The Proceedings of the Thirty-first SIGCSE Technical Symposium on Computer Science Education

SIGCSE 2000

Austin, Texas
March 8-12, 2000

Symposium Co-Chairs:
Boots Cassel, Villanova University
Nell Dale, The University of Texas at Austin

Program Chair:
Henry Walker, Grinnell College

Proceedings:
Susan Haller, University of Wisconsin - Parkside

Sponsored by:
The Association for Computing Machinery
Special Interest Group on Computer Science Education

Table of Contents

CS 1/2
Fri., 8:00-10:00, Trinity

CS Education Research
Fri., 8:00-10:00, San Antonio

Social and Ethical Issues
Fri., 11:00-12:00, Pecos

First Year Courses
Fri., 11:00-12:00, Ballroom B

Object-Oriented Issues
Fri., 11:00-12:00, Trinity

Networks and E-commerce
Fri., 11:00-12:00, Sabine

Undergraduate Research/Capstones
Fri., 2:00-3:30, Wedgwood

Seminars

Teaching *Software Psychology*: Expanding the Perspective

Kam Hou VAT
Faculty of Science & Technology
University of Macau, Macau
fstkhv@umac.mo

Abstract

This paper describes the curriculum development and teaching experience of a junior core course entitled *Software Psychology*, offered in the undergraduate Software Engineering program at the author's affiliated university. In particular, the pedagogy of problem-based learning is introduced, together with the evolution of the course content. It will also address issues such as resources and facilities needed for the course, and the students' perceived learning as well as the author's lessons learned therein.

1 Introduction

Software Psychology, according to our Faculty (founded in 1989) records, derived its name from the domain of study of human behavior in software engineering. The first suggested textbook in the course back in 1989, was found to be Ben Shneiderman's 1980 edition of *Software Psychology: Human Factors in Computer and Information Systems*. Since 1993, an ongoing tailoring process is in place to deliver an appropriate curriculum, which is composed of a suitable mix of such elements as human factors, user expectations, human-computer interfaces construction, cognitive psychology, and some latest development on user-centered and/or performance-centered design in interactive system development. Yet, the original course title has been retained because any change in course name involves some lengthy bureaucratic approval process in the local Authorities. It is understood that if we intend our students to have better exposure to this field of human-computer interaction (HCI), as it is presently known today, we need more than a continually updated curriculum. We also need an appropriate pedagogy, whose mission is to facilitate students' active learning.

And the author has chosen the Problem-Based Learning (PBL) approach [1, 2, 3]. It has been reported that PBL helps develop in students the following characteristics of quality performance:

- high level communications, technological literacy, and informational abilities that enable individuals to gain and apply new knowledge and skills as needed.
- the ability to arrive at informed judgements; namely, to effectively define problems, gather and evaluate information related to those problems, and develop solutions.
- a range of attitudes and dispositions including: flexibility and adaptability; ease with diversity; motivation and persistence; creativity and resourcefulness; ability to work with others in team settings.

2 The PBL Pedagogy

The modern history of PBL began in the early 1970s at the medical school at McMaster University in Canada, and ever since, PBL has been adopted in various fields such as Teaching, Engineering and Management. Pedagogically, the PBL approach uses real-world problems to drive the learning rather than mere lectures with the instillation of subject matter. It acknowledges the possibility of prior knowledge held by the learner. Further knowledge is acquired on a 'need to know' basis, enabling the learner to diagnose one's own learning needs. Knowledge gained is fed back into the problem in an iterative loop, allowing the synthesis of topics and know-how [3]. When applied to the course setting, PBL should encourage students' active participation and develop in them self-directed learning and problem-solving skills while they interact, discuss and share relevant knowledge and experience. More importantly, PBL revolves around a focal problem, group work, feedback, class discussion, skill development and final reporting. The instructor's role is to organize and pilot this cycle of activity, guiding, probing and supporting students' initiatives along the way so as to empower them to be responsible in their own learning.

