Participatory Learning Approach: A Research Agenda

Jia Shen**, Dezhi Wu**, Vikas Achhpiliya*, Michael Bieber and Roxanne Hiltz,
** Masters student ** Ph.D. student*

Information Systems Department
College of Computing Sciences
New Jersey Institute of Technology
http://is.njit.edu/pla/

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1. MOTIVATION

The Participatory Learning Approach (PLA, pronounced "play") engages students as active participants in the full life cycle of homework, projects and examination. PLA's core idea is that students design the questions or projects, execute them, and then assess and grade their peers' solutions. Each stage can be performed by individuals or by teams. Students should be able to observe (read) everything their peers do so they can learn further from others' efforts.

PLA is designed to work for a wide range of students from junior high though graduate and professional schools, as well as for training and adult learning.

Many instructors have tried various pieces of the PLA technique on their own, and individual aspects have been studied more rigorously. For example, many instructors have students generate questions (and sometimes answers), as a study tool or to foster class discussion (de Jesus et al. 2003, Dolinsky 2001, Foos et al. 1994, Hargreaves 1997, Silva 1995). Others have students grade peers' projects, either sharing them on-line or after a class presentation (Hersam et al. 2004, Reynolds 2004, Richards et al. 2004, Wiswall & Srogi 1995). This occurs at the college and secondary school level. The Networked Peer Assessment System (NetPeas), e.g., facilitates peer assessment of (instructor-created) mathematics homework problems at the junior high level (Liu et al., 2002). Furthermore, inquiry-focused approaches (Polman, 2000) and problem-based learning (Koschmann, 1996), in which students develop problems and investigation strategies, are often used in secondary school classrooms. Nobody, however, has systematized the PLA approach across the entire problem life cycle, developed the supporting tools and documentation ensuring ease of use on a large scale, or scientifically evaluated its effect on learning, either at the secondary school or college level.

Our PLA research has the following major objectives.

- To increase learning of course materials (primarily) and assessment skills (secondarily).
- To provide and evaluate a systematic, collaborative approach to homework assignments, projects and examinations, focusing on active participation and peer evaluation.
- To ensure this approach supports pedagogy effectively across different cultures.
- To design the PLA approach to minimize additional overhead and whenever possible save the instructor time.

Two other major objectives highlight our commitment to ensure that PLA will be widely applied and will be easy to take advantage of.

- To develop accompanying software that maximizes student learning, facilitates collaboration, and minimizes student and instructor overhead in conducting PLA.
- To broadly disseminate both our approach and our lessons, so that as many other instructors as possible can learn about them and deploy PLA.

To date we have pioneered and refined the PLA for five semesters with essay-question exams in a graduate-level information systems course, with both distance learning and traditional sections (Shen et al., 2001, 2004; Wu et al. 2004a), and in an undergraduate programming class with short essay questions. Experimental results show that a large majority of students believed that their learning had increased through the PLA process, recommended its use in future courses, and actually reported enjoying the exam process.

In this short introduction to PLA we present some of the literature upon which PLA builds, describe the approach and how it engenders learning. We present an overview of the evaluation we have conducted while using PLA for six semesters at NJIT, and some of the research questions that will guide future evaluation. We close with a series of interesting issues this research raises.

2. FOUNDATIONS

PLA is grounded in constructivist theories of learning (Piaget 1928, Vygotsky 1978), which suggest that knowledge is actively constructed by, rather than transmitted to learners. People learn by applying their knowledge to meaningful problems (Brown, et al., 1989; Hawkins and Pea, 1987), actively building their own understanding.

Assessment and instruction typically are viewed as separate activities with different purposes. Some researchers have called for changing classroom culture so assessment becomes *authentic*—a fundamental part of the learning process (Shepard, 2000; Wright 2003). In PLA, assessment is closely tied to the learning process, in which students both assess other students' work and have their own work assessed.

