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ABSTRACT

Two graphic computer simulations have been prepared for teaching high school and middle school students about how business organizations and financial systems work: "Parkside," which simulates managing a hotel; and "Guestwear," which simulates managing a clothing manufacturer. Both simulations are based on six principles of constructivist design proposed by the authors: (1) students generate the knowledge as much as possible; (2) knowledge is anchored in authentic situations; (3) cognitive apprenticeship methods are used; (4) knowledge is situated in multiple contexts; (5) cognitive flexibility is created; and (6) students collaborate in knowledge construction. Both simulations are implemented in the "Toolbook" hypermedia authoring environment running in Windows on the schools' computers. Problems with the initial field test were in the area of school and teacher involvement rather than that of student enthusiasm. A second brief test with a receptive teacher suggested that students learned from the simulation and improved in higher level thinking. (Contains 16 references.) (SLD)

Title:

Constructivist Design of Graphic Computer Simulations

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Several proposals have appeared recently arguing that the design of educational systems should take a constructivist rather than an instructional approach (e.g., Bednar, Cunningham, Duffy, and Perry, 1991; Harel and Papert, 1991; Newman, Griffin and Cole, 1989). However, while there are established, integrative frameworks for guiding the design of instructional systems (e.g., Gagne, Briggs and Wager, 1992; Reigeluth, 1983; Romiszowski, 1981), there does not appear to be an integrated framework for guiding the design of constructivist educational systems. We take a first step in this direction by proposing six interrelated principles for constructivist design. Versions of the individual princples have appeared in a variety of places, but we have tried to formulate them in such a way that they work together.

The six **principles of constructive design** that we propose and their sources are:

1. Set the stage but have the **students generate the knowledge** for themselves as much as possible (Jacoby, 1978; Black, Carroll and McGuigan, 1987)

2. Anchor the knowledge in **authentic situations** and activities (Cognition and Technology Group at Vanderbilt, 1990)

3. Use the **cognitive apprenticeship** methods of modeling, scaffolding, fading and coaching to convey how to construct knowledge in authentic situations and activites (Collins, Brown and Newman, 1990)

4. Situate knowledge in **multiple contexts** to prepare for appropriate transfer to new contexts (Gick and Holyoak, 1983)

5. Create **cognitive flexibility** by ensuring that all knowledge is seen from multiple perspectives (Spiro, Feltovich, Jacobson and Coulson, 1991)

6. Have the **students collaborate** in knowledge construction (Johnson and Johnson, 1975)

We have created two graphic computer simulations for teaching high and middle school students about how business organizations and financial systems work (these programs are currently being used in a number of New York City public high schools). The two simulations are *Parkside*, which simulates managing a hotel, and *Guestwear*, which simulates managing a clothing manufacturer (formative work showed these topics to be motivating to the urban student population we targeted). Both of these simulations are implemented in the *Toolbook* hypermedia authoring environment running in Windows (3.0 or higher) on 386/486-based IBM and equivalent computers. Here, we use the design and use of these simulations to illustrate how the constructive design principles can be applied.

For example, in *Parkside* we set the stage for student knowledge generation **(Principle 1)** by providing an authentic hotel environment for the students to interact with, while providing supplemenatry information that the students can use to figure out how to accomplish goals and deal with problems that arise in this setting. As they sit in their simulated office or wander around the simulated hotel, various problems arise (through interacting with simulated people, reading memos, answering phone calls, etc.) that they have to deal with. They gather relevant information that they can use to figure out how to deal with the problems through a variety of information sources that the simulation provides (e.g., an icon-activated "Managers Guide" that whenever requested can provide context-sensitive advice and feedback; an icon-activated quantitative report that provide a variety of performance indices like occupancey rates, income, customer satisfaction, newspaper articles, advice from staff at simulated meetings that can be called at any time, etc.). This fairly-realistic graphic display and the underlying functional relations (implemented as a set of complex if-then rules and equations) provides the authentic situations and activites that anchor the material covered (**Principle 2**). Thus the students deal with business concepts like supply and demand or the importance of a trained workforce not in the abstract, but in terms of concrete actions needed to make their hotel work better.

