COMPUTER SUPPORTED GENERATIVE LEARNING

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1. INTRODUCTION

The rapid changes in technology, the explosive growth in global competition, and the restructuring and flattening of organizations are dramatically changing the career requirements of computer scientists and engineers. It has become crucial to engage in a life-long learning process, where knowledge and skills are continually updated to maintain professional vitality. We term this learning process *generative learning.* Our work uses modern computing and communication technologies to provide a generative learning environment in which professionals will enjoy maximum support for their learning activities. In this paper, we present a computer supported generative learning (CSGL) model where the learner goes through cycles of learning-application-assessment over different time scales. Key components of our model are multi-grained assessment and cooperative learning. We describe a knowledge-based framework to support these activities. Our proposed CSGL environment will enlevin and enrich life-long learning by providing the instructional and organizational resources needed to plan, execute, manage, and regularly assess the progress of the integrated career and education processes.

2. CSGL MODEL

We define *Computer Supported Generative Learning (CSGL)* as the application of computing and communication technologies to actively support the instructional and organizational activities that provide life-long learning in an environment where the learner goes through cycles of learning-application-assessment at different time scales. In this environment, a person's career and education go hand-in-hand and therefore they must be integrated in a common framework.

Integrated career and education activities are complex, demanding, and cyclic. Hence the term *generative learning activities* [Desmond94]. These GL activities have to be carefully planned, managed, and progress must be regularly assessed. Equally important is the cooperation among the learning professionals, academia, industry, and professional societies to successfully develop and implement the framework needed for such activities.

Computing and communication technologies improve connectivity, presentation, organization, and convenient interaction. Consequently, they have the potential to support GL activities. A system for CSGL should satisfy the following requirements: (1) provide processes to strategically and effectively plan for career and education; (2) provide an integrated framework for career and education planning activities and processes; (3) provide coherent structure to CSGL offerings; (4) provide tools for management and regular assessment of career progress; and (5) integrate computing and communication technologies into the GL processes to maximize supporting all of the preceding requirements.

Figure 1 shows our CSGL model. The input in this model is principle-based career goals and the output is sustained professional vitality. To formulate his/her plans, the learner seeks external career and education guidance to enhance the probability of career success and the opportunities available for career growth. The learner goes through cycles of planning/learning-application-assessment over different time scales. In each cycle, equipped with an appropriate plan, the learner uses past learning to analyze problem situations and apply *selected* optimum solutions. He/she then assesses the results to learn from this application of past learning. Using this process, the principal components of our CSGL model are described as follows:

- *Plan career/education:* the career/education plan provides a strategy for success: it identifies necessary areas of focus, organizes activities to meet deadlines, and help keep track of planned career and educational priorities and goals [Johnson94].
- *Plan project/semester:* similar to the career/education plan but has a shorter range; the semester/project plan includes a curriculum of courses to take and projects to pursue.

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- *Attend courses/workshops/OJT (On-the-Job Training):* these provide academic and technical competences and skills needed for a professionally vital learner.
- *Assess knowledge/skills:* the assessment process identifies the differences between the current capabilities and skills of a computer professional and those required of his/her chosen career path. Based on the progress assessment, plans need to be updated. Goals might also change occasionally to adapt to changes in the work environment. Observe that our model requires multi-grained assessment: at a coarse level of granularity, a career/education plan has to be regularly assessed and updated if needed; assessment must also be applied at a finer level to project/semester plans, and at an even finer level, to courses/workshops/OJT.

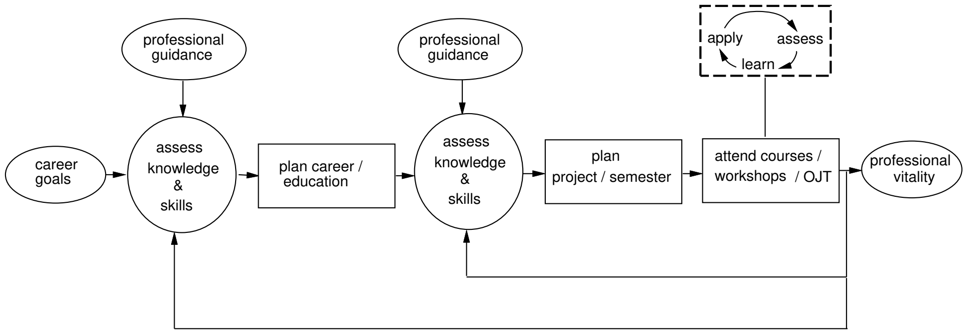

Figure 1: CSGL model.

