MUPPETS : Multi-User Programming Pedagogy for Enhancing Traditional Study

A Collaborative Virtual Environment designed to enhance student involvement in programming coursework

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Abstract:

The experiences of the authors and others in delivering coursework to students in the area of multimedia programming have lead us to seek ways to enhance student involvement. Through capitalizing on research in the areas of gaming and virtual community social psychology, the authors plan to develop a Collaborative Virtual Environment (CVE). This CVE will be aimed specifically at engaging upper-division students in the education of lower-division students. The authors propose to build on existing research and technical developments in the field to design and construct a CVE and supporting infrastructure. This will be aimed at encouraging and rewarding student engagement and peer knowledge-transmission.

Project Summary:

This project seeks to define a Collaborative Virtual Environment (CVE) for the express purpose of enhancing student education in the areas of programming and problem solving. We contend that the use of a CVE can be successful where other more traditional methods (such as lab tutors) have proven to be of limited utility, at best. The use of CVE's as educational tools is currently a focus of research at a number of institutions of higher learning [1][2][3], including R.I.T. This project would seek to capitalize on prior technical development of foundation applications [4][5], as well as seeking to integrate with current research projects funded by both the NSF and the Cornell Theory Center [6]. We propose to implement a CVE for the express purpose of aiding students in learning to perform more effectively in programming courses within the Department of Information Technology. Specific courses that would benefit from a system such as this would include: 4002-217, 4002-218, 4002-219, which comprise the undergraduate 'core programming sequence' in the IT department, and on the high end the 4002-734 and 4002-735 graphics courses, as well as thesis students doing work in virtual environments, shared space simulation, and Java programming.

The use of the freshman year to provide a programming core is not unique to the IT department, and is in fact implemented (and also problematic) at most institutions with a Computer Science program. It is the opinion of the applicants that while there is moderated success in many of these programs, there is a rapidly occurring shift in the overall student population such that students are no longer interested or engaged in their coursework, particularly in the first year. This can be seen in the general indifference to grades as a motivational mechanism, as well as general apathy to the first year of study. Because universities around the world are currently faced with the issue of how best to engage students in programming coursework, this study (once conducted) should be interesting to a large number of institutions at several academic levels. Our desire to develop the MUPPETS system is based on the following observations by the applicants in their teaching:

- *Students are not motivated to seek help outside of the classroom.* This is demonstrated by the fact that a majority of students do not attend office hours, or only attend office hours after failing major assignments. Through the inclusion of a CVE, materials designed to help students work on additional problems will be available at all times. As a CVE is collaborative, students will have the opportunity to ask other users in the system for help. The development and incorporation of 'Bots' or virtual beings, pre-programmed by the course instructor, will also serve to provide real-time interaction on demand.
- *Students in programming courses very rarely, if ever, seek out the advice of those upper-division students who have taken the course previously.* If students in both upper- and lower-division courses are using such a system concurrently, then opportunities arise for beginning students to seek advice and for experienced students to have 'contests' on who is the most knowledgeable and/or can help the most people. Indeed, if parts of the CVE are modeled after current game design practices, then it is in the interests of upper-division students to help tutor entry-level students, as this will enhance the reputations of the upper-division students within the virtual system. (See the recent proceedings of the Game Developers Conference [7][8] and essays on 'virtual glory' from Gamasutra [9]). Very careful attention will have to be paid to the constructs put in place so that users will gain prestige from actually instructing other users, rather than simply 'giving them the answer'.

- *The current tutoring system is inadequate in the sense that it requires students to go to the lab at specific times and thus is not 'always available'.* As a persistent CVE, the proposed system would be always present (so long as the server maintaining the system was operational).
- *Students lack a sense of community.* Many students perform poorly in classes for reasons that are not academic. Students otherwise capable of mastering the material often will fail through an apparent disinterest in either the community or their fellow students. This has been the topic of recent conversation with regard to student retention, campus life, and many other topics. Students can be proven to perform somewhat better when connected to a social entity like Computer Science House or the Electronic Gaming Society. As a CVE is, at its roots, a virtual community, it is our intention to use such a virtual place to foster a sense of community among programming students. This would be accomplished both by allowing the virtual presence of existing social outlets such as CSH and EGS, and by allowing the formation of 'groups' of users within the system on their own. Thus, students have a convenient mechanism to form (and re-form) groups based on their own social structures, but they can do so around curriculum enhancement (it is our hope that students in lower-division courses will bond with upper-division students, and the world will be designed to encourage such bonding).
- *Upper-division students need an outlet for creative programming.* They need an area in which to showcase their work. An interesting transformation occurs when students move through our programming sequence in multimedia: students tend to transform from users of systems in their early coursework into to users who are capable of architecting spaces of their own within systems and of extending the overall functionality of the CVE and other systems. The proposed CVE system would extend this model so that all students had an area in which to showcase their work (again capitalizing on game and 'virtual community' structures in which reputation is reward), and so that the most advanced students would work with the faculty to maintain and extend the system over time. Needless to say, this topmost level of participation would be desirable to a great number of students. In order to compete for that type of experience, students would have to be well known within the world. This kind of reputation is achieved by helping other students to learn. It presents a near-ideal mechanism in which students help other students because they feel it is in their own best interests that their fellow students grasp and understand the material.