3 Course Goals

The course entitled *Software Psychology*, is offered annually in the fall semester as a compulsory subject for

Software Engineering majors. The goals of the class include the following:

- to help students become HCI-literate by developing fundamental understanding of HCI in relation to human factors, usability engineering, cognitive psychology, and computer science.
- to encourage students to formulate and express their views on user interface design of interactive systems, through project development, written work, oral presentations and classroom discussions.
- to raise students' awareness of the HCI impact on computer industry, and the wide-spread focus of HCI from human factors, to usability engineering, to user-centered design, in constructing systems that support human activity.

4 Course Content

The fall semester of about 15 weeks' duration, is structured into three sessions of loosely 5 weeks each. The course content is then arranged into three sessions as follows:

4.1 First 5-Week Session

The first session covers the basic foundations of HCI, introducing the idea that HCI is concerned with understanding, designing, evaluating and implementing interactive computing systems for human use. And it draws from the knowledge and methods of many different disciplines, chiefly computer science, cognitive psychology, social sciences and human factors. Next we try to interpret HCI as a model where people, activities, technology and the environment are closely interrelated. We then emphasize the need to identify the design problem, and to differentiate the situation of concern, which brings about designing the system. Often we need to involve some key concepts, such as usability factors and representations of human activities.

4.2 Second 5-Week Session

The second session focuses on the design process, developing the idea that HCI is concerned with designing computer systems to match the needs of people. It explains how to gather data about human activity in preparation for design, and discusses how to approach the design process from a user-centered perspective. It will also cover modeling techniques used to ensure usability principles, such as the task analysis methods. Furthermore, we will introduce the concept of requirements definition from the software engineering perspective, explaining the need to define, in a set of requirements, a usable functional form for the system.

4.3 Third 5-Week Session

The third session extends the second with more coverage in design support, deepening the idea that HCI design employs a rapid, iterative design process with comprehensive evaluations. It will look at analytic and empirical methods for evaluating interactive systems prototypes to meet user requirements. Students are reminded that design support is needed to deal with the complexity of a design process. It will also cover the use of guidelines, explaining how to make use of sources of design knowledge and how to apply guidelines to answering questions of detailed design.

5 Course Activities

In each of the three sessions throughout the semester, students, on being presented with a problem or scenario, embark on the PBL cycle of learning through organized groups of 3-5 students. Initially, they will not possess enough prior information to solve the problem or to clarify the scenario. Problems are often ill-structured, but devised according to concrete, open-ended situations. To construct a solution, students must identify, locate, and use appropriate resources. They ask questions referred to as "learning issues" on the various aspects of the problem, which help them realize what knowledge they require, thus focusing their learning efforts and establishing a means for integrating the information they acquire. There are generally three relevant stages of activities: analysis, research and reporting, with discussion and feedback from peers and teacher at each stage [1, 2, 3].

5.1 Analysis. Throughout this stage, students organize their ideas and prior knowledge related to the problem, and start defining its requirements. This helps students devise a specific statement of the problem. Meanwhile, they are encouraged to pose learning issues, defining what they know and what they do not know. This helps them assign responsibilities for research, eliciting their existing knowledge as a crucial step in learning new information.

5.2 Research. Throughout this stage, students collect necessary information on specific learning issues raised by the group. They may conduct library searches, seek sources on the Internet, and/or interview knowledgeable authorities. Students teach themselves as they research their learning issues. It is intended that when they come to realize the complexity and texture of the problem, they may see that information is meant to manage problems effectively.

5.3 Reporting. At this stage, students report their findings to the group. Individual students become "experts" and teach one another. Subsequently, their discussion may generate a possible solution, or new learning issues for the group to explore. Final solutions are reported to the class as a whole, and to the teacher. The teacher's feedback addresses if the original learning issues were resolved and if the students' grasp of the basic principles, information, and relationships is sufficiently deep and accurate.

For inexperienced learners, or for retaining clear control, instructors could intersperse mini-lectures or teacher-led discussion into the group-oriented PBL work. Likewise, the problems should contain some breaks at which teachers can shift attention from the group to the instructor. At such breaks, the teacher may deliver critical information, lead a class discussion to clarify concepts or misconceptions, introduce the next stage of the problem, shift students' attention to a different skill, or compare groups' progress.

