer Assessment Strategies Through Active Learning

A number of different approaches were taken to create a peer learning environment. These approaches promoted deeper learning strategies to understand, absorb, and critically review the contents of the peer work based on the knowledge and one's own experience. The active learning activities performed individually and in group provided a promising environment to learn, implement, evaluate oneself, and extend the critical thinking to evaluate others. Several phases of the active learning approaches were incorporated in the course. Each of the activity involved promoted a collaborative atmosphere to learn and relearn the concepts. Several combination of peer-evaluation was experimented. The student groups evaluated the peer-group work, individual students assessed three other individual students work, and individual students assessed the work of three other peer-group work. In addition to the peer evaluation the students / groups received assessment from the instructor. The details of the assessment for the different projects are shown in Figure 1.

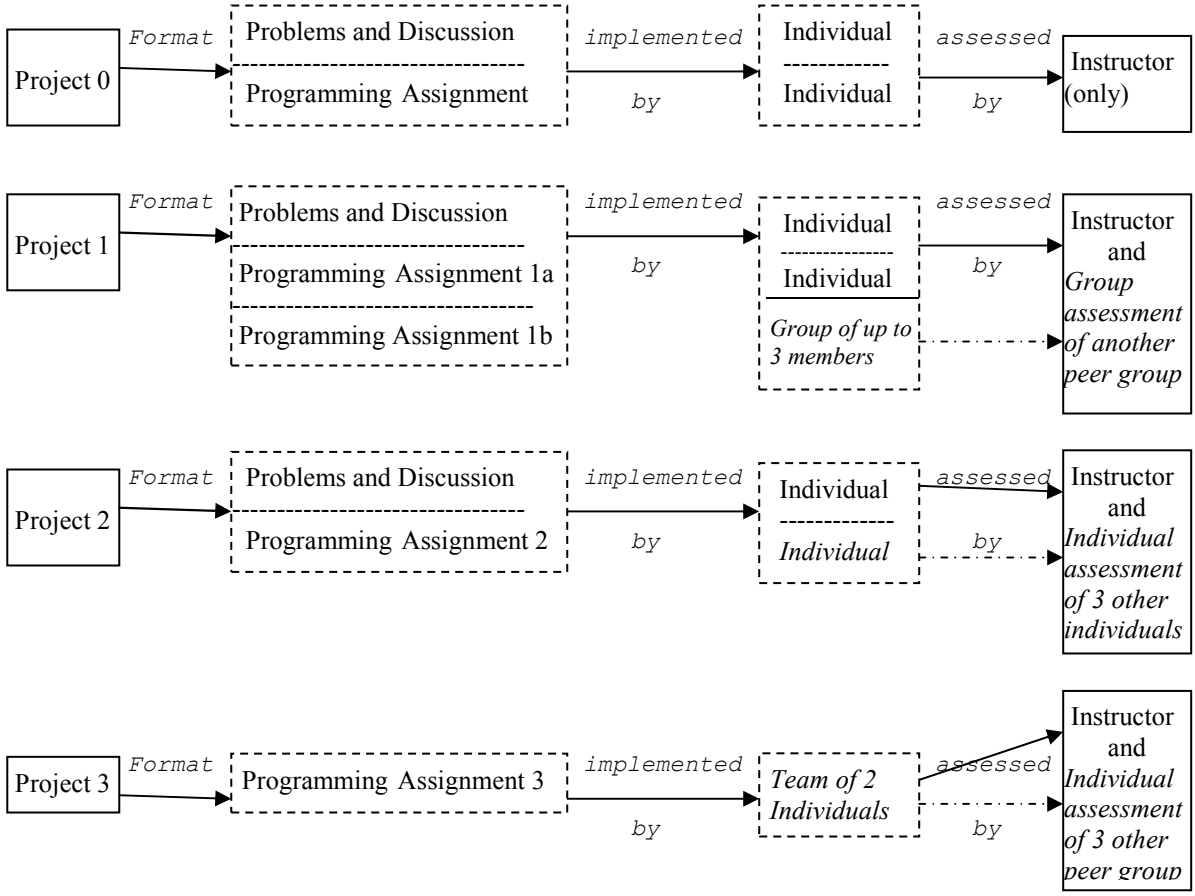

Figure 1 Peer Assessment strategy used in the Project Implementation

The activities involved in creating a collaborative environment for peer interaction are detailed in the following section. This includes the format of the activities, evaluation and assessment methodologies, and the electronic interactive platform employed. The feedback from the students encompasses the effectiveness of the individual as well as the overall medium of assessment and collaboration.