The applicants to the project have already constructed a well-known collaborative virtual environment system, VNet, which was pioneering at the time of its release [10]. The applicants also have already secured some funding through the NSF to explore the use of CVE's and game technologies as effective measures in High School education (and in particular the biological and chemical components of high school science classes). Adapting pedagogy to virtual delivery is non-trivial, as can be evidenced by both successes and failures in the larger research community, and would require a significant effort on the part of the faculty involved to create materials complimentary to the courses in the programming sequence.

Additionally, the construction of large, graphically rich, multi-user simulation environments is, at best, difficult. If the system designed is not state-of-the-art it is doubtful that the system will be impressive enough to garner student interest at the outset. While the underlying crux of the experiment is to facilitate peer knowledge transmission, the 'hook' to garner interest is the graphical CVE, and as such it must perform solidly and become a place where students want to be, as participation can almost certainly not be mandatory. This project will involve the adoption and re-tooling of several current gaming technologies in the genesis of the MUPPETS engine, and will rely heavily on the ability of the faculty to lead and interact with student teams throughout the design and production phases. In addition, to provide persistence of data and recovery mechanisms the system must be back ended by a reliable data store (for this reason the authors plan to leverage our existing relationship with Oracle for server software and recovery techniques).

Targeted Learners and Educational Impact:

The number of students that this system could impact is enormous. At the time of this writing, in winter quarter, the IT department offers a combined total of 10 sections of 217 and 218, each of which is capped at 30 for a total of 300 students. This does not include 219, which has yet to be offered as this sequence is just now being phased into operation. If proven a successful educational strategy, the system could have significant impact beyond these courses as student could continue to develop modules of their own and incorporate coursework from other courses within the curriculum of the entire Institute. Such modules would be reviewed by the appropriate faculty whenever possible to prevent the spread of disinformation.

In short, this project seeks to provide a resource to students that has hitherto been almost entirely unavailable in virtual form: the ability to seek out and interact with study partners in their programs, with the added benefits of a visualization environment for both social interaction and problem solving. This has significant ramifications in learning style, culture, and the 'freshman experience', and, we hope, will further connect students with our program and the 'R.I.T. experience'. We believe this to be possible as many studies now indicate that virtual relationships can have a stronger social impact on the current generation than ever before (and in some cases stronger than real-world relationships) [12]. If students can connect with a system such as MUPPETS and become a part of that virtual community, then it is more likely they will continually seek out help and support from such a system even beyond their initial programming coursework. We believe that this lack of community and isolationism is a contributing factor in the freshman class' segmentation from the upper division, and that a system like this could significantly alter the entire college experience for those that move through it.

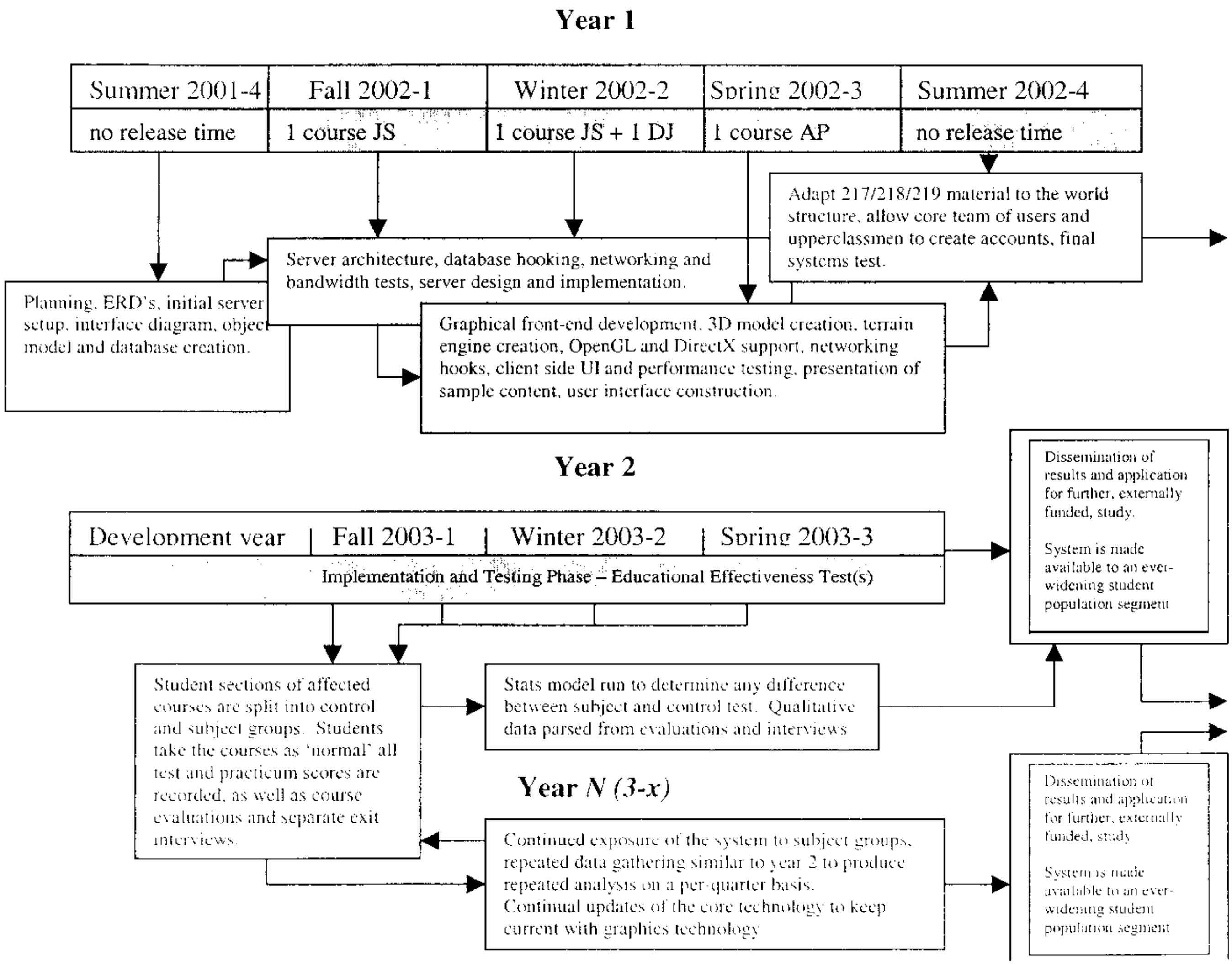
In assessing educational impact, the ideas of 'community' and 'overall learning environment' have long been vague and intangible. This system, while seeking to provide help outside the classroom, as opposed to inside it, is based on what we believe to be an accurate portrayal of the student mindset and experience. Further, because of the number of sections of the Java sequence taught every year, it is possible to have both control and test groups, and after a few years to have a large enough test-bed from which to draw a reasonable N to run a repeated measures analysis of variance, in addition to several other models to determine if student learning was impacted by the introduction of the MUPPETS system as an educational resource.

Timeline and Budget:

The development of this system is exceedingly complex; as such, the authors are asking for a significant amount of time to develop the engine and network infrastructure. Professional game engines of this type typically spend between 18 – 36 months in development with a staff of 10-20 full-time developers. We feel we can significantly cut this time by (a) incorporating approaches that are already well documented and have sample implementations available under Open Source agreements, and (b) use student teams to help with the development effort. Several students have already come forward as willing to participate in the design of the system, many of whom requested a preference for an independent study researching and building the system and publishing their findings as opposed to the traditional method of paid student hires.

We are requesting a total of four (4) course releases in order to have at least one (1) faculty member leading the development team at all times during the course of the development year (see figure 1). Additionally, the second year, while not requiring release time, does require faculty coordination of schedules such that the team members on this project teach the courses that are both pilot and control sections of the target population. The Chair of the IT program is aware of this and has given her consent to schedule the faculty in this manner as necessary.

Figure 1: Graphical Timeline and Planning Schematic for Development and Education Study



As shown in the preceding figure, this project hinges on four (4) course releases: two (2) for Prof. Jeff Sonstein (JS), and one (1) each for Prof. Donald Joy (DJ) and Prof. Andrew Phelps (AP). In consultation with the Chair of the IT Department we have valued these at $3,000 a piece. This accounts for $12,000 of the proposed budget listed on the form provided by the review committee. We have allocated $500 for incidentals, submission fees for conference abstracts, mailings, etc., which brings the total to $12,500. The Chair of the IT Department, Prof. Eydie Lawson, has initialed her approval on the attached budgetary form. Equipment expenditures are, thanks to the generosity of the IT Department, accounted for – the IT Department recently approved the purchase of a Sun workstation valued at approximately $25,000 to use as the server during the development and initial testing cycles. Oracle Corporation and Sun Microsystems are providing software through our existing campus-wide agreements without the need for renegotiation. Additionally, the faculty involved with this proposal will be preparing applications for additional funding from the NSF, DoE, and other agencies to extend this project beyond the life and scope of the beginnings proposed here (years 3-x).

Evaluation:

A. Human Subjects Issues

Sections of each course will be assigned to the experimental and control groups on a random basis. Each student in the experimental group will be provided with an explanation of the experiment, a no-consequences "opt out" process, and (at the end of the study) a summary of the findings and aggregated data with identifying information removed. Institute human subjects review processes will be followed.

B. Background and experiment/conceptual models:

Causality versus differences between groups:

> A perusal of research on teaching would soon convince one that the causal interpretation of correlational data is overdone rather than underdone, that plausible rival hypotheses are often overlooked, and that to establish the temporal antecedent-consequence of a causal relationship, observations extending in time, if not experimental intrusion of *X*, are essential. Where teacher's behavior and students' behavior are correlated, for example, our cultural stereotypes are such that we would almost never consider the possibility of the student's behavior causing the teacher's. [13]

Quasi-experimental research:

> Purpose: To approximate the conditions of the true experiment in a setting which does not allow the control and/or manipulation of all relevant variables. The researcher must clearly understand what compromises exist in the internal and external validity of his [sic] design and proceed within these limitations. Examples [...] Educational research involving a pretest-posttest design in which such variables as maturation, effects of testing, statistical regression, selective attrition, and stimulus novelty or adaptation, are unavoidable or overlooked. [14]

We shall utilize the t-test initially for showing that we have different groups, without getting involved in causality issues, to avoid those presented above. An analysis of variance model will then be employed after gathering and aggregating repeated-measures data for building causal-models, and this model will then be utilized for overall analysis (see figure 1, above).

C. Data-collection and sample-size: one-shot v repeated measures

We will use standard statistical formulae to determine our needed sample-size based on the level of error we are willing to accept. As the project increases in lifespan, the number of students in both control and experimental groups will continue to grow, producing an *N* large enough to (hopefully) produce statistically valid results.

D. Null Hypotheses (which we hope to reject)

- Experimental-group lower-division students will not seek advice from experimental-group upper-division students significantly more than control-group lower-division students seek advice from control-group upper-division students.

- Experimental-group upper-division students will not be reported to have enhanced reputations as compared to control-group upper-division students.
- Experimental-group lower-division students will not participate in the virtual environment's on-demand learning activities significantly more than control-group lower-division students participate in scheduled lab/tutorial activities.
- Experimental-group students will not report a greater sense of community than control-group students.
- Experimental-group upper-division students will not volunteer to work with the faculty to maintain and extend learning systems significantly more than do control- group upper-division students.
- Experimental-group lower-division students will not master programming concepts more than control-group students as measured by scores on the (existing) practica given to both groups.

Deliverables:

- Each quarter of development a report will be written documenting progress and current engine state, as well as any additional research efforts as needed in development.
- After the 'System Development Phase' (year 1), a report and documentation set for the system will be available.
- After the 'Evaluation Phase' (year 2) a final report will be available documenting the performance of the system as an education tool, using the statistical model(s) presented in 'Evaluation' and any additional qualitative data.
- Papers on the technical aspects of the system will be presented to the appropriate technical journals for review and publication, and the theoretical aspect of the CVE as a tool for student learning will be disseminated through both publication, presentation, and web presence to the R.I.T. community and the educational community at large.

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Annotated Bibliography:

[GT]= Game Theory [VE] = Virtual Environments [MUC]= Multi-User Culture / Virtual Community
[GE]= Games for Education [G] = Graphics

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Grant Application Budget 2002

Funds can be used for release time, student workers, and for purchasing supplies and services (such as CD pressing, video production, digitizing, photography). Funds will generally not be available for activities consistent with normal college business, doctoral research, equipment purchase or travel (though the latter will be considered if a clear connection can be demonstrated between the project and a given conference or workshop).

	Start and End Date	Total Amount	Budget Officer Verification
SALARIES:			
Faculty Compensation: (College guidelines for adjunct teaching pay-scale should be used.)	1 FALL 02	$3,000	eal
	2 WINTER 02	$6,000	eal
	3 SPRING 02	$3,000	eal
	4		
If you are requesting adjunct faculty money, include 8% of the salary dollars requested to cover the associated benefits.			
If you or another full-time faculty or staff member will be paid from the grant, the rate is 22.8% for benefits.			
Student Assistants: There are no benefits for graduate assistants or student workers.			
Other: (Professional services, consultant, staff support)		$500	eal
SALARIES TOTAL		$12,500	eal
MATERIALS: Give kind, quantity, cost:			
MATERIALS TOTAL		$	
SERVICES: Attach appropriate estimates.			
Educational Technology Center:			
Other: (Describe)			
SERVICES TOTAL		$	
TOTAL BUDGET REQUEST		$12,500	eal
COLLEGE SUPPORT: Support provided by college in addition to grant request, if applicable. (Explain)			