Self- and peer- evaluation contribute to learning in several ways. This awareness is facilitated when students are given specific criteria by which their own work is evaluated (Shephard, 2000). Students participating in assessment activities develop a metacognitive awareness of what constitutes excellent work (Frederikson & Collins, 1989; Liu et al, 2001). Students reported benefiting from needing to defend their opinions about their work (Klenowski 1995) and from having access to their peers' work (McConnell, 1999). Knowing that their peers would read their assignments also motivated their learning (McConnell, 1999).

An analysis of 62 studies showed that self-, peer- and co-assessment are effective tools for developing competencies required in professional organizations (Sluijsmans et al, 1999). Peer assessment practices should develop lifelong learning skills such as ability to evaluate one's own work and of one's peers, which the employers seek from students when they enter the professional world (Boud, 1990; Hargreaves, 1997).

3. PLA PROCESS

PLA embodies the following systematic process, which our planned software will facilitate. The following description assumes that students work individually on each stage. Alternatively, collaborative groups could perform the task at any stage, which would further enhance learning.

Students should be able to read everything peers post on-line, which is an important learning component. All entries will be "threaded" so that description, solution and grades are grouped together for each problem. Figure 1 illustrates the PLA process.

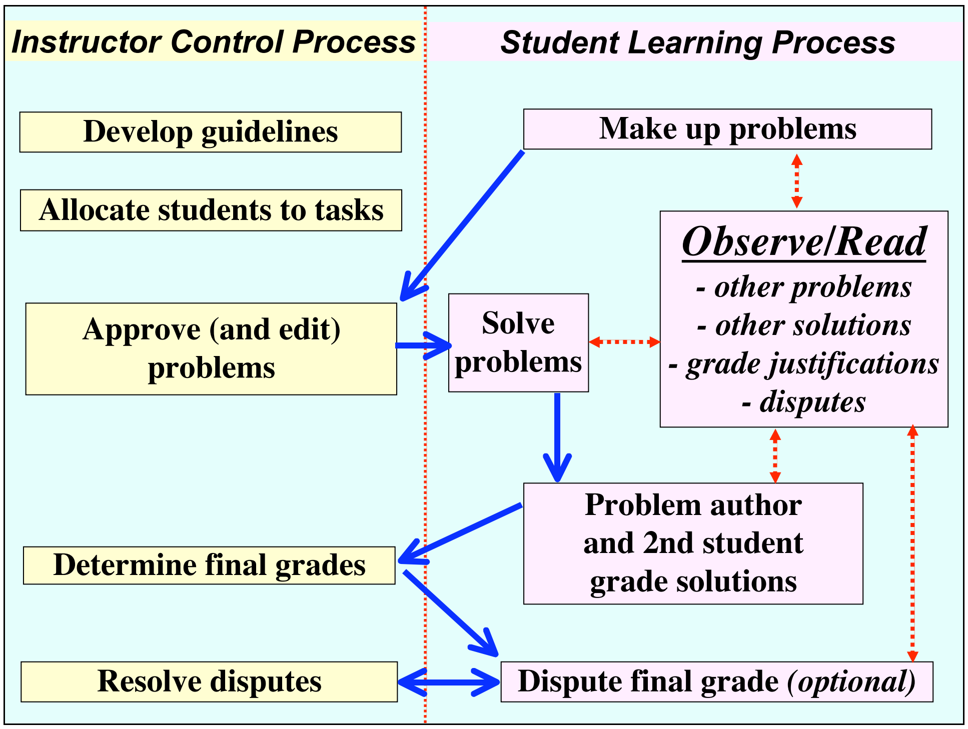

Figure 1: Instructor and student processes within PLA. Solid arrows show the process flow. Dashed arrows emphasize that students also learn by observing everything their peers do. The PLA support software will guide students and instructors, as well as assist with administration, such as allocating students to PLA tasks and emailing anyone late.