Hands-on Activities Employed:
The computer networking course taught at the author's institution included traditional lectures and scheduled group activities. Students were assessed based on assignments, projects, tests, and lab work. Assignments and tests were individual work of the student. Laboratory work was team-based performed in a closed environment and the members of the lab team did not change through out the course. The projects were assigned in a hybrid setting and the members of the project group were subject to change. Each project consisted of a group component and an individual component. The individual part of the project held each student accountable for learning and implementing the outcome on their own, while the group part of the project encouraged them to interact and work together for a common problem. This permitted the students' to stretch beyond their limits and learn from their peers. This approach also handled the 'social loafing' characteristics discussed in [4]. In addition, the turn-in details for the group project varied from the turn-in details of the individual part of the project. Each group was required to maintain a group log by dates, and provide the role played and the contribution of each member. Also the communication between the different members of the group was enforced through WebCT (discussed below). Students were forced to follow up with the course content to keep up with their individual score. The individual accountability included in the project brought strength and knowledge to the group and more fruitful discussions were carried out.

Format of the Hands-on Activities:
In order to enhance the quality of the hands-on activity, three different formats were adopted. The students' active learning experience was maximized by including three different techniques – visualization, exploration, and implementation. Abstract concepts were brought to life through visualization and exploration. By utilizing existing Java applet codes [4] and Ethereal software [5] the students were quickly brought a par in their interpretation of the concepts and principles. They were able to enhance their understanding with minimal effort. The Java applet codes were part of the class assignments and the students' were asked to exercise and explore using existing codes. This approach helped them study the impact of the different concepts like packet transmission, flow control for the reliable data transfer protocols, Dijkstra's algorithm, and CSMA/CD without actually coding or computing. The benefit of this approach is that by executing the applets the students were able to view and explore the possibilities and limitations of the different parameters without much effort. The visual impact for the abstract concepts helped their sense of understanding and enabled them to move on further with ease. Thus this type of activity firmed up the principles and enhanced the reasoning.

The second type of activity was useful in figuring out what was going behind the protocols. Ethereal software is a freeware/shareware used as a packet-sniffer to monitor and observe the messages exchanged between executing protocols. This software is available for a number of operating systems such as Windows, Linux/Unix, and Mac. The Ethereal software sniffs and copies messages sent from and received by the computers. The captured messages of the contents of the various protocol fields can then be displayed and analyzed. This tool is extensively used by network administrators in the real world to debug and fix network problems. The students familiarized themselves with a series of lab experiments to analyze the

different protocol layers discussed in class and the impact of the different protocol fields. They were also able to witness some of the network commands in action. The above two exercises enriched the students knowledge and understanding of the network concepts and prepared them for the implementation of the protocols.

The third approach was the actual implementation of the protocols. This part of the project was further divided into individual and group work. This was done to maximize the benefit of implementing the required protocols to deepen the understanding and applying their knowledge without overwhelming the students with projects and labs. The implementation of the protocols was approached in two different ways. Students were asked to either modify existing scripts and / or write their own code. Modification of the code was adopted in the initial stages to familiarize the students with the network communication concept of the client and server interacting with each other. A top-down approach worked well to incorporate this form of activity early in the curriculum[4]. By implementing their own protocols, one layer at a time, the students were better engaged and reason out what was going on behind that layer with their presumption of the default underlying layer. Each layer was then unwrapped one at a time and was exposed with the principles and paradigms of that specific layer. In addition to the projects assigned two sets of labs, with one lab for client communicating with existing server and one lab for implementing client and server communication protocol for FTP, increased the interaction between students and improved learning environment. The hands-on approach to implement the protocols added value to the classroom discussion and firmed up their understanding of the network layer architecture and services.

