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# The Design of Goal-Based Scenarios

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Outside school, people typically learn during their experiences while addressing desired goals. The Goal-Based Scenario (GBS) framework describes computer-based learning environments that exploit this simple fact. In this article, we propose a structure and a set of design criteria for learn-by-doing environments that enable students to work towards desired goals. A key issue we address is the content to be taught by GBSs. Because skills are the form of knowledge that, when applied, enable students to achieve valued goals, we argue that GBSs should be designed to teach a set of target skills required to achieve a specified goal. Two programs we built prior to specifying GBSs but motivated by many of the same ideas will be analyzed according to the proposed principles. We conclude by briefly describing tools currently under development to facilitate the construction of GBSs.

An interest is a terrible thing to waste. This is perhaps the simplest way to express the fundamental principle underlying our ideas about education. In another article in this issue, Schank (1993/1994) reviews some problems with the present educational system and argues that many of these shortcomings can be addressed by restructuring courses around what we termed Goal-Based Scenarios (GBSs; Schank, 1993/1994).

GBSs are problems in the domain of a student's interest that present definable goals and encourage learning in service of achieving those goals. A GBS is a type of learn-by-doing task with very specific constraints on the selection of material to be taught, the goals the student will pursue, the environment in which the student will work, the tasks the student will perform, and the resources that are made available to the student. For

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example, tasks such as composing a piece of music, designing a car, or starting a business each can provide the foundations for a GBS.

In this article, we aim to make this notion meaningful by describing, as precisely as possible, the constraints on the development of GBSs. We introduce a general structure for GBSs and discuss the design principles that apply to each component. Examples of software and courses that embody the important ideas of GBSs are used to illustrate the principles involved in their design. The heart of our thesis is that all courses should be constructed in the form of GBSs. The goal to be achieved by the task should be stated in such a way that the student will genuinely want to accomplish it. The course designer must construct a course that both motivates and enables the student to acquire the skills necessary to accomplish that goal. As long as the goal is of inherent interest to a student, and the skills that are needed in any attempt to accomplish that goal are those that the course designer wants students to learn, we have a match, and thus, a workable GBS. Learning will occur as the student discovers a need to know in order to complete the current task.

The structure for GBSs proposed here is designed so that the various components can be analyzed according to their potential to achieve these aims. We intend this structure as a guide to the development of the educational software we are building at The Institute for the Learning Sciences. We hope it will be useful elsewhere as well. Note, however, that GBSs are not a type of educational software, but rather an approach to teaching. There is nothing about GBSs that prevent them from being implemented without computers. Building a house, for example, might make a wonderful GBS that could be used to teach a myriad of skills. Nevertheless, we do feel that computers are particularly well suited for implementing GBSs because they may facilitate meeting prerequisite conditions that, although often difficult to achieve in the classroom, are necessary for the proper use of GBSs. Therefore most of the examples of GBSs we mention are computer based, and the design principles we discuss are intended primarily for designers of educational software.

## SO WHAT IS A GBS?

GBSs are developed based on skills a student can learn. Consequently, designers need to express their pedagogical objectives in terms of skills they would like students to master rather than topics to which they would like students exposed. The emphasis on working towards a goal serves to ensure that designers will include opportunities to acquire and practice useful skills while illustrating to students the potential utility of the skills they are learning. GBSs essentially comprise a clear, concrete goal to be achieved, a set of target skills to be learned and practiced in service of this goal, and a task environment in which to work. To emphasize the role of the goal in GBSs, we have adopted the metaphor of a student embarking on a "mission."

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The type of task environment in which the mission is pursued will be referred to as the mission focus. These terms are discussed later.

The fundamental idea underlying this model is that learning of skills takes place within some authentic activity. This notion is both an observation arising from research in the anthropological tradition and a theory arising from psychological accounts of learning. In the former case, this notion was expressed in terms of situated cognition (Brown, Collins, & Duguid, 1989). In arguing for the inseparability of concepts, activity, and context, Brown et al. (1989) paint a picture of learning in which the situatedness of instruction facilitates comprehension, retention, recognition of the conditions of applicability, and when the situations are varied, transfer. The observation that learning in a task context is characteristic of most apprenticeship styles of learning led Collins, Brown, and Newman (1989) to propose cognitive apprenticeship, which adapts characteristics of traditional apprenticeship instruction to thinking skills. This model further suggests an alternative role for the classroom teacher (i.e., as a mentor who gradually reduces the level of coaching given the student). The GBS framework shares with cognitive apprenticeship an emphasis on practicing skills within an authentic context.

Anchored instruction (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990) is also based on the principles underlying situated learning. Anchored instruction is a model of instructional design in which the student acquires knowledge to be used rather than facts to be remembered. This approach calls for creating an authentic task environment in which learners can appreciate the utility of the skills and knowledge they are acquiring and, furthermore, can recognize conditions under which these skills are applicable. Anchored instruction is similar in some respects to the GBS framework: Both recognize the importance of situating activity, and both regard the authentic practice of skills as essential.

However, GBSs differ from anchored instruction in an important way that relates to our use of the phrase *goal-based*. The role of the student in anchored instruction activities includes observing some events (e.g., a video), verifying the accuracy of the information, looking for clues in the materials, and applying those clues to solving a problem faced by some character (Cognition and Technology Group at Vanderbilt, 1990).

In a GBS, on the other hand, the student becomes an active participant in the scenario. The student's motivation within a GBS is to move toward completing some task on his or her own behalf. We do not mean to imply that anchored instruction prevents students from assuming a participatory role within the simulation. Rather, we wish to highlight how central the students role is in a GBS. GBSs and anchored instruction both have in common the end goal of overcoming the inert-knowledge problem. However, anchored instruction attempts to provide opportunities for teacher-guided discovery, whereas GBSs strive to create environments in which the target issues arise naturally in the course of pursuing the defined objective.

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GBSs can be designed for almost any domain and skill. Their wide applicability, however, may tempt one to call virtually anything a GBS. In order to make the concept more meaningful, and to inform the design of new GBSs, we first introduced two educational software systems that were developed with the same basic philosophy that underlies GBSs and constituted important steps in our development of the framework. In fact, part of the motivation for the work described here was our desire to better understand the common properties of the software we have built in order to facilitate the construction of such systems in the future. Even though the software systems we describe as follows are not complete GBSs, they provide a basis for discussing their properties and the design criteria they would need to meet to be effective as learning environments.

## Broadcast News

The *Broadcast News* program (Kass & Guralnick, 1991) teaches high school students a variety of social studies topics, such as history, political science, international affairs, economics, current events, and journalism, by allowing them to produce their own TV news show. Students using the program work with real news sources—that is, actual newswire text and news video footage—for a day in the recent past. The stories are selected based on the important social studies issues they relate to, and the tasks students must perform require them to understand those issues. Subject-matter experts (e.g., political science and journalism professors) are available through video to answer students questions about the stories and to challenge the students' decisions. The end product of a session with *Broadcast News* is a videotape of the newscast a student has put together.

A student using *Broadcast News* typically plays the role of producer. This role is fairly complex and requires the student to organize the stories for broadcast and edit each story to a reasonable quality and length. The student can also take on the additional responsibilities of writer and on-camera anchor if he or she desires. The computer fills the roles that the student does not play. The following description revolves around a student new to the system, who plays the entry-level role of assistant producer.