- Each student designs a problem, using guidelines provided by the instructor. Students post the problem description on-line.
- The instructor approves the problem description, editing it if necessary.
- Each problem is allocated to a different student who will solve it.
- Each student posts his or her solution on-line.
- Students grade the solution to the problem they authored, using guidelines provided by the instructor. Students may be required to grade along several different criteria. They must provide a written justification of at least two sentences for each evaluation criterion. *Justifications, a detailed written critique—positive or negative—are a vital aspect of learning how to assess.*

- Students are allocated a second solution to evaluate, providing each solution with a second opinion.
- Instructors assign a final grade to each solution, using the two student evaluations as input. If the two student grades are close enough (e.g., within 10 out of 100 points), to conserve time the instructor optionally may choose to accept the higher grade without re-evaluating the solution.
- Students optionally may dispute their grade, in which case they must re-grade their own solution using the same evaluation guidelines. *Disputes are an especially important feature. They help ensure the fairness of the PLA approach, especially when instructors do not have time to carefully review each answer and evaluation. If a student believes the peer (or instructor) evaluations were incorrect a dispute will ensure that the instructor focuses adequate attention to this specific problem.*
- The instructor determines the final grade for the disputed solution.

3.1 Opportunities for Learning

PLA incorporates several opportunities for learning, in addition to the theoretical advantages of the constructivist approach noted in §2, in designing problems, answering them, grading them, disputing results, and in observing/reading what everyone else does.

PLA forces students to view a subject from several new vantage points. Designing problems challenges students to analyze course materials in order to determine the most important aspects for critically assessing understanding of a subject by their peers. Evaluating solutions and arbitrating disputes challenge students to assess how fully a set of materials (the solution) fits their understanding of the field as well as the problem posed. Often solutions will be quite different from how the evaluator views the problem, forcing a rethinking of the material. The PLA stages of problem design, solution design, solution evaluation and dispute arbitration take place over a period of time and often the class will have moved on to new materials while the latter stages are being conducted. This repetition provides reinforcement. The extended time span fosters synthesis, as students revisit prior topics at the same time they are learning new materials.

Finally, students learn from reading what their peers have written—problems, solutions, grading justifications and disputes. Students read their peers' work out of curiosity, for new ideas, and for comparison to their own work. Message counts in our on-line system at NJIT (WebBoard) showed that students spent a lot of time reading what their peers had written, confirming this as a valuable component of the PLA.

3.2 Extending the Basic PLA Process

PLA can be extended in several ways from this basic model, which we plan to investigate. Some are features within the PLA Environment (PLAE) support software we currently are designing, in order to make it more flexible and customizable for instructors. Others can be thought of as additions to the PLA model itself (and also will necessitate changes to the PLAE software.)

- Collaboration: Groups of students could work together to create problems, solve problems, evaluate, arbitrate disputes, and assign final grades. PLAE will build in extensive group support techniques and tools.

- Multiple Problems: Students could design and solve more than one problem within a single assignment (homework, project, quiz or exam), and thus be involved in various roles for different problems under the same assignment.
- Sub-problems: Problems could be designed to contain several sub-problems. Each could be conducted in tandem or sequentially when the prior part was complete. Each sub-problem would be assessed separately. For sequential sub-problems, students would not start solving the next sub-problem until the prior one passed assessment.

  An example of two sequential sub-problems could be (i) the design of a large computer system, followed by (ii) its implementation and testing. The instructor may want the class to use PLA to assess the design before students move on to the implementation. Similarly, the instructor may break a semester project into an extended outline and its completion, and use PLA to evaluate the outline before students complete it.

  For complex problems, the individual or group designing the problem may wait with designing a subsequent sub-problem until its prior sub-problem has been completed.
- Multiple Evaluation Opinions: The PLA model supports any number of evaluations for each problem, instead of always two.
- Separating Evaluation from Grading: For larger projects and in cases where instructors may wish to limit potential bias, PLA will support separating the assessment of the solution from its grade. One evaluator would write up a detailed evaluation. A second evaluator would assign a grade based on the evaluation. The instructor should separate evaluation instructions from grading instructions.
- Evaluating Other PLA Activities: In addition to evaluating solutions, the PLA model supports evaluating (grading) other PLA activities, such as grading problem statements, dispute arbitration, and even other evaluations, and when separated from the other evaluations, grades. This could motivate students to take these other aspects more seriously and learn more deeply from them. Such additional evaluations could also be disputed and arbitrated. Additional activity evaluation reinforces the need for PLAE to be extremely clear to avoid confusion.
- Activity Rejection: Evaluation could be used to reject any activity (problem statement, sub-problem solution, etc.) that is so poor that the process cannot continue effectively with it. In this case the activity could be redone and re-evaluated, or the evaluator or instructor would provide a substitute, and the PLA process would continue. For example, when evaluating a semester project outline (a solution to the first semester project sub-problem), the evaluators could determine it not strong enough and reject it. In this case the group that created the semester project outline would have to redo it, hopefully benefiting from the evaluation justification.