Peer Evaluation:

As a chance to improve the network protocol implementation skills, all the students were required to evaluate other students' code as part of the project work. Normally each student was assigned to evaluate three other peer projects. This approach gave the students a passive way to learn and to improve on the flow of the algorithm, coding, and error handling aspects of the protocol implementation. For students who strive to get better and improve, observing the code written and perform in a better manner helped raise the overall level of the implementation of the projects. And for students who were better programmers and more efficient, the course provided an opportunity to share their talents with their peers and provided a chance to implement the same with confidence. When evaluating a code that does not meet the standard, the students sense the need for a robust functioning code. This was a way to judge the outcome and focus on what one is looking for when the code is complete. As part of the evaluation process the students were asked to comment on the implementation, test outcome, and offer suggestions to improve the code.

Discussion Forum:

Another hurdle that the members of the group found difficult to work as a team was to find a common time and means to execute the group operation. To alleviate this hurdle, an open discussion forum was set up (in WebCT, CCSU's online course management system) for each of the labs and group projects. Part of the grading was based on the involvement and effort that was put upon by the individual in bringing the project a success. This forum provided a convenient medium for the students to discuss online. The discussion forum for the lab was open to the entire class while the discussion forum for the projects was limited to the members

of the group. Students were encouraged to post the questions related to the principles and strategies but not the code itself. All the communication related to the lab and projects were enforced on WebCT. These discussions were valued towards the group assessment and were counted towards the final grading.

Hands-On Activities For The Computer Networking Course

The course was structured in such a way to maximize network learning using a top-down approach. Varied aspects of the networking field were dealt with in the traditional assignments, labs, and projects format. In addition, the active learning group work was superimposed in a team-based hands-on learning environment. This was executed through projects and labs. The projects and the labs that were executed as part of the course requirement are listed under. All the labs were performed in groups during scheduled lab hours. The projects were assigned as the out of class activity. Each project had an individual piece and may or may not have a group piece. In some instances, the group was substituted with the evaluation of the project. The breakdown of the composition and assignment of the projects are also detailed.

List of Projects:
Project 0 – Getting acquainted with the client /server model
Individual - modifications to TCP client/server script and UDP client/server script
Project 1 –
Individual – Simple Web Proxy Server
Group – Mail Client
Group – Peer Group Evaluation
Project 2 –
Individual – Implement an Alternating bit protocol;
(For extra credit) GBN protocol
Individual – Evaluation of three other peer projects
Project 3 –
Group (Pair) - Implementing a routing protocol using Dijkstra's Algorithm
Individual– Evaluation of three other peer projects

List of Labs:
Lab 1 – Ethereal labs – HTTP and DNS
Lab 2 – FTP Client communicating with an existing FTP server
Lab 3 – FTP Client and Server communicating with each other
Lab 4 - Ethereal labs – IP and ICMP
Lab 5 - Ethereal labs – ARP and DHCP

Course Outcome From A Student's Perspective

To complete the loop of instruction delivery and measure the completeness of the result, the effectiveness of the approach adopted in this course was obtained from the end-users, in this case, the students. At the end of the course students were surveyed and were asked to give their opinion for a number of questions that relate to the non-traditional active learning

methodologies incorporated in this course. The impact on students learning in this unique approach is discussed in this section.

Question 1: What do you think is the strength of the course?

From the students response it was found that 53% felt that the hands-on approach was the strength of the course while 27% of the students claimed that the emphasis on the networking principles was stronger than the other aspects of the course. The remaining 20% of the students thought the combination of the different approaches used in the class was the strength of the class.

Question 2: How useful were the labs you exercised in class?

The response from the students for this question was that all 100% felt that the labs were very helpful. The students felt that the Ethereal labs helped them understand what was going on behind the network and the actual communication carried on between the default protocols. This made more sense to them when they had to implement their own version of the protocols. The students also commented that the FTP labs helped them most in providing an insight into how FTP works and they seemed to enjoy this particular lab to have the interaction in working as a group.