As assistant producer, a student edits a story assigned by the executive producer. The system presents the student with a rough draft of the story along with video clips that will be shown during the presentation of the story. The program allows the student to read the source material upon which the story is based, to watch the video clips that the writers (whose role is played by the computer) have selected, to ask questions about the content of the story, and to request that specific changes be made to the story by the writers. To get the student to think critically about issues in the news and about how best to present a given story, curriculum designers who develop the initial stories intentionally place errors and biases into the stories, leave important things out, or choose a confusing video to accompany the story.

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Here is what a student might experience when using the *Broadcast News* system. The student first sees a brief introduction informing him or her that he or she will be working on a newscast for a particular day in history; for example, one date that is used is May 21, 1991. The student is then given a rough draft of a news story that requires revision so it can go on the air. The first sentence of one of the stories for May 21, 1991 is as follows: Rajiv Gandhi was assassinated today at an election rally near Madras. The student may not understand this sentence when he or she first reads it. Many students did not know who Rajiv Gandhi was or where Madras was. Some did not know what an assassination was.

A student who did not understand what the story was about could click on the history button. This brings up a list of general background questions about the story as a whole. One such question in this case is: What makes this story newsworthy? Selecting this question brings up video of an expert journalist explaining that Gandhi was a world leader and that news is the reporting of change, such as the death of a world leader. Whenever a question is answered, the student is offered a set of follow-up questions that he or she can then ask the expert.

Once the student has read and understood the story, usually with the help of the experts, he or she is ready to consider what changes are desired. The student can send parts of the story back to the writers to be rewritten with instructions as to what type of revisions he or she desires. For example, a student who did not know who Gandhi was may wish to include Gandhi's title in the first sentence, so that viewers do not experience the same confusion. A student can also edit or replace the video footage that accompanies a story.

It is important to note that none of the choices is intended to be right or wrong in any absolute sense. Different students will make different choices, just as different TV stations make different choices. Of course, the fact that there is no definitive right answer does not mean the experts do not have their preferences. If the student opts to include a lot of gory detail about the method of assassination, the program's political science expert might object with a comment such as, "I think that the details of the assassination are less important than what this means for the future of Indian democracy." But the fact that an expert objects does not mean the student has made a bad choice. Often, the student will find that the experts have incompatible opinions. The student may be challenged no matter what they choose. The purpose of the challenges is to ensure that the student thinks about what the important issues are and makes an informed decision.

After the student gives final approval to a story, he or she can then choose to play the role of anchorperson for the newscast as well. The program then acts as a teleprompter and editing booth. The student reads the story as the text rolls by on the screen. A video camera controlled by the computer records the student as he or she plays the role of anchor; the computer also supplies the video footage that accompanies the story. A complete videotape

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of the student's newscast is ready as soon as the newscast ends. After anchoring the broadcast, the student can watch this tape, and then, for comparison, can watch a professional network newscast from the same date. Incorporating the edited story in an actual broadcast allows students to create artifacts comparable to those they already hold in esteem. Comparisons among student broadcasts as well as to actual network broadcasts provide a good starting point for class discussions; such comparisons also allow students to take pride in their accomplishments, reflect on what they have learned, and develop an appreciation for the power of the skills they have developed.

## Sickle Cell Counselor

*Sickle Cell Counselor* (Bell & Bareiss, 1993) is an exploratory hypermedia system that The Institute for the Learning Sciences designed for the Museum of Science and Industry in Chicago. The program provides a basic understanding of sickle cell disease by offering museum visitors the chance to assist couples who seek genetic counseling and express (for various reasons) an urgent desire to learn more about the disease. Visitors perform activities that our data has suggested they find engaging, including performing laboratory tests, asking questions of several experts, calculating the probabilities of different outcomes, and advising clients about the results of their tests.

For a novice user (which almost all of our users are), being asked to counsel clients in matters regarding sickle cell disease is likely to be met with, at best, only a vague sense of what to do next. To help the user, an experts screen is available that provides access to four experts: a physician, a geneticist, a lab technician, and a guide. The geneticist and the doctor have similar roles—offering expert knowledge to the user at appropriate times. The lab technician also provides some expertise, but in addition helps the user with the mechanics of the blood lab. The guide serves as the voice of the tutor, offering help and suggestions regarding not only how to navigate through the program, but also what to look for and what to try next. The questions that each expert is prepared to answer change, depending on what the student is doing when he or she asks for help.

An important step in determining clients' risk factors is identifying their hemoglobin gene types. The program provides access to a simulated blood lab—the user can draw blood samples from each client, view them under the microscope, and perform a conclusive lab test. In the course of using the blood lab, users see what red cells look like and how sickling affects their shape. Users also observe how the differing electrical properties among hemoglobin types permit their differentiation within an electrical field.

To calculate the clients' genetic risks, the user can access a Punnett Square—a simple visualization tool most secondary school students see in biology class. This Punnett Square also acts as a graphical spreadsheet, allowing the user to

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TABLE 1
Client Responses to User Advice in *Sickle Cell Counselor*

| *User's Advice* | *General Client Response* |
|---|---|
| "You don't need to worry about sickle cell." | Clients become more specific about what it is that is worrying them. |
| "Let's get more answers." | Clients imply what they would like to find out. |
| "It's too risky for you to have kids." | Clients angrily insist on a more detailed justification. |

select the gene types for each parent (i.e., normal [AA], trait [AS], or disease [SS]) and then watch the resulting possibilities get filled in.

When ready, the user can elect to advise the clients by selecting one of three types of advice from a menu. The clients' reaction depends on what the user has explored but, as shown in Table 1, can be generalized according to the type of advice the user offers.

Once the user calculates the clients' risk factors, he or she can then give another form of advice, namely, "You've learned enough. Do as you think is best." Choosing this option leads to an epilogue in which the clients return a year later to report their decision and its outcome. If the user determined the clients' risk factors, then the clients express their gratitude, even though in some cases the outcomes are worst-case (i.e., a child born with sickle cell disease). In contrast, a user who ends the session before determining the risks will see clients frustrated and angry about having to make decisions without sufficient information.

These example programs will be revisited in our discussion of the design of various GBS components. We turn now to an examination of what constitutes a GBS. This analysis is based on the components that are necessary to achieve the pedagogical goals of a GBS as well as the design criteria these components should meet. GBSs challenge the status quo on two fundamental fronts: the type of content to be taught and the methods of presenting this content. We begin by reviewing the goals from these two perspectives.

## WHAT GBSs TEACH

### The Role of Skills in GBSs

Presently, curricula call for a certain set of subjects to be covered. Verifying that students have learned the subjects is a primary concern of the educational establishment because it provides the basis for the evaluation of the student. Verifiability has consequently become a fundamental selectional criterion for content. Facts, of course, are the easiest thing to verify. Standardized tests by which schools are evaluated have resulted in the teaching of a largely uniform set of facts.

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Little attention is given to the utility of the material presented. What will the students do with what they have learned? Clearly the answer right now is, in all likelihood, forget it. But it is the promise of being able to apply knowledge that makes that knowledge valuable to a student. Multiplication, for its own sake, is pointless. However, when the need to multiply numbers arises naturally in the context of a task, the value of the skill is not something of which the student needs to be convinced. Students should learn that knowledge of this skill enables them to accomplish a desired task.