4. Prior Evaluation Results

Four instructors participated in our trials at NJIT over six semesters. Problem, solution and evaluation guidelines were posted on the course Web site. All problem postings were conducted anonymously on WebBoard grouped by problem IDs. All allocations were done manually, including manually re-allocating students to tasks if anyone dropped out, and managing problem

IDs. Allocations and grades were kept on a spreadsheet. (The PLA software will alleviate this overhead and handle problem situations.)

For brevity, we only provide a subset of the experimental results here combining the most recent two semesters, which were both distance learning sections. (Wu et al. 2004a,b) provides more details as well as extensive discussion. Results from the first three semesters were also very positive (Shen et al. 2001, 2004).

We used a research model and survey questions grounded more deeply in learning theory in these most recent two semesters. Figure 2 shows the research model. A correlation analysis results show that perceived exam process quality is correlated to enjoyability (0.308*, p= <.05) and real exam grades (0.346*), enjoyability is significantly correlated to perceived learning from the participatory exam (0.521**, p= <.01), and that perceptions of learning are also highly correlated with recommendation for future use (0.653**).

A major addition to the proposed study will be objectively measuring actual learning, as §5.2 describes.

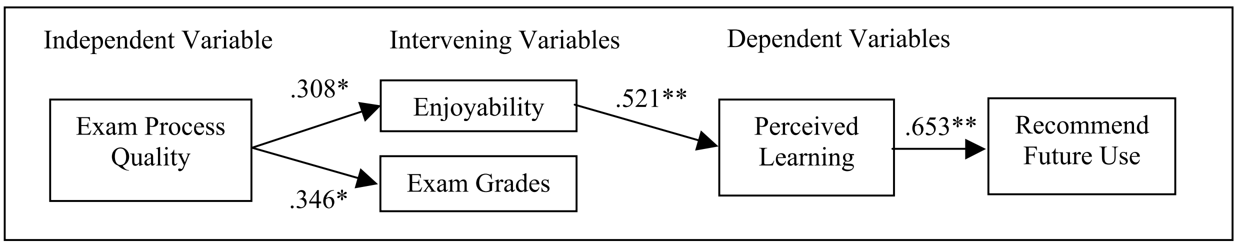

Figure 2: Participatory Exam Final Research Model, showing Pearson's r for the correlation of the variables, significant at the.05 (*) and.01 (**) levels (2-tailed). (Hypothesized correlations of the final exam grades with enjoyability and perceived learning turned out not to be significant.)

Tables 1-3 present survey items incorporated in the research variables "enjoyability," "perceived learning" and "recommendation." Table 1 confirms our prior experiment's research question that students enjoyed their learning experience in the participatory examination. Measuring enjoyability by the three questions shown was confirmed with a Cronbach Alpha value for the enjoyability index of 0.6793. Table 2 similarly confirmed the research question that the participatory exam afforded a good learning experience for students. Table 3 reports that over 70% of students recommended the participatory exam for future use.