Question 3: What effects did the labs have in your understanding and implementation of the projects?

On the impact of the lab in the overall course material roughly about one-third of the class felt that the lab experiments enhanced their understanding and was helpful in implementing the projects. About one-third of the class felt that the labs reinforced the understanding of the course material and the other one-third felt that the interaction and group effort during the lab hours was more beneficial.

Question 4: How helpful/not helpful was the group labs/projects to enable your understanding of the concepts?

All 100% of the students felt that the labs and projects were very helpful and some noted that without the labs and projects the course would have been very difficult. However, the reasons for this justification varied. The top in the list was learning from each other in a group was the most helpful feature. In addition, about 40% of the students felt the hands-on experience reinforced the concepts discussed in class. One student indicated that the FTP labs were very helpful in understanding protocols.

Question 5: What was the most useful feature (for you) in working with your group?

The feedback for this question varied a lot. Some of the answers are given below –

- WebCT
- Comparing and sharing ideas and figuring out problems
- Learning from each other
- Understand what is involved in making larger projects happen
- FTP client/server project
- Improve programming skills

Question 6: What was the least useful feature (for you) in working with your group?
The most popular answer for this question was finding a common time to work out the solution. Interestingly one student indicated that trusting others to give up some of the work which contributed towards the grade was the difficult aspect of the course.

Question 7: In what ways did peer reviewing help/motivate you?
Comments and suggestions (from others) towards improving the code and finding ways to refine the code by viewing and testing other codes was the top answers. One student had commented that the process of analyzing other peoples' work helps one to see ones' own strength and weakness and in doing so, help improve ones' skills.

Question 8: How useful was the discussion group?
As for the discussion area that was set up for each of the lab activity and for each of the group project, 70% of the students felt that the WebCT discussion was very helpful. Surprisingly, only about 40% of the students participated in the discussion. From the survey it is obvious that the rest of the class were acting as silent observers.

Question 9: To what extent did you use the communication medium?
The answer for this question ranged from very little to extensive use of the discussion group. This may be probably the use of the discussion medium was not mandatory. The actual points that the discussion group was valued towards the grading system may not have been apparent to the student.

Question 10: Do you agree that a conventional approach of homework and projects would have had the same effect and understanding of the subject matter?
For this question that on comparing the traditional approach against the hybrid approach followed in this class, 18% of the students thought that the conventional approach worked better for the first part of the class where numeric computations were involved. However, the majority of the class responded that the key to success in understanding and implementing network principles was brought by human networking which involved group effort and sharing information across inter and intra group through open discussion.

Question 11: In your opinion, what is an ideal working group?
Interestingly different answers were seen for this question. Some of the answers are listed below –

- a compatible working group that can move the project forward
- work together and communicate effectively
- a mix of students at different levels
- all of the students at the same level
- each member is responsible to contribute his/her part of the project
- group members open to everyone's opinions and ideas
- whose schedules match

Summary And Conclusion

Assessing the course outcome is an important part of the curricula. Assessing completes the loop of instruction delivery and measures the completeness of the result. It can be measured both ways – as the knowledge and skills acquired by the end-user and as the effectiveness of the methodology and delivery of the content. It is a measure of the factors that influence the absorption and the assimilation of the material acquired by the student at the end of the semester. Assignments, tests, and quizzes are some of the assessment methods in the traditional approach. Apart from this, team-based and project-based hands-on learning environment has received lot of attention in recent years. The benefits of this hands-on approach include engaging and motivating, inducing creative thinking, peer-learning and sharing environment, building self-confidence, and improving communication and team-building.

In this paper the different types of active learning approaches used in a computer networking course is discussed. This includes the varied types of hands-on activities, the different learning environment of individual and group setting, peer-learning mechanism practiced through peer code evaluation, and the discussion platform to share and communicate are detailed. The effectiveness of this approach as perceived by the students is also presented. Some of the factors that were cited by the students towards the course improvement are imposing the discussion through WebCT mandatory and making the lab accessible to the students at all times. Overall, this course was well received by the students who felt they learned a lot from this course and enjoyed working in teams.

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