Two classes of knowledge promote this sense of empowerment: skills and *complex systems.* A skill is valuable both to the student, who upon its acquisition feels empowered, and to society, which relies upon a skilled population. By complex systems, we mean domains that are characterized by underlying sets of causal relationships that result in the phenomena characteristic of the domain. That is, we are interested in the systems and processes of the domain. Such systems include the circulatory system, an automobile engine, democracy, or capitalism. These systems differ from facts in that knowing a system entails understanding a functional process, whereas, in one sense, knowing a fact *as a fact* simply means the ability to recall it. Understanding complex systems allows students to make predictions and create explanations for the various phenomena occurring in the world around them. Moreover, skills are usually exercised in the context of a larger complex system. People participate in these systems by performing skills that achieve some necessary subgoals of the system. Understanding these processes therefore allows students to appreciate the role their skills play in an overall system.

The desire to teach certain skills or systems is therefore a valid reason to develop a GBS. Teaching complex systems directly, however, runs the risk of degenerating into teaching facts. Moreover, as opposed to skills, which can be learned by using them to accomplish a goal, the simple presentation of a system to students is not relevant to any of their goals and therefore does not provide any motivation. Complex systems, therefore, should not be taught by being presented directly, but instead by identifying a goal to be achieved and a set of skills the student can learn and apply in the context of the system in question. The proper application of the skills and consequently the achievement of the goal should depend on an understanding of the process. Enforcing the use of skills to teach complex systems ensures that students will continue to learn by doing, the method we believe to be most effective.

It is neither plausible nor desirable to teach the same set of skills to every student, however. People's interests and goals vary. Students are more likely to learn a skill if it is one they have chosen to study or one for which they have great aptitude. It is more important that students learn, and be excited about doing so, than it is to specify precisely what is to be learned and when. Allowing students choice in the interests they will pursue is therefore critical. As long as they are choosing from material that has been judged to be

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worthwhile, we can be sure they are not wasting their time. In most of today's classrooms, all students are presented the same material at the same rate because of constraints on the delivery of material and the desire to have a basis for evaluation. The inherent nature of skills, as well as the diversity in student exposure to skills, necessarily complicates the evaluation of students. We do not believe, however, that the capacity for evaluation should be a significant factor in determining the material to be taught.

We are not excluding other classes of knowledge (such as facts and cases) in our focus on skills. On the contrary, the hope is that the student will seek relevant knowledge of any kind in service of the skills and systems being learned. However, only the desire to teach a set of skills or systems should motivate the development of a GBS. Even when understanding a complex system is the pedagogical goal, the GBS should teach it by stressing the acquisition of skills that cannot be mastered without such an understanding. The pedagogical goal of a GBS should always be to master a set of target skills.

## What is a Skill?

Given the prominent role skills play in GBSs, we want to clarify what we mean when we call something a skill. Broadly speaking, a skill is something you know how to do. If the sentence "John knows how to X" makes sense for a given X, then X is a skill. Mathematics, for example, is not a skill, because "John knows how to mathematics" does not make sense. One could, of course, easily circumvent this heuristic with syntactic tricks, but the point is, when we assert that we want to teach something, we ought to ask what, exactly, knowing that something will enable students to do.

Describing skills as "knowing how to do something" suggests that skills are related to goals. People tend to possess skills that allow them to do something they want or need to do. So one way of viewing a skill is as *the ability to execute plans to achieve a class of goals.* It follows from the above description that skills are acquired in the process of pursuing some goal. Furthermore, practice, in this view, means repeated episodes of the pursuit of a goal. Skill acquisition via practice in the context of an authentic environment is a central notion in the GBS framework.

Because the literature on practice and skill acquisition is extensive, we will only briefly refer to it here. In the early stages of learning a skill, practice helps establish an encoded representation of that skill (Brown, Collins, & Duguid, 1989; Fitts & Posner, 1967). Further practice strengthens the connections among the procedural and conceptual bits of knowledge supporting that skill (Anderson, 1983; Fitts & Posner, 1967). Eventually, practice leads to more efficient and effortless skill performance, as the knowledge shifts from declarative representations to procedural representation (Anderson, 1982; Sweller, Mawer, & Ward, 1983). It is also through practice in applying a skill that one gets feedback about how effectively it was employed and can therefore fine-tune the skill (Anderson, 1982; Rumelhart & Norman, 1978).

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Later, we discuss what we view as the principal motivation behind the teaching of skills in authentic settings: namely, exposure to a variety of cases. In this section, we briefly summarize prior work suggesting that context and skills are not easily separable. One immediate influence of context occurs when perceptions of the skill are being encoded, because context helps shape the resulting representations (Brown et al., 1989). Thus, practice that occurs in an authentic context helps learners acquire the appropriate environmental cues. Furthermore, decontextualized practice can lead to acquisition of inappropriate cues, which may be artificial and therefore absent from the community of real practitioners (Brown et al., 1989). A concept is not separate from its context; rather, knowledge can be seen as consisting of combinations of conceptual and contextual elements (Brown et al., 1989; Lave & Wenger, 1991; Pea, 1992). Thus, practicing a skill in the appropriate context would seem to be a necessity.

This is not a universally accepted view. It has also been argued that if a skill can be decomposed into independent subskills, then teaching each subskill separately might offer some advantages (Gagne, 1973). But in talking about skills, we are not presupposing that such a decomposition is always possible. Independent subskills notwithstanding, the principal argument for teaching skills in a meaningful context has more to do with exposure to a variety of conditions than with part versus whole learning, a notion upon which we elaborate on later.

We have already identified context and concept as elements of the knowledge underlying a skill. Another is the set of strategies used to identify when it is most appropriate to select and utilize a given skill. People who are very skilled at something often employ complex strategies, learned over time in the course of exercising their skill, that help them know in what situations the need for that skill arises. Learning the context in which a skill is appropriate arises from applying that skill in authentic settings (Bransford, Sherwood, & Hasselbring, 1988; Collins et al., 1989), a practice that we will argue, is enabled through the implementation of GBSs.

To conclude our brief discussion of what we mean by skills, it might be helpful to consider a few examples. Skills include things like reading, addition, driving, cost accounting, and applying formulas. Each of these can be expressed in the sentence "John knows how to X." Each can be tried out in order to encode procedures and concepts, improve how well they are applied, and associate outcomes with variations in practice.

One further point about skills deserves mention before we discuss our approach in detail. In our use of the term, a skill is what the GBS designer wants the student to learn how to do. There may be ancillary activities in which a student might engage within a GBS; these activities are purely motivational in nature or serve to increase the realism and cohesiveness of the simulated environment. An activity of this sort may resemble a skill (and may even be a skill in another GBS), but without the designer explicitly designating it as such, it is not a skill. The point is that, although not

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everything a student does in a GBS is necessarily a skill, everything the designer wants a student to learn from that GBS must be a skill.

Just as facts in isolation are likely to be ignored, unmotivated skills are likely to go unused and forgotten as well. Students need to come to view the skills of a GBS as capacities that will empower them to achieve a valued class of goals previously beyond their reach.

It is not enough, however, to simply assure students that these skills will enable them to achieve desirable goals. They need to be given the chance to actually do so. Writing, for example, is certainly a skill worth teaching, but it may not be particularly interesting to a student unless he is able to use it to create, say, a play that is subsequently produced. GBSs, therefore, are designed to teach a set of target skills by providing the student with an opportunity to learn these skills in the context of achieving a desired goal.