Items	SA	A	N	D	SD	Mean	S.D.	NR
Exam time was sufficient	14%	53%	10%	12%	10%	3.5	1.2	49
I enjoyed the flexibility in organizing my resources	32%	55%	8%	2%	2%	4.1	.82	49
I enjoyed the exam process	22%	45%	22%	6%	4%	3.8	1.0	49

Cronbach's Alpha=0.6793

SA - strongly agree (5 points); A - agree (4); N - neutral (3); D - disagree (2); SD - strongly disagree (1); the mean is out of 5 points; S.D. - standard deviation; NR - number of respondents

Table 1: Participatory Exam Enjoyability

Items	SA	A	N	D	SD	MEAN	S.D.	NR
The exam was a good overall learning experience	29%	53%	16%	0%	2%	4.06	.80	49
My skill in critical thinking was increased	29%	49%	20%	2%	0%	4.04	.76	49
My ability to integrate facts and develop generalizations improved	33%	41%	25%	2%	0%	4.04	.82	49
I learned to value other points of view	22%	59%	16%	0%	2%	4.00	.76	49
I was stimulated to do additional reading	35%	41%	16%	6%	2%	3.98	1.05	49
I learned from reading peers' work	20%	56%	18%	4%	2%	3.88	.85	50
I learned from making up questions	20%	48%	22%	4%	6%	3.72	1.03	50

Cronbach's Alpha=0.9074

Table 2: Perceived Learning from the Participatory Exam

Items	SA	A	N	D	SD	MEAN	S.D.	NR
I prefer this exam over a traditional exam	28%	34%	24%	12%	2%	3.74	1.07	50
Recommend using this exam in future courses	29%	43%	20%	2%	6%	3.86	1.06	49

Cronbach's Alpha=0.6821

Table 3: Recommendation of Participatory Exam for Future Use

In addition, we conducted the PLA for the midterm in CIS365 at the New Jersey Institute of Technology during Fall 2002. CIS365, "File Structures and Management," is an upper-level undergraduate course with programming and conceptual aspects. We have conducted preliminary data analysis for the 17 questionnaires returned, but they show very positive results. Table 4 lists student responses to several questions.

Items	Agree (%)	Strongly Agree (%)	Agree + Strongly Agree (%)
I learned from making up questions	47.1	35.2	82.4
I learned from answering questions	52.9	41.2	94.1
I learned from grading students' answers	70.6	17.6	88.2
I learned from reading other's questions, answers and grading.	76.5	11.8	88.3
I felt the grading procedure was fair	70.6	0	70.6
My skills in critical thinking was increased	41.2	11.8	53.0
My ability to integrate facts and develop generalizations improved	52.9	29.4	82.4
I learned to value other points of view	47.1	23.5	70.6
Overall, I felt the online exam was a good learning experience	52.9	29.4	82.3
I enjoyed the examination process	35.2	29.4	64.7
Would you recommend this online exam process be used in the future	41.2	35.2	76.5

Table 4: Preliminary Results from CIS365 Data Analysis

In the first three semesters where both distance learning and traditional classes participated, students agreed on the vast majority of survey questions. The only ones with significant differences are shown in Table 5. This affirms that PLA would be successful in both modes.

Item	Sec	NR	Mean	S.D.	Item	Sec	NR	Mean	S.D.
Developed new friendships (Fall '99)	DL	21	2.9	1.00	Developed new friendships (Spring '00)	DL	15	3.0	0.85
	T	41	3.6	1.02		T	59	3.8	0.96
Flexibility (Fall '99)	DL	18	4.4	0.62	Value others' viewpoints (Spring '00)	DL	15	3.1	1.03
	T	25	3.8	0.88		T	59	4.0	0.79
Stimulated to read more (Fall '00)	DL	16	4.1	0.89	Enjoyed the exam process (Fall '99)	DL	21	4.1	1.16
	T	36	3.5	0.95		T	41	3.3	1.23

Table 5: Survey items with any significant difference between the distance learning (DL) and traditional classroom (T) sections. Each was significant at least to the .05 level.

Why was the PLA approach perceived to be so successful? We believe its success comes from the increased control students have over the process, the flexibility in the process (that it takes place over a period of time) and that the students learn in so many ways.

5. Research Questions

We shall continue to rigorously evaluate PLA. Table 6 includes several of the research questions we shall be investigating.