3. KNOWLEDGE/SKILL ASSESSMENT AND COOOPERATIVE LEARNING

A computer supported courseware should model all aspects of the teaching and learning process, namely, declaration, construction and dialogue [Brailsford95]. The majority of the courseware currently available makes effective use of the technology only for the declaration aspect. Usually, declarative material are electronically published, for example, in a course directory or on a Web page. Such limited use of technology is, however, not sufficient to support the constructive and dialogue aspects. Just posting assignments electronically or carrying discussions on a course (private) electronic mailing list are common examples of very limited use of technology.

As to assignments, there should be a CSGL system, where assignments are dynamically generated to address weaknesses and reinforce concepts. Clearly, this constitutes *knowledge/skill assessment* at a very fine level of granularity. As mentioned earlier, knowledge/skill assessment must be carried out at different levels. At each level, the system should effectively support knowledge/skill assessment followed by some form of plan to close the gap between the learner's goals and his/her current skills and knowledge.

In case of discussions, if a help question asked by a student on a private mailing list is not answered by the teacher or other classmates, then the question should be forwarded to other experts, bulletin boards or other forums. Therefore, in a CSGL system, the help request is escalated (possibly under user control) until it can be answered [Ackerman96]. This escalation mechanism truly supports the concept of *cooperative learning.* The system would not only allow for a closed interaction between the instructor and his/her students, but also allow for an open learning environment, where one can learn from peers and experts.

Figure 2 shows our proposed architecture to effectively support both the construction and dialogue teaching/learning aspects through knowledge/skill assessment and cooperative learning.

The architecture has a *knowledge base* which provides the user with assessment questions and feedback in terms of current strengths, weaknesses, and teaching tools to address those weaknesses. This feedback depends on the user's knowledge state, which is derived from the user's answers. This knowledge base also contains answers to commonly asked questions. New questions are automatically escalated to relevant subject experts and their answers are then placed in the knowledge base. Experts could be bulletin boards, software agents, or other people. A *dialogue box* provides an

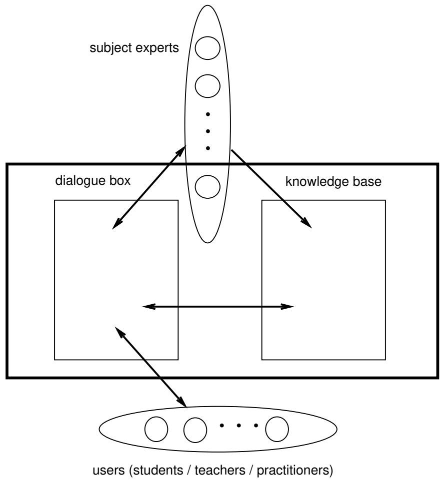

Figure 2: Knowledge-based architecture for CSGL.

interactive interface that allows the user to ask help questions and receive answers from other users, experts, or knowledge base. The dialogue box also allows the system to ask the user assessment questions at various depth levels and give him/her feedback.

4. CONCLUSION

We introduced CSGL to provide maximum support for life-long learners. Our approach is innovative. The CSGL model is inspired in part by the work in [Johnson94] which presents a flowchart for career/education processes. Unlike [Johnson94], our work includes multi-grained assessment, and is based on utilizing computing and communication technologies to maximize supporting GL. Our knowledge-based system, unlike previous work, supports *both* knowledge/skill assessment and cooperative learning dialogue in a common general learning framework. For example, [Thiery95] discusses a system that only assesses knowledge in mathematics grades 4 to 8. [Brailsford95, Ackerman96] discuss Answer Garden, a system developed at the University of California - Irvine to provide structured assistance to professionals. Future work remains on the technology infrastructure including networking support and knowledge-based system implementations.

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