It is easy to propose GBSs that satisfy the definition, but much harder to specify the ones worth producing. One may, for example, propose that balancing chemical equations is a skill worth teaching, specify the goal of scoring the most points in the class, and present students with a barrage of equations to balance in order to score points. This is, of course, a terrible approach to teaching this skill, but one that does loosely satisfy the definition given above. It is therefore crucial to establish criteria that can assist in designing good GBSs and to understand the ideas that lie behind this definition.

## HOW GBSs TEACH

### Learning, Goal-Pursuit, and Memory

The core principle underlying GBS design, that a learning environment should be organized around the pursuit of a goal of interest to the student in order to allow the student to acquire the skills necessary to achieve the goal, largely grew out of our earlier work in memory and learning (Schank, 1982; Schank, 1986). Briefly, we argued that memory is organized into packets of temporally ordered scenes indexed by the features of the situation in which they typically occur. These *memory organization packets* (MOPs) typically encapsulate knowledge of events involved in typical plans for a particular goal, such as going to a restaurant, an office visit, and so forth. MOPs allows us to recognize instances of common situations and predict upcoming events. Failures due to deviations from these sequences, which are termed *expectation violations,* are often due to exceptions to the principles captured by the general sequence. These exceptional cases are indexed by the expectation failure and allow us to avoid similar problems in the future.

Our memories, to a large extent, consist of stories of our expectation failures. Often, when we feel we have deeply understood something, we remember the particular example or situation that finally elucidated the point. It therefore seems natural that storytelling should be such an effective teaching technique; indeed, storytelling programs appear to be a promising

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class of educational technology (Edelson, 1993). The GBS environments we envision are intended to allow students to learn by enabling them to have experiences that will constitute their own stories.

Essential to this learning process, therefore, is generating expectations and encountering failures in the pursuit of a goal. From this perspective, it follows naturally that traditional didactic and decontextualized forms of teaching lead to the problem of what has been called *inert knowledge* (Whitehead, 1929). Simply explaining concepts or stating facts will not be effective because it does not permit indexing according to the features of the situations in which the concepts or facts are relevant. On the other hand, the effectiveness of storytelling in teaching depends to a large extent on the storyteller's ability to model the expectations of the students, or more crudely, to recognize when a student is ready to hear a story (or case). This is similar to what Papert (1980) calls the *continuity principle.*

Our reluctance, therefore, to teach concepts or facts "directly" does not stem from a belief that they are not valuable or necessary, but simply from the conviction that it cannot be done in a way that renders such knowledge useful. The exercise of skills in pursuit of a goal, however, can create the preconditions for learning described above. Earlier, we described a skill as a technique for achieving a particular goal. From this viewpoint, acquiring a skill is a matter of generating the proper expectations and learning how to react appropriately when these expectations are met. Encounters with exceptional cases are needed to generate failures, which will help us learn the features that enable us to predict and avoid such failures in the future.

This theory of learning informs the GBS architecture by guiding the specification of constraints on the tasks and environments to be used. In particular, the learner's need to extract the proper defining features of a situation requires the environments both to generate these features and to make them apparent to the learner. What we learn, however, is not simply defined by characteristics of our environment, but by its relationships to our goals as well. Many of the crucial features of a situation will therefore be cognitive states of the learner, such as expectations and goal conflicts. The tasks we present the learner with must therefore generate suitable goals and progress in such a way as to develop appropriate expectations.

The environment necessary for effective learning, one in which students are pursuing goals of interest to them, also creates conditions that produce strong intrinsic motivation to learn. The importance of creating intrinsic, as opposed to extrinsic, motivation has been discussed by a number of researchers (e.g., Deci, 1975; Keller, 1983, Lepper & Greene, 1978; Malone, 1981). For example, a study by Lepper, Greene, and Nisbett (1973) found that extrinsic motivators such as grades actually reduced students desire to pursue a learning task. The pursuit of an inherently interesting goal creates intrinsic motivation in a student via a number of mechanisms.

By having students pursue a goal of interest to them within a realistic context, we create an environment in which the student performs authentic

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tasks. This authenticity occurs because all activities in a GBS are directly relevant to the pursuit of a meaningful goal, and this relevance is always made apparent to the student. Research has shown that students attend more to authentic tasks, and because the tasks' goal is interesting to the student, the student will exert more effort in understanding the material needed to accomplish that goal (Collins et al., 1989; Leinhardt, 1987; Schoenfeld, 1992).

## Goals and Instruction

The importance of goals in learning has been the subject of some discussion and has recently been explored in the theory of Intentional Learning. This theory holds that proper learning requires that learning itself must become a cognitive goal of students above and beyond the requirements of a particular task (Bereiter & Scardamalia, 1989). In a later paper, Ng and Bereiter (1991) identify three distinct classes of learning goals. Task achievement goals involve doing what is necessary to complete a given task. Instructional goals are those pursued by students who go beyond the needs of the immediate task to address the issues intended by the course of study. Finally, students who pursue a task with the goal of relating new material to their knowledge are pursuing knowledge-building goals. Citing evidence from a study in which they monitored the learning goals of subjects learning computer programming where students who were inclined to pursue knowledge-building goals tended to perform better, Ng and Bereiter promote instructional techniques in which knowledge-building goals are explicitly formed and addressed by a community of learners.

Although we concur with their stress on having goals drive the learning process, our emphasis remains on the goals achieved by the particular skills being acquired. Skills ultimately derive their value from the class of goals they can be employed to attain and can only be properly learned when practiced in service of those goals. Therefore, the prominent role of goals in GBSs stems from their capacity to establish the proper context and motivation for learning a set of target skills. The class of goals we are referring to are those that would naturally lead to the exercise of the target skills in question, as opposed to, for example, the knowledge-building goals Ng and Bereiter discussed.

The mere selection of an appropriate goal, however, does not guarantee the requisite motivation or the context to support the proper acquisition of the target skills. The situation within which the skills will be taught must also be carefully crafted to support these goals. Most generally, for the achievement of the goal to be meaningful, it must occur within the context of a reasonable premise. In order to maximize the motivational potential of this approach, it makes sense, in choosing goals and developing the premise,

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to draw upon the potential interests of students. The stress on the context of the activities perhaps makes it more appropriate to view the student as engaging in the pursuit of a mission within a given cover story.

## GBS COMPONENTS

If one is to understand how to design a GBS, it is critical to identify the various parts that comprise one, the role each part plays in the overall structure, and how the parts relate to each other. A GBS is made up of two main parts—the mission context and mission structure—each of which in turn is composed of two subparts. The components of a GBS are organized as shown in Figure 1.

The mission context essentially deals with the development of the thematic aspects of the GBS. The mission is the overall goal of the GBS. Running a trucking company might be a suitable mission. The *cover story* is the premise under which the mission will be pursued. The particulars of the trucking company to be run, the services to be offered, the competitors and customers one must deal with, and so forth, constitute the cover story for the "run a trucking company" mission.

The *mission structure,* on the other hand, is the means by which the student will pursue his mission. More broadly, missions can be achieved by numerous plans. It is only feasible, however, for a GBS to support a subset of these plans, presumably those that require the execution of the skills intended to be taught by the GBS. The mission structure, therefore, must specify the plans to be supported in terms of the themes developed in the cover story. For example, what will constitute running the trucking company? Are they starting one from scratch? Can they diversify their product

- Goal - Based Scenario
  - Mission Context
    - Mission
    - Cover Story
  - Mission Structure
    - Mission Focus
      - Control
      - Design
      - Discovery
      - Explanation
    - Scenario Operations

**FIGURE 1 The components of a GBS and their organization.**

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offerings? Take over other companies? Or will the emphasis be on managing the production and sale of a particular product?

Once the mission structure is outlined, the style of the activity in which it will be implemented must be considered. This is the problem of selecting the *mission focus*. A mission focus may include a combination of approaches such as design, explanation, discovery, and control tasks. Although it is not necessary to select one of these as the main focus, it is useful to identify the set of mission focuses in a GBS because each raises its own particular set of issues that should be considered.

An additional issue to consider in the mission structure is the set of actual actions the student will perform. Will he or she be writing text, drawing pictures, or engaging in conversation? The set of actions the student performs constitute the *scenario operations*. Because the student must ultimately learn the target skills through the use of these operations, they must be chosen carefully.

Having described a few programs motivated by the underlying principles of GBSs and proposed a structure for future systems, we now ground the discussion by describing existing learn-by-doing programs according to the terms introduced above. There are an increasing number of sophisticated simulations that allow for great flexibility on the part of the students who use them. Though not designed as GBSs, of course, these programs do loosely fit the structural description of a GBS. By examining them as such, and identifying areas in which they differ from GBSs, we can begin to lay the groundwork for some of the design criteria discussed next. Two such programs are described as follows.

## SimCity

*SimCity* (Maxis Software, 1985) is a popular new type of entertainment/education software in which the user plays the roles of mayor and city planner. *SimCity* provides a fairly sophisticated simulation of cities; a user may select a predefined city and manage it or design a new city from scratch. In the former case, the user's goal is to correct or repair problems in the city, and success is rewarded with the key to the city; in the latter, the goal is to manage and maintain a workable city design.

The user manages the city by setting tax rates, setting zoning boundaries, setting funding levels for city services, and by designing the layout of the city. The layout includes placement of roads, rails, airports, seaports, fire and police stations, and power plants; it also involves zoning for parks, residential, commercial, and industrial areas. The city dynamically responds to these decisions based on human factors, such as residential space and amenities, crime rates, and availability of jobs; economic factors, such as land value, industrial and commercial space, internal and external markets, electric power, and taxation; and political factors, such as public opinion and zoning. When conditions are favorable, simulated citizens build in zoned

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areas, and when conditions are unfavorable, disgruntled citizens move out of town, thereby causing a reduction in tax revenues.

The mission focus of *SimCity* is three-fold, including elements of design, control, and explanation. The user has to design a city, control and manage its growth and development, and in the process, explain and analyze the problems that emerge. Pedagogically, the skills that are learned from playing with this simulation mainly relate to economic analysis and planning. The user faces a myriad of supply-and-demand relationships for public goods such as crime prevention, affordable housing, transportation, public utilities, quality of life factors, and low taxes. The user directly observes the outcomes of oversupply (wasting limited tax revenues) and undersupply (reduced efficiency, reduced growth, system bottlenecks, and unhappy citizens), and learns how to control the parameters that lead to these conditions.

On most counts, *SimCity* could be considered a very effective GBS. The scenario is fairly realistic, feedback is continuously provided, many different actions are possible for the student, and the causal connection between actions and outcomes is based on plausible (though simplified) economic and environmental models. Furthermore, the cover story is immediately comprehensible and involves an "empire-building" mission that most people will find alluring and adoptable. And it is challenging and possible to fail, though there are limited ways to adjust some constraints and the degree of difficulty.

*SimCity* does, however, have its shortcomings as a pedagogical tool. One is the vagueness of the mission. On the positive side, this may allow students to set their own objectives, but it also may leave them frustrated and confused. Some students will not have any idea what to do next unless they have some concrete intermediate goals such as "eliminate traffic jams" or "save up enough money for an airport," or a more specific final goal like "increase the population to over 50,000 inhabitants." Cities are scored with a numerical value; thus, students are tempted to adopt "getting a high score" as a goal.

The scenario operations the student performs are often, at best, tangentially related to the mission. Users spend a large percentage of their time laying roads, railroads, and power lines. These tasks consume a disproportionate amount of time given their relative unimportance to the skills being learned. Another problem is that it is difficult to obtain an explanation from the program for many outcomes, and it is also nearly impossible for users to gain insight into the connection between their specific past actions and these outcomes. When, for example, affordable housing becomes too scarce, it is impossible to query the system as to what factors have contributed to this problem. Or when traffic jams persist despite the student's repeated efforts to address the problem, the student has no way to see into the underlying model. The user documentation does provide insights and general principles concerning the underlying models, but these are never contextualized to specific situations.

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These shortcomings are related to what might be the most serious problem: lack of support for learning. Putting the user into a realistic simulation without a tutor or coach in the background to provide needed information is a missed opportunity. Ideally, when finished using the simulation, the student would understand the underlying economic and environmental models. However, without a tutor to answer users' questions when they know they need the information, students may never gain this type of insight. The user can play with the simulation without really understanding the system's causes and effects very well.

## Where in Time is Carmen Sandiego?

The Carmen Sandiego[1] series is one of the best-selling educational games on the market today. The players mission is straightforward. Upon entering the game, the player is told that an international and/or historical treasure has been stolen, ostensibly by Carmen Sandiego or by one of her world-famous criminal associates. The student then assumes the role of an international (and in some versions, intertemporal) crime-stopper who must catch one of Sandiegos minions. To do so, the student "travels" to different places and follows up "clues" that lead him or her to the next place. The clues consist of cultural, geographic, and historical allusions, usually relayed to the student by some innocent bystander from the culture being visited.

In many ways, the Carmen Sandiego series has some of the right ideas for a GBS. The user assumes a role and there is a cover story and a mission (i.e., stop the thief). The mission focus is discovery—a task that is both coherent within the cover story and something that the player should find interesting. Feedback to the user about the distance to the goal (finding the thief) is easily available. It is possible to fail, and yet a user who is falling behind can recover.

Despite all the positive aspects of the mission itself, the game has two very serious problems that prevent it from being a good GBS. The first, and most obvious, is that the pedagogical goal of Carmen Sandiego is primarily to convey a set of random historical facts. This, in and of itself, should be taken as a clear warning sign, not just in the case of Carmen Sandiego, but for any system being considered as a GBS. The pedagogical goals of a GBS must always be specified as a set of skills. To neglect this element is to miss the entire point of building GBSs in the first place.

The second problem centers on how the activities of the player relate to the skills being taught. Recall that the pedagogical goal of a GBS is to teach a set of skills within a plausible context by engaging the player in a set of

[1] Titles in the series include *Where in the World is Carmen Sandiego?* (Broderbund Software, 1985a) and *Where in Time is Carmen Sandiego?* (Broderbund Software, 1985b).

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activities that draw upon those skills. Facts or subject matter conveyed by the GBS should relate naturally to the activities. There should never be an arbitrary linkage between the activities undertaken and either the skills or the subject matter taught.

The Carmen Sandiego series, upon a closer and more generous examination, can be construed as teaching two skills through the players detective activities. First, it teaches some inferencing skills that are involved in deducing where the criminals are from the clues presented. Second, it teaches the player how to look up facts in books. What these activities do not teach directly are the historical, cultural, and geographic facts that the program is presumably trying to teach. In other words, the relationship between these activities and the geographic and historical information being conveyed is tenuous at best. The facts retrieved by the players are simply keys to the next place to travel—the player never uses the facts in an attempt to either understand history or the culture being visited. Thus, if such knowledge is retained (an unlikely outcome to begin with), it is doubtful that it will be understood in anything other than an abstract and decontextualized way.

Although the Carmen Sandiego series does teach simple inferencing and research skills, there is no reason to believe that it effectively accomplishes the pedagogical goals of teaching history or geography. Based on this analysis, it is clear that the Carmen Sandiego series is missing several key elements of a GBS.

## GBS DESIGN CRITERIA

Having identified a few of the problems associated with existing programs, we will now outline a more general set of design criteria that specify the necessary properties or qualities of each GBS component. The problems described above should be subsumed by these criteria. Most comprehensively, a GBS must present both a set of target skills and an environment that will motivate the student and enable the productive use of the skills upon completion. The following seven issues should be considered in the design of each component of a GBS.

1. *Thematic coherence.* A student will remain motivated to achieve the mission of a GBS only if the process of achieving it is thematically consistent with the goal itself. No student will feel like he or she actually successfully ran a trucking company if doing so consisted of answering questions about supply and demand. Every component of the GBS must be evaluated in terms of its ability to support the premise of the GBS.

2. *Realism/richness.* It is not enough for the story to be coherent. The GBS must be realistic and rich enough to provide varied opportunities for learning the target skills. If running the trucking company simply consisted

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of repeatedly selling the same services to the same customer—a thematically coherent activity—little would be gained by the student. Not only must opportunities for the acquisition of the target skills arise, but they must arise in a realistic and varied enough way to render the skills useful to the student.

3. *Control/empowerment.* Ensuring a sense of accomplishment and empowerment is not simply a matter of developing a thematically coherent scenario. What is important about the accomplishment of the mission is not, of course, the fact that it is completed, but rather that it is the student who has done it. It has previously been argued that putting students in control increases their sense of self-determination and is therefore intrinsically motivating (Deci, 1975). Students will only appreciate the power of their newly-acquired skills if they feel responsible for the completion of the task.

4. *Challenge consistency.* Managing the degree of effort required by the student is essential to making the achievement of the mission worthwhile. The various components of the GBS should promote a consistent degree of difficulty. They must ensure that an environment presents neither insurmountable obstacles nor trivial and distracting subtasks. The GBS should include methods for dynamically adjusting the level of challenge according to the abilities of the student.

5. *Responsiveness.* One important reason an otherwise well-designed GBS might fail is that it simply does not provide students with the information they need to operate. The student must see both the need for, and the effects of, his or her actions. It is pointless to be in control if the effects of one's actions never become apparent. Prompt feedback has been shown to increase the speed at which learners acquire skills (Lewis & Anderson, 1985). Therefore, a key consideration in designing each GBS component must be whether it is possible to convey the right feedback in a manner that is useful, timely, and understandable to the student.

6. *Pedagogical goal support.* Most of the previously listed criteria are primarily concerned with assuring the quality of the GBS environment. It is all too easy to become engrossed in the details of the cover story and lose sight of the fact that the whole enterprise is ultimately intended to teach the student a set of target skills. A fundamental criterion is, therefore, to ensure that the proposed scenario is compatible with and supports the acquisition of the skills. The target skills must make sense in the context of the proposed scenario. Ample opportunities must arise for the use of the skills. The scenario should not distract students by engaging them in irrelevant and time-consuming activities.

7. *Pedagogical goal resources.* The student will often need help completing the mission, and the GBS must be capable of providing it. The strategies and materials used to assist the student, from on-line video tutors to simple reference texts, must be carefully chosen to match both the skills being taught and the premise of the GBS. Ultimately, the type and quality of the methods selected will have a profound influence on whether the skills are learned correctly or even learned at all.

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In the remainder of this article, we explore how these criteria should be applied to the design of each component of a GBS. We examine in greater detail each of the four components of a GBS. Each section provides a more exact description of the component, the particular design criteria it must meet, and several concrete examples of that component as it is realized in each of the examples introduced previously.

## Mission

The primary component of a GBS is the mission. Once a mission is selected that corresponds well with the pedagogical goals of the GBS, the remainder of the design becomes more clearly focused. The mission of a GBS specifies the goal the student is trying to accomplish. It is the component that most immediately sets the tone for the student's actions. Although the mission of a GBS is (and should be) closely related to the cover story and the scenario operations components, it is concerned with what the student achieves, not how he or she goes about it. Thus, the same mission may be used for a variety of GBSs. The mission "build a house," for example, may involve drawing up a set of blueprints, putting together a set of specifications, or assembling a toy house using certain materials.

If the mission of a GBS is one of general interest to a learner, then we can reasonably expect learners to develop the relevant knowledge-building goals (Ng & Bereiter, 1991) that will enable them to further their interests. The mission must therefore be representative of a general class of goals that will be accessible to the learner upon its completion. Moreover, the fact that this class of goals will be attainable must be clear to the learner.

### *Criteria for Designing the Mission*

*Goal distinction.* The mission should be genuine and should make sense in the context of the cover story. Nebulous attributes or activities simply rephrased as goals such as "Your mission is to be honest," or "act responsibly," defeat the purpose of providing a specific mission.

Two points to keep in mind here are the following:

1. *The criteria for achieving the goal should be clear to the student.* In order to be able to work towards a goal, the student should be able to recognize what success would mean. It is meaningless to say "Finally, I'm honest!" On the other hand, one knows when one has completed a news broadcast. A crude test one can apply is to see if it makes sense to say "Today I'm going to set a few hours aside and try to (insert GBS mission description here)." This statement makes sense for goals such as creating television broadcasts or providing genetic counseling but seems rather odd for things like honesty or responsibility.

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All missions will inevitably fail to capture the imaginations of some students. Lack of universal appeal, however, is a problem with any one instance of any medium. Attempts to appeal to everyone result in a homogeneity that excites no one. One should therefore avoid trying to maximize the audience of a GBS at the expense of its potential to truly excite a smaller subset. Just as there is more than one book on any subject, more than one GBS will need to be developed as well.

2. *The mission should be suggested by the nature of the cover story.* It is not enough that the mission include a genuine goal in the sense just described. The goal must also be reasonable to pursue in the context of the cover story. If a student hears about the scenario, he or she should be able to readily infer the mission and vice versa. For instance, if a cover story in which the role provided for the student is CEO of a company, and the setup involves a company facing certain problems, the mission should presumably be to solve those problems through actions normally available to a CEO, as opposed to say, writing a report about those problems.

The mission and the cover story must correspond in this manner because if they do not, neither will motivate the student. The mission might consist of an otherwise wonderful goal, but an inappropriate cover story will not allow the achievement of the goal to be meaningful. Similarly, a fascinating cover story will go to waste if it cannot be employed to achieve a worthwhile mission.

*Goal motivation.* The single most important consideration in designing a GBS mission is to motivate the student in a way that makes what is learned useful, relevant, and exciting. Much of a student's motivation to become interested in a GBS, especially at the beginning, must come from the desire to complete the mission.

Some points to consider to help ensure a mission is properly motivating include the following:

1. *The mission, whenever possible, should consist of goals that the student already has, or ones that he or she would be willing to adopt.*

Perhaps the safest way to motivate students to get involved in a GBS is to give them a chance to achieve a goal they already have. One can choose goals that students do not already have; however, if selecting such a goal, one should think carefully about why students do not have it. For example, one reason students might not already have a given goal is that they know they could not possibly achieve it. A student with a burning interest in astronomy would probably jump at the chance to travel to another galaxy but will probably not have that as an active goal because it is presently impossible. This kind of goal however, would be a good one to choose for the mission, because the student would be willing to adopt it quite readily.

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2. *The mission should be broad enough to involve a variety of activities.* An overly narrow mission runs the risk of being unappealing to those students with interests even slightly different from those involved in that mission. A mission with greater breadth and depth, that is, one with a wider variety of paths available to achieve the mission, is more likely to have something for everyone.

*Target skill dependence.* It is crucial that completing the mission depend on mastering the target skills. In designing the mission, a GBS designer must not lose sight of the fact that ultimately, the acquisition of the target skills is of primary importance. A mission may be motivating and include distinct goals without necessarily depending on the target skills in question. When selecting the mission, the designer should keep in mind situations in which the target skills may be used to help achieve it, by asking questions such as: Are these situations plausible? Can they be tied together into a coherent cover story? Is the inclusion of the target skills forced, or are they naturally called for? Can the situations in question actually be reproduced reasonably for the student?

*Empowerment.* In addition to motivational impact, a key reason to embed target skills in a realistic scenario is to situate the knowledge being taught. The target skills are only useful to a student if he or she knows what to do with them. Simply being able to apply them, however, is not enough. Students must be made to understand that success at the mission actually means that they will be able to accomplish a general class of goals outside the GBS. This emphasis helps clarify the utility of the target skills. The mission must be one that allows the student to say, "If I can do this, I can also do all these other things," as opposed to, "OK, I did this and it was fun, but so what?" Learning how to drive by delivering packages in Manhattan, for example, allows a student to say, "If I can drive here, I can drive anywhere." Navigating around cones in a parking lot involves some of the same skills, but does not convince students of the utility and robustness of their skills in the same way.

*Flexible completion criteria.* Just as a mission should be broad enough to appeal to a variety of interests, it should be achievable through a variety of approaches. Students experiencing difficulty with one approach should be able to step back and try another. To maximize student control, and hence "ownership" of a GBS session, a mission should allow a student freedom to decide how to tackle it. Some students may wish to plunge right into devising a solution; others may wish to first gather facts, get recommendations, and so forth. The point is that the mission should not be a puzzle with a single definitive correct path to the solution.

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A related concern is that there should be no tricks to completing the GBS. At an elementary school we recently visited in Evanston, the head of the computer room discussed a story-problem-based computer program they use, called *WiCat.* After listing the many features she liked about it, she mentioned its biggest weakness. It seems that some students have discovered that, if they purposefully get each story problem wrong, they can write down the right answers, then go through it again and get them all correctly, resulting in a recorded score of 100%.

In *Broadcast News,* for example, the student's mission is to put together a newscast, which is not a simple task. But a student can start off as responsible for editing a single story, and later move up to more challenging jobs such as organizing the entire newscast. The student is also in control of the learning process. The student decides such things as when to ask for story rewrites, when to view and edit videos, and when to look up background information about a topic.

It is always clear when the student has finished the newscast: upon completion, he or she clicks a button to go on the air. At this time, the programs experts may make comments about the students newscast, and the student can choose to make further revisions or ignore the experts advice.

One of the main motivational aspects of the *Broadcast News* mission is that producing a newscast is something many students would love to be able to do in real life. Allowing the student to anchor the newscast and make a videotape of his or her work adds to the real-life motivation.

All stories in *Broadcast News* are directly related to subgoals within the student's mission. In other words, as a student is generating a newscast, he or she might need some help or advice about parts of the various news stories. The experts video stories are linked directly to the content of the news.

## Mission Focus

Once a mission has been selected, the second component of a GBS that should be specified is what the mission focus will be. The mission focus provides the overall framework around which the rest of the GBS can be structured. There are few limitations on the range of GBSs possible: One program may offer the chance to build a railroad switchyard, whereas another may ask the student to zone government lands to protect endangered species. But beyond such obvious features as mission and cover story, there is a deep sense in which one GBS may differ from another. This difference is related to the overall type or focus of the activities most central to the GBS. The underlying organization of the students activities is what we call the mission focus.

It may not always be obvious what to call the mission focus of a GBS in which the student is apt to be engaged in a range of activities. Nonetheless, a single type of activity often predominates in guiding the student toward the instructional goals. In the example of building a switchyard, the central type of activity would probably be one of design. If the target knowledge and skills can

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TABLE 2
Mission Focus Category Descriptions and Examples

| *Mission Focus* | *Description* | *Example* |
|---|---|---|
| Explanation | Includes GBSs where student's focus is on accounting for phenomena, diagnosing systems, predicting outcomes. | *Sickle Cell Counselor* |
| Control | Includes GBSs in which student runs an organization, operates a system, etc. | HeRMiT (Feifer & Hinrichs, 1992) |
| Discovery | Includes those GBSs that provide a microworld within which student operates, infers laws governing that microworld, notices opportunities for participating in activities, etc. | *Yello* (Kass et al., 1993/1994) |
| Design | Includes GBSs where student's principal activities are creating some artifact, specifying how a system should be organized, etc. | *Broadcast News* |

be effectively acquired by a student engaging in the process of rail yard design and construction, then the GBS would seem to have some internal coherence. Thus, an important reason for discussing the mission focus is to highlight the linkage between classes of activity and pedagogical goals. A second reason is that the mission focus can be an important guidepost during the design phase. If the nature of the activities begins to suggest something other than the mission focus, then there may be some divergence of the GBS from its instructional goals.

We have identified four types of mission focuses: explanation, control, discovery, and design. These are described later and summarized in Table 2.

### *Criteria for Designing the Mission Focus*

*Task consistency.* The overall focus of the student's activities should be suggested by the mission. For example, if the mission asks the student to be a pastry chef; then it is clear that the mission focus is one of design (i.e., create a dessert). Consider now a mission in which the student manages a baseball team. The suggested mission focus is control. If instead the intended mission focus is discovery (e.g., learning Newtonian Laws from ball trajectories), this mission focus would not be clearly suggested from the mission. The expectations generated by the promise of managing a baseball team (e.g., determining the lineup and positions, playing a game, choosing plays, etc.) will go unfulfilled, and the student will be frustrated as a result. The actual activities the student performs will go largely unmotivated. Instead, a mission like capturing a fort more naturally suggests a discovery mission focus in which, for example, a catapult might be provided for the student to experiment with in order to discover Newton's laws.

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*Student investment.* One of the main responsibilities of the mission focus is to encourage a sense of investment in the GBS. The students should come to have ownership over some aspect of their experience with the GBS. This sense of ownership can be a powerful motivating force. In a design task, for example, students who feel responsible for the artifact they create will work hard to improve it. The student's investment in the GBS is his or her reason for caring. It is what makes the achievement of the mission his or her own.

*Process emphasis.* One reason to make the notion of mission focus explicit is that, in the best case, the student will not only learn the target skills, but also acquire or enhance general problem-solving skills brought to bear in pursuing the mission. The nature of these more general skills is described by the mission focus, and knowing this, we can go about designing the program to support the acquisition of these fundamental skills. For an explanation-oriented GBS, for example, features in the program that highlight the mission focus might include a graphical presentation of the explanation the student is constructing. A design mission focus could be supported by, say, a designer's notebook, to provide the student with a conceptual framework for viewing the mission in general design terms.

*Artifact dependence.* The artifact of the mission focus should reflect the student's understanding of the domain and embody a solution to the problem at hand. The subsequent performance of the artifact within the cover story should be causally dependent on the ideas expressed in the artifact. In other words, the artifact should not merely be a form of external reward that promotes student investment. Rather, it should be the medium through which the student tests his or her ideas about how to complete the mission. The GBS should respond by carrying through the repercussions of the solution.

In *SimCity* (Maxis Software, 1985), for example, the artifact is the city the student creates and the policies he or she implements. The design of the city is an expression of the students idea of how a city should be designed. The city's performance is a function of the design. The feedback is expressed through changes to the city generated by the simulation. These changes allow users to infer the repercussions of their actions. For example, underfunding the police department results in areas of high crime. The system does not immediately simply say, "Your policy is wrong. You should increase funding for the police department or else crime will be rampant." Instead, it implements the effects of the policy. Raising taxes too high can lead people to flee the city, which means less revenue is generated than before. Once again, the student views the effects of the idea through the fate of the artifact.

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### *The Four Mission Focus Categories*

We have identified four categories of mission focus that can be used to describe a wide range of possible GBSs: design, explanation, discovery, and control. In this section, we discuss some properties of each category and present an example GBS with that kind of mission focus. Table 2 contains a summary of the four mission focus categories and examples.

*Design.* Characterizing a GBS as having a design mission focus means that the interaction will center around some generative activity such as creating an artifact, specifying how a system should be organized, or specifying how a process should be executed, to name a few. A design-oriented GBS should include design-oriented instruction. For example, the type of questions students are asked should focus on the design aspects of the task, such as, "How did you accomplish this transformation?," or "Why did you do it that way?" A design mission focus also suggests that the type of scaffolding most appropriate to the task might be a partially completed artifact (such as already written news copy).

*Broadcast News* is essentially a design task. At the conclusion of a session with the program, a student will have produced an artifact: a finished newscast. As an added bonus, the student gets to see himself or herself on videotape, if desired, as part of the finished product.

Students using *Broadcast News* understand from the start of the program what their task is. As an assistant producer, the student must design a newscast but is actually only responsible for editing one particular story. A student playing the role of executive producer would be responsible for all of the stories in the newscast and for organizing the newscast as a whole. Allowing students to get their feet wet by starting with a simpler role prevents them from being overwhelmed by the task.

Learning in *Broadcast News* occurs as the student puts together the news show. The student must understand the content of the news in order to design a good newscast. Experts challenge the student's news judgments at various times; as a result, the need and motivation for a well thought-out design is increased. A student interested in a particular news event, or one interested in making the best newscast possible, has many opportunities to learn about each news event.

*Explanation.* Explanation describes those GBSs in which the student's principal activities center around accounting for unexplained phenomena, diagnosing system anomalies, or predicting outcomes. Explanation as a cognitive endeavor places different demands on a student than does design, so it makes sense to structure a GBS with an explanation mission focus with explanation in mind. Most notably, explanation tasks involve articulating an

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explanation explicitly as opposed to expressing one gradually and implicitly through the design of an artifact. Having identified an explanation-oriented GBS, we could frame any analysis of performance or assessment issues of that GBS in terms of general models of explanation (e.g., Schank, 1986). It also follows that activities central to explanation should be supported by structural features in the program.

The mission focus of *Sickle Cell Counselor* is explanation. Two aspects of this program support the explanation process: The relevant causal information is accessible, and the explanation requirements are explicit.

The experts screen acts to support the mission focus by offering information useful in constructing explanations. Information is gathered incrementally as the user follows paths by asking questions—a pattern of interaction closely related to ask systems (our approach to hypermedia organization; see Ferguson, Bareiss, Birnbaum, & Osgood, 1992). Applying what the experts say to constructing an account of sickle cell disease is an important part of the explanation mission focus.

The criteria by which the users explanation will ultimately be judged are embedded within the model that directs how the clients respond to the users advice. For example, a response like "What's so risky about carrying the Sickle Cell Trait?" provides implicit guidance for the user to explore the medical implications of carrying the trait. The clients serve, then, as a representation of the user's mission. It is this implicit representation that helps the user acquire an understanding of what sort of explanation is called for.

*Discovery.* GBSs, by definition, include a cover story that will often be manifested as some kind of microworld within which the student operates. It may therefore be tempting to label the mission focus of any such GBS discovery. What makes a GBS discovery-oriented, though, goes beyond having a simulated environment. If the mission focus is discovery, the primary activities of the student must be to infer the laws governing the microworld, notice opportunities to participate in activities or acquire resources, or discover how to deal successfully with the simulated agents that populate the microworld. One could be misled into describing programs such as Smithtown (Shute & Bonar, 1986) as discovery GBSs because students are intended to discover underlying economic principles by manipulating a variety of factors and observing the resulting effects. Unfortunately, the lack of a goal leaves students with no reason to care about these principles and no way to judge the importance of the changes they observe.

*Control.* GBSs have a control mission focus if the student's principal activities center around, for example, managing an organization, operating a complex system, or controlling a mechanism. At first glance, it may seem like managing a software project, for example, and running a nuclear power plant are

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very different tasks. In this example, though, it is the missions and cover stories that are the most dissimilar. The structure of the activities in both cases is essentially one of control. This helps inform the design of the GBS: It becomes important, for example, to help students learn what features in the environment can serve as indicators, which actions influence which parameters directly and indirectly, and so forth. It may seem as though learning to associate features in the world with system behaviors is a discovery activity. But in this case, discovery is a tool with which the student can more effectively engage in the central activity. A control GBS, which may include discovery-like activities, should therefore support those processes most likely to lie at the focus of the student's attention.

## Cover Story

After the mission and the mission focus, the next component of a GBS to specify is the cover story. This component is particularly important in making the GBS coherent in the mind of the student. The cover story, in conjunction with the mission, establishes the context of a GBS. The cover story defines more specifically the role the student plays, the scenes where the action takes place, and other details that flesh out the GBS and make it more plausible and enticing to the student. Two hints for selecting motivating cover stories are to choose either something that people like to do (or would be interested in doing, such as being President of the United States) or something people would fear doing in real life—that is, stories about which the student will have some strong feeling. The cover story is crucial in drawing the student into the task from the beginning. A boring cover story will lose the student for the entire GBS. It is just like reading a novel: If it sounds like it will not be fun to read in the beginning, you probably will not want to keep reading to see if it gets better.

The cover story has three elements: the role, the setup, and the scenes.

*The role* The role defines who the student will play, such as an advertising agent, a company manager, or a senator. The nature of the role affects how the student achieves the mission. Consider a mission to increase a company's profits: An advertising agent might develop a new public relations campaign, a company manager might try to reduce inefficiency in his or her division, a senator might want to introduce legislation offering a bailout, and so forth. A role will often be defined by an occupation, but other attributes may also be useful in describing the role. Useful role-defining attributes might include factors such as occupational experience, wealth, ideology, and social status. For example, in a GBS that is designed to teach about the stock market, it might be useful to specify that the investor is a person who wants to support only environmentally friendly companies.

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*The setup.* The setup provides the other details of the premise of a GBS. A setup might explain to students why the mission is important and with whom they will be working. It may need to specify exactly what tools the student will have available, what they are for, where various events will take place, and the obstacles and rewards to come. The mission generates relatively high level expectations on the part of users regarding the class of activities they will perform. The setup should give them a more concrete idea about how their expectations will be fulfilled.

*The scenes* A given cover story might include multiple locales, or *scenes,* as plausible elements of the story line. So a scene is nothing more than a specific physical setting that presents opportunities for the