Main Research Questions	Sub Research Questions
Does PLA improve students' learning?	Does active participation by students in the entire problem life cycle result in greater learning of class materials than traditional methods? If so, why?
	Does active participation improve students' assessment capability over time?
	Which activities and other aspects of active participation in the entire problem life cycle contribute most to learning, and why?
	For which kinds of courses and problems does active participation most effectively support learning, and why?
	Is active participation equally effective for distance and on-campus classes? How should this approach be tailored for these two settings?
Does PLA improve satisfaction of students and instructors?	Does active participation give students a deeper interest in the class materials than traditional techniques? If so, why?
	Which aspects of active participation in the entire problem life cycle do students and instructors find most enjoyable, and why?
	For which kinds of courses and problems do students find active participation more enjoyable than traditional techniques, and why?

How does PLA affect instructor's teaching and preparation?	Does PLA improve instructors' understanding of individual students' progress?
	Do instructors learn new ways to teach course materials from the use of PLA?
	Does the PLA approach integrate well with instructors' existing practices? What type of support do instructors need to implement PLA?
	Does the PLA reduce instructors' preparation time? How does it impact teaching time?
Does PLA's effect differ across cultures?	How does active participation fit into the varying educational, social, and cultural systems of different institutions and communities?
	How does student learning and participant satisfaction vary across cultures?
	How should differences in cultural and educational context reflect in the implementation of the PLA technique and in the design of PLA support software?

Table 6: Research Questions

6. Issues

Extremely interesting questions arise in the context of embedding peer assessment within learning activities. Pragmatic concerns also arise when coordinating a new teaching approach. While we cannot discuss these in detail here, we briefly mention several of them to demonstrate that we are aware of the complex nature of this educational research. Many of our research contributions will be solutions (or at least approaches) to these issues. Questions pertaining to them will be part of our evaluation.

Students have concerns when working with the PLA. They often believe it is the instructor's job to evaluate students. They feel unqualified to evaluate their peers, and indeed they often have no practice within an academic setting. Furthermore, when everyone in the class is responsible for evaluating a few questions, quality can be quite inconsistent. For all these reasons, there sometimes is a *perception* that the PLA is inherently unfair. Therefore it is critically important to explain to students that they indeed are qualified to assess concepts and people, and that they will often do this in the workplace (Hersam et al. 2004).

Equally important is assessment training and repeated experience (Kerr & Park 1995). Assessment is a skill that must be learned. Part of developing PLA will be developing methods to teach students how to assess. Training, experience and excellent guidelines should improve inconstancy in grading, and the ability to grade in groups should also help. We shall look into ways to build assessment training into the software, as other peer assessment systems such as the Calibrated Peer Review (CPR) system [http://cpr.molsci.ucla.edu/] does. (CPR provides automated feedback as students grade pre-loaded "calibration" essays, after which they can grade peers' essays.)

Guidance for all PLA tasks could be built into the software, including how to find and analyze information when solving the problems. We shall investigate incorporating inquiry-based methods within PLA and its software to better guide students in developing problems, solutions and evaluations.

Instructors can involve students in planning assignments. Several possible activities could get students to start thinking about developing problem statements, including developing a common concept map of the domain, creative brainstorming, etc. Students also could be involved in designing the assessment criteria (Hersam et al. 2004).

Students often are concerned about the lack of privacy when the process is not anonymous. Pressure to award positive evaluations to peers is offset by the desire for integrity when evaluations are entirely visible. Anonymity most likely is not practical in smaller classes when multiple sections cannot be combined for PLA activities.

Cheating is always an issue with on-line systems. Instructors should take advantage of anti-plagiarism services that are becoming available (such as turnitin.com [http://www.turnitin.com]). Answers cannot generally be copied from classmates because each student (or collaborative group) makes up different problems. However, the danger always persists that students will find someone else to do their work, and we shall continue to monitor techniques developed within distance learning programs to combat this.

Instructors may resist PLA and peer-assessment for many of the same concerns as students. In addition, because PLA is a new technique it necessarily will take time to learn and instructors will experience a learning curve until they are comfortable with it. Instructors also may be concerned with the additional time PLA takes (see below). The experimental results of this research should convince many instructors that PLA's benefits offset its challenges. Also, the PLAE support software will facilitate both students and instructors, reducing the cognitive overhead of participation.