6 Course Resources

In each of the fifteen weeks throughout the semester, we have four hours (extendible to six upon students' initiative and instructor's schedule) of contact with the students, devoted to PBL activities, and when required, to tutorials on foundational understanding, technical and team support. In the PBL classroom, also one of our Software Engineering Laboratories, equipped with UNIX-based workstations and Windows-based PCs, we have collected some tools and references for students' exploration, with the help of a laboratory technician, a teaching assistant and the course instructor.

6.1 Course References

1) Baecker, R.M., Grudin J., et al. (Eds.). Readings in Human-Computer Interaction: Toward the Year 2000, 2nd Edition. Morgan Kaufmann (MK), 1995.
2) Baecker, R.M. (Ed.). Readings in Groupware and Computer-Supported Cooperative Work: Assisting Human-Human Collaboration. MK, 1993.
3) CHI Conference Proceedings, "Human Factors in Computing Systems," 1995, 1996, 1997, 1998, 1999.
4) Dix, A.J., Finlay, J.E., Abowd, G.D., and Beale, R. Human-Computer Interaction, 2nd Edition. Prentice Hall (UK), 1998.
5) ***interactions***: a quarterly publication of ACM.
6) Johnson, P. Human-Computer Interaction: Psychology, Task Analysis and Software Engineering. McGraw Hill, 1992.
7) Newman, W.M., and Lamming, M.G. Interactive System Design. Addison Wesley, 1995.
8) Nielsen, J. Usability Engineering. AP Professional, 1993.
9) Preece, J, et al. Human-Computer Interaction. Addison Wesley, 1994.
10) Preece, J., and Keller, L. (Eds). Human-Computer Interaction. Prentice Hall (UK), 1990.
11) **SIGCHI *bulletin*** : a quarterly publication of the ACM
12) Wiklund, M.E. (Ed.). Usability in Practice: How Companies Develop User-Friendly Products. AP Professional, 1994.

6.2 Course Development Tools

We have acquired the following software at educationally discounted prices or free from the Internet for students' project work in interface design for interactive systems:

- Java Virtual Machines with suitable JDK (ver 1.1/1.2)
- C++ Builder 4 Enterprise edition
- Delphi 5 Enterprise edition
- JBuilder 3 Enterprise edition

6.3 Course Support Web-sites

Starting from the fall 1999 semester, we are experimenting with the faculty-wide WWW-enabled course support environment and the PBL support environment. These two web-sites are respectively to support the concept of learner-centered education. The former being oriented towards the constructivist model, is called **REAL** [4], implying a **R**ich **E**nvironment for **A**ctive **L**earning and the latter, oriented toward the PBL model, is called **SUPER** [5], denoting **SU**itable and **P**ractical **E**ducational **R**esources.

7 Course Assessment

There are three 5-week sessions of activities throughout the semester. Students' teams each with a designated team leader, are supposed to complete a session-long assignment in each period. Each PBL group will be given a different topic within the same context area to explore. At the end of each session, a project document is due for grading, and the resulting group grade is the same for all students in the team. Each student is also graded individually by the instructor and by each of the team members. The instructor's evaluation is based on what each team member adds to the team discussion and presentation, and what the instructor perceives each member's contribution to the team to be. The peer's evaluation is based on a confidential rating sheet, to be completed by each team member at the end of each major assignment. It includes each team member's contribution for that phase with explanatory comments. The overall assignment assessment is composed of the group grade and the individual grade. The course evaluation is made up of the total grades of the three project assignments in the three sessions of the semester, plus the final examination grade, which comprises reading some research articles and writing responses within a 3-hour period.

8 Course Delivery

In each fall semester, the author has to plan from three to five sets of study materials, based on the number of groups whose size is of 3-5 students, for each of the semester's three sessions, for a total of about twenty-five students enrolled in the course. The following presents the author's preliminary selections for the first two sessions, and the arrangement of group-based project work in the last session.

8.1 First Session

In each session, individual PBL groups are assigned to read a number of articles and some tutorial chapters from reference texts. They are to conduct the analysis-research-reporting cycle of PBL studies, and culminate their results in a study report and a presentation in front of all other groups, at the end of the session. In the process, they need to have at least two in-class team meetings (plus some self-directed group meetings outside the class schedule, without the instructor's presence, in which they organize themselves to manage the assignment) to which they invite the instructor to observe and give feedback to their discussion. The topics selected for the five groups in the first session are respectively as follows:

8.1.1 Compulsory Articles

- Norman, D.A., "The Psychopathology of Everyday Things," Section 6.1, Book #1, 5-22.
- Baecker, R.M., and Buxton, W.A.S., "A Historical and Intellectual Perspective," Section 6.1, Book #1, 35-48.

8.1.2 Selective Articles

Individual PBL groups are to read a different article, besides the compulsory ones, to extend their understanding.

- Barnard, P., "The Contributions of Applied Cognitive Psychology to the Study of Human-Computer Interaction," Section 6.1 Book #1, 640-658.
- Card, S.K., and Moran, T.P., "User Technology: From Pointing to Pondering," Section 6.1, Book #1, 587-602.
- Landauer, T.K., "Let's Get Real: A Position Paper on the Role of Cognitive Psychology in the Design of Humanly Useful and Usable Systems," Section 6.1 Book #1, 659-666.
- Landauer, T.K., "Relations Between Cognitive Psychology and Computer System Design," Section 6.1, Book #10, 141-160.
- Olson, J.R., and Olson, G.M., "The Growth of Cognitive Modeling in Human-Computer Interaction Since GOMS," Section 6.1, Book #1, 603-625.

8.2 Second Session

In the second session, each PBL group is mainly responsible for investigating a specific case study of HCI design, and for proposing a topic of interactive system design for experimentation in the third session.

8.2.1 Compulsory Articles

- Gould J.D., "How to Design Usable Systems (Excerpt)," Section 6.1, Book #1, 93-121.
- Lewis, C, and Rieman, J., "Getting to Know Users and Their Tasks," Section 6.1, Book #1, 122-127.
- Mountford, S.J., "Tools and Techniques for Creative Design," Section 6.1, Book #1, 128-141.
- Boehm, B.W., "A Spiral Model of Software Development and Enhancement," Section 6.1, Book #1, 281-292.
- Grudin, J., "Interactive Systems: Bridging the Gaps Between Developers and Users," Section 6.1, Book #1, 293-303.

8.2.2 Selective Case Studies

- Jackson, S.L., Krajcik, J., and Soloway, E., "The Design of Guided Learner-Adaptable Scaffolding in Interactive Learning Environments," In Proc. of CHI 98, Apr. 18-23, Los Angeles, 187-194.
- Wallace, R., Soloway, E, Krajcik, J, et al., "ARTEMIS: Learner-Centered Design of an Information Seeking Environment for K-12 Education," In Proc. of CHI 98, Apr. 18-23, Los Angeles, 195-203.
- Rose, A., Ding, W., Marchionini, G., et al., "Building an Electronic Learning Community: From Design to Implementation," In Proc. of CHI 98, Apr. 18-23, Los Angeles, 203-210
- Tamaki, M., Kuwabara, T., et al., "Network-based Education System Designed to Allow Individual Student Progress and Improve Teacher Efficiency," In Proc. of the third Asian Pacific Computer & Human Interaction, Jul. 15-17, 1998, Kangawa, Japan.
- Yoshino, T., Munemori, J., Ito, S., and Nagasawa, Y., "Development of a Multi-User Electronic Conference System DEMPO III for Supporting New Ideas," In Proc. of the third Asian Pacific Computer & Human Interaction, Jul. 15-17, 1998, Kangawa, Japan.

8.3 Third Session

In this last session, each PBL group is assigned the project of designing an interactive application and constructing a prototype for evaluation. Prototyping tools such as those mentioned in *Section 6.2*, are introduced in the weekly tutorials. The prototyping process requires each team to designate a client, apart from the already selected team leader and other team members. Each team is then assigned a client from another team. Namely, each team, acting as developers, is to complete an interactive system design and prototype for another team. Yet, the same team is the client of another group. The instructor will act as the project supervisor for all teams. To help students work in team, it is stipulated that the client's role is to clarify the project, and to resolve ambiguities as they arise, whereas the supervisor's is to guide, motivate and provide feedback to the team. The team leader has to coordinate the team activities, and ensure effective team communications, whereas the team members have to help set the project goals, accomplish tasks assigned, meet deadlines, attend team meetings and participate in editing the document to be turned in at the end of the project period. To support students' activities in this session, instructors, depending on the projects, will suggest suitable chapters from reference texts, and timely and informative articles from different research magazines and journals. At the end of the project, each PBL team is required to present their project, and lead a class discussion to elicit students' responses, besides submitting the project document and demonstrating the software product. In the process, the supervisor must be ready to resolve any team conflicts, which arise from lack of coordination or communications. It should be noted that team coordination could be enhanced by exercising care in teaming up the PBL groups from the very beginning.

9 Course In-Class Organization

The course is organized to encourage students to come to class on time and to read the assigned articles and start the PBL-cycle of activities. We have a flexible time-slot for progress briefing with questions, if available by each team at the beginning of each meeting. This is then followed by the instructor's update. Next comes the student-led team-based PBL discussion. Those teams, which fail to conduct regular progress briefings because of members' absence or late arrivals or under-preparation, will be tracked and have negative score recorded for lack of professional attitude. This is considered as a sign of under-performance, and is strongly discouraged. However, this arrangement requires cautious and flexible time management. It is the author's experience that the PBL discussion often overruns the scheduled class-time slots, and we have to re-arrange our classes so that we have a weekly seminar/workshop-like meeting whose duration could go from 3 to 4 hours, with some refreshment(s) breaks.

10 Lessons Learned

Admittedly, the students' responses to the PBL approach are not deprived of barriers. Some students reported that since they came from the didactic model of education, they did not have the skills to work as an independent group, which involves setting their own learning objectives and having to research them. And there are students who just prefer to be given the information (answers). They encounter the discomfort to "learn to learn". They often find the group process and the notion of independent learning particularly hard to cope with. As PBL instructors, it is found that we could become most helpful as facilitators if we could balance directions to students with assistance to them. We must be prepared to ask leading and open-ended questions, monitor progress, help students to reflect and create a positive learning atmosphere. This process requires time on the part of both students and the instructor. Nevertheless, knowing how to work with groups as well as how to train group-members to work with one another, is not something most faculty presume expertise in. It is also learned that alignment among the course content, PBL instructional objectives, team evaluation, and student practice, is of critical concern. Such expectations should be communicated continuously so that students are not confused and can efficiently learn without guessing "what the professor wants." Positively, it has been observed that students in PBL groups use their training to enrich their performance; they articulate their newly constructed ideas and through argument and persuasion, build shared meaning. This is something not often seen in the traditional format of teacher-centered, subject-based learning, with the dominant mode being courses of lectures. Yet, it is convinced that the PBL-approach requires trust and cooperation among students and the instructor, so as to promote meaning-making and shared ideas among all participants.

11 Conclusion

In this article, the author has presented one approach to teaching human-computer interaction, incarnated as *Software Psychology*. This approach may not work in every situation or for every instructor. Yet, it is believed that the PBL method enables students to be active learners. As they determine what will be learned and how, they question, explore, explain, evaluate, and collaborate. They tailor their learning by pursuing individually the learning issues that interest them and by focusing in groups on the areas they understand least. The resulting learning should be integrated, accumulative and connected.

References

[1] Albanese, M., and Mitchell, S., "Problem-Based Learning: A Review of Literature on Its Outcomes and Implementation Issues," Academic Medicine, Vol. 68, No. 1, 1993, 52-81.

[2] Engel, J., "Not Just a Method But a Way of Learning," In D. Bould and G. Felletti (Eds.), The Challenge of Problem-Based Learning. New York, N.Y.: St. Martin's press, 1991, 21-31.

[3] Ryan, G., "Student Perceptions about Self-directed Learning in a Professional Course Implementing Problem-Based Learning," Studies in Higher Education, Vol. 18, 1993, 53-63.

[4] Vat, K.H., "REAL: Towards a WWW-Enabled Course Support Environment for Active Learning," Faculty Technical Report, FST/SE-1999-01, University of Macau, Macau.

[5] Vat, K.H., "SUPER: Towards a WWW-Enabled PBL Support Environment for Software Engineering Education," Faculty Technical Report, FST/SE-1999-02, University of Macau, Macau.