The students get started on the *Parkside* simulation by having the teacher "walk-through" an initial portion of the simulation designed for this purpose (module 0) verbalizing how he or she is thinking through the situations and problems encountered. Gradually the teacher fades out their contribution to this "walk-through" and the thinking is taken over by the students in a class discussion. Then the students proceed through the rest of the simulation (modules 1-5) working in groups around computer workstations while the teacher walks around the room providing help (scaffolding) and advice (coaching). Thus the students are introduced to and guided through the simulation using a cognitive apprenticeship approach (**Principle 3**). Cognitve apprenticeship is also provided in the simulation program itself by the "Managers Guide" and other information aides mentioned earlier that the students can activate whenever needed.

The students work through the simulation in groups (generally four per group in the current sites) around each computer so that they can collaborate on exploring the simulated world and making decisions (**Principle 6**). Since the various group members each have their own perspectives on the material, the discussion in the groups and the later discussion between the groups provide multiple perspectives (**Principle 5**). Multiple perspectives are also provided by design in the comments and suggestions made by the simulated people of the hotel world. Most of the knowledge that we want the students to learn appears in more than one context in the *Parkside* simulation, and later is covered again in the *Guestwear* simulation, which provides them in the very different context of a simulated clothing manufacturer (**Principle 4**).

Problems with Initial Field Test

For an initial test of the effects of the *Parkside* and *Guestwear* simulation programs, we placed them in two New York City public high schools using computer laboratories donated for this purpose by IBM. These schools were quite happy to accept this computer equipment and have us run our simulations there as part of their *Introduction to Occupations* course, and the students received the programs enthusiastically (e.g., attendance skyrocketed to virtually 100%), but the school adminstrations balked at moving beyond this superficial involvement.

The first sign of trouble was the school administrations refusal to give the teachers release time to receive training in how to use the program and the teachers were unwilling to devote their own time to this. In fact, the depth of teacher training needed soon became apparent: the teachers not only had no experience using simulations (and not much using computers in general), as part of their teaching but, the mode of thought embodied in the simulation was completely alien to them. In particular, the simulations were designed to inculcate a mental model style of thinking (e.g, Gentner and Stevens, 1983; Mandinach, 1989) about business and financial systems. Thus we wanted the students to learn that making decisions can affect a system of interacting entities in various ways (e.g., increasing hotel room rates might increase initial revenue but depending on circumstances might decrease occupancy rates and change the image of the hotel, and so forth). The teachers never did grasp this style of thinking: they kept insisting that there was no way they could teach using the simulation unless we told them what the "right" answer is at each decision point. In the end, our project team had to take over the parts of the class using the simulations.

Even worse, when the time came for us to administer a test (presenting a new business case and having the students make decisions and explain their decisions), the Principals of the schools refuse to let us test their students. It seems at the point they had gotten what they wanted from the project (e.g., new computer labs) and did not want to chance our revealing any weaknesses in their students. Thus, we were not able to evaluate the effects of the simulations, but we were left with an appreciation of the difficulties of accomplishing anything within the current organizational structure of the New York City Public Schools.

A Quick-and-Dirty Field Test

Fortunately, we were able to use an *Applied Economics* class in a Connecticut public high school to do a pilot pre-and post-test using our assessment instrument with a class that used the *Parkside* simulation. The teacher of this class is a graduate student in our department and thus has the requisite understanding of computers, simulations and cognition to make meaningful use of the simulation. The tests administered described new business cases (e.g., managing a pizza parlor) and required the students to make a series of decisions about the business (choose from a set of alternatives), acquire new vocabulary about business and economics, and explain their reasoning in essay questions. the class was composed of 16 students, and 12 of them completed both the pre-test and the post-test (which were equivalent but with different content). These 12 students improved form the pre-test to the post-test 10% on the multiple-choice decisions, 13% on the vocabulary (being able to explain what the terms mean) and 22% on the quality of reasoning expressed in their essay answers. Thus, while far from definitive, these results suggest that the students are indeed learning from the simulations and improving most in higher-level thinking (the essays). Particularly interesting was the teachers report that 2 of the 12 students had been uninvolved in the classroom part of the course, but became enthusiastic leaders during the simulations. This suggests that simulations like Parkside may reach students who do not relate to other methods of instruction.

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