Groups can work well or they can be disastrous. We shall incorporate many structural tools (e.g., for discussion, assigning roles, tracking tasks, voting) into the technique as well as the PLAE software, to ensure the groups collaborate effectively in the PLA process.

A practical issue concerns the amount of time the PLA takes. When instructors make up questions and then grade, students generally do the assignment and receive results quickly. The PLA process can take up to 2-3 weeks for classes meeting once a week and where part-time students might only allocate one day a week to homework. Instructors may need to engineer their classes so multiple PLA processes at different stages are underway at the same time (grading, answering questions, formulating new problems—each from a different topic in the course). As noted in §3.1, this actually builds in opportunities for reinforcement and synthesis as students work on materials from several topics at the same time.

The larger the class size, the more relative benefit PLA may bring. Instructors sometimes do not have time to give the detailed, thoughtful feedback that PLA will engender from peers. PLA, therefore, can free instructors from commenting on every activity. Instructors, of course, can give feedback on any individual activity, and (especially with anonymity at the peer level) everyone in the class will be able to read and learn from this.

A fascinating challenge for enhancing both quality and fairness will be to structure ways for students to dispute a grade if they feel it is too high. Doing so would be instructive for the disputing student, who would have to justify why his or her work was overrated, for the evaluator who potentially overrated, and the dispute arbitrator. One approach would be to award bonus points greater than the grade were the dispute successful. The graders could optionally lose points for grading poorly. We shall explore other mechanisms as well.

The right to dispute evaluations acts as a safety net for many fairness issues. Disputes can rectify most cases where students feel something has gone wrong, and instructors should take them seriously. The PLA model supports involving students in collaborative dispute arbitration, adding an additional level of learning to the process.

Writing the problem description, solution, evaluation justification, and disputes may prove a challenge. Students with varying writing abilities, including those for whom English is a second language, take the same technical courses.

Several aspects of PLA inherently teach workplace skills. Referring to the SCANS report [(Secretary of Labor's Commission on Achieving Necessary Skills) - http://wdr.doleta.gov/SCANS/], these include some of the basic skills, thinking skills and personal qualities, as well as the workplace competencies of managing resources and interpersonal relations. The basic skills include *reading* and communication through *writing*, as much of the PLA process takes place on-line and will require written rather than spoken responses. Thinking skills include *creative thinking* in all PLA processes, as well as *reasoning* when addressing unusual problems and unexpected solutions. Personal qualities include the *responsibility* and *self-management* promoted by PLA's active engagement and collaborative aspects. Dealing responsibly with peers should promote both *integrity* and *self-esteem*. The PLA process, group collaboration and leadership also teaches several workplace competencies such as *human resource management* (which indirectly includes PLA assessment and feedback), *time management*, *team member participation*, *serving clients* (in this case the team, people being evaluated and the instructor), *negotiation*, and *exercising leadership*. In addition, the ability to assess confidently also is a life-long skill.

An interesting side issue we hope to explore is whether PLA makes instructors better teachers. In part, instructors may improve because PLA imposes a student-centered, constructivist approach to teaching, which has been shown to be beneficial to learning. In part, instructors should find students learn better, and this may improve attitudes towards the class (and teaching evaluations).

Existing differences in educational systems and pedagogical approaches will necessarily influence PLA's application in different countries and multi-cultural settings. Both the PLA model and the PLAE software interface may have to be adjusted to the different contexts. To address this challenge, we will study PLA in many different settings.

7. Concluding Remarks

PLA pioneers a computer supported, student-centered learning approach that trains students to assess and builds the self-assurance to assess confidently. Such evaluation is a valuable, lifelong, everyday skill that incorporates critical thinking and analysis. In the classroom, the active participation and collaboration of the PLA process appears to result in deeper learning as well as increased awareness of, and interest in, the issues surrounding topics covered in class. This expanded awareness and deeper learning should translate into enhanced productivity in the workforce.

While we have just conducted preliminary studies, we are greatly encouraged and excited by the results of the participatory approach. We envision PLA becoming a major, general pedagogical tool. PLA will foster more knowledgeable students, confident and skilled in collaboration and subject-, self- and peer-assessment.

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