Provost’s Learning Innovations Grant for Faculty
Full Proposal, 2002-2003

Project Title: Programming Language Concepts based on LEGO Mindstorms

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Summary: Programming Language Concepts is a required course, typically taken in the third year of the Computer Science, Software Engineering, and Computer Engineering Technology curricula. I would like to develop new course materials based on the LEGO Mindstorms Robotics Kit and on the plethora of programming languages and platforms available for this kit on the Web. The gadget appeal of robotics and programming languages and platforms available for this kit on the Web. The gadget appeal of robotics and platforms available for this course to improve student motivation and challenge curiosity in this course.

Targeted Learners:
Students attending the Programming Language Concepts course in Computer Science, Software Engineering, and Computer Engineering Technology, which is a required course and suggested for the third year. The course meets four hours a week.

The proposed budget is for deployment of the materials in one section of the course (40 students per quarter). Full deployment could affect as many as 300 students per year in up to 3 sections per quarter; this would require an additional $5600 per parallel section. However, it is at this point not expected that each and every section of this course adopt this methodology.

The department has no Windows platforms that can be used for this course. Therefore, participating students are expected to provide their own host computers. Judging by the present experience with the course, this should not create a hindrance.

Anticipated Impact:
The Programming Language Concepts (PLC) course should introduce students to different programming paradigms and different languages for these paradigms. It should enable students to learn new languages on their own and to relate them to a general set of concepts so as to master them quickly.

In PLC one must teach a small subset of Lisp (required for later courses) and one typically introduces two or three other languages to illustrate concepts. There is a programming project in each language to encourage some active comparison.
Learning a programming language just for the sake of working on a more or less contrived programming project lacks motivation. Moreover, the projects tend to be geared towards the chosen languages, i.e., they tend to be fairly diverse and not encourage much comparison.

There are a multitude of programming environments for LEGO Mindstorms available from the Web, ranging from purely graphical and child oriented (thus illustrating the very essential concepts in visual paradigms) to cross compilation of small operating systems written in C, C++, and Java (illustrating parallel programming, low-level reaction to events, etc.)

For many students Mindstorms provide a very high gadget appeal which can be channeled into writing programs to solve very similar problems in very diverse environments, in order to study and compare paradigms in very different clothing.

By basing a PLC course on several different Mindstorms environments I expect to benefit from the gadget appeal to create and maintain more interest in different programming paradigms and thus increase student excitement about the course content and therefore improve participation, time spent on learning and discovery, and thus retention. [Consult http://www.vorlesungen.uos.de/informatik/robot06 about such a course from a low-level programming and mechanical construction perspective; the response was simply overwhelming.]

**Evaluation:** Computer Science typically offers two sections of PLC per quarter. I am currently scheduled for the 2002-1 quarter to run one section based on Mindstorms and one section based on the current format and to design a final exam common to both sections that focuses on concepts and paradigms to evaluate student performance. The results of the finals should then be compared.

I also propose to augment the usual evaluation questionnaire with questions aimed at motivational issues and at the question, how much time the students devoted to the course and if they found the time spent relevant to the course objective of learning programming paradigms. Maybe some interviews could be conducted by a third party, e.g., by one of my colleagues in computer science.

I would consider the new course format a success if performance on the finals by both groups is at least equal and if the evaluation documented some excitement.

**Report:** I always produce course materials, both, in HTML on the Web and in PDF for easy printing, and I always produce a copy on CD-ROM. These
materials are freely available. My Web pages on robotics in Osnabrück led to numerous contacts to industry and educational institutions in Germany and other countries.

I would also report on the results at least within the colloquium series in the department. Other well-targeted forums could include the lego-robotics newsgroup and O'Reilly's online article series which has had several articles on LEGO Mindstorms and education.

**Rationale:** Basing PLC on programming environments for Mindstorms is an experiment. I have some previous experience from the robotics course at the University of Osnabrück which leads me to believe that it should succeed.

However, the materials have to be focused differently in this case and they have to be updated considerably because development in this area moves at a very rapid pace. The department does not currently own any equipment appropriate for this project. Investing time (and money on the necessary kits for the students) in this kind of experiment cannot be regular college business, as desirable as the outcome may be.

PLC is an important course that impacts students in multiple disciplines. It is supposed to broaden the students' horizons: before PLC they have learned mostly one programming language; PLC should confront them with more and different ones and should enable and encourage the students to learn new languages on their own. This requires considerable persuasion before benefits of new paradigms can be appreciated. The gadget appeal of robotics should improve motivation and encourage students to master more on their own.

Creating robotics materials targeted to PLC requires a lot of work. My past experience is that a considerable amount of software from the Web will not perform as advertised, has to be documented and extended, etc. I am confident that I can find or create different paradigms but it will take some effort. Once the materials exist, however, they can easily be used by other faculty — at least, given a certain basic interest in robotics and a willingness to work with other paradigms rather than the customary format of choosing some languages of their own preference. Some of my robotics materials from Osnabrück are in use at other schools.

The proposed proof of concept of an alternative teaching methodology based on robotics for motivation has potential to be used in other computer science courses such as Operating Systems, Network Programming, or Computer Organization.
Dealing with robotics requires some interest in mechanics. However, the prerequisites for faculty and students are small enough: Mindstorms is targeted at 12-year-olds. The programming environments are for the most part no more convoluted than more conventional systems, they tend to be a bit smaller and should therefore require less startup time for other faculty willing to get involved.

Timetable: If this proposal is approved I will spend June through August 2002 developing the course materials for deployment on the Web prior to teaching the course in the 2002-1 quarter. I will produce a beta cut of the course CD which contains links to or copies of the relevant software.

I would ask the department office to acquire the necessary kits over the summer, well in time before the quarter starts.

I would try to recruit graders to meet weekly with the students by advertising near the end of the 2001-3 quarter.

As outlined above, the course based on these materials would be run in the 2002-1 quarter and compared with a conventional course run at the same time.

The results can be compared after final exams in the 2002-1 quarter, as soon as I have access to the evaluation forms. They can be presented at a computer science colloquium in the 2002-2 quarter.
### Grant Application Budget 2002

#### SALARIES:

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<th>Start and End Date</th>
<th>Total Amount</th>
<th>Budget Officer Verification</th>
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<tr>
<td>Faculty Compensation:</td>
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<tr>
<td>Equivalent of one summer course for myself</td>
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<td>If you or another full-time faculty or staff member will be paid from the grant, the rate is 22.8% for benefits.</td>
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<td>Student Assistants:</td>
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<td>2 graders at 10 hours per week for 10 weeks in quarter 2002-1</td>
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**SALARIES TOTAL**

9588.40

#### MATERIALS:

- LEGO Mindstorms (Team Challenge USB Pack) 230.00
- 9 Volt Angle Sensor 16.95
- Remote Control 20.00
- 20 Kits for 20 groups of 2 students, 1 Kit for graders

**MATERIALS TOTAL**

5605.95

**TOTAL BUDGET REQUEST**

15204.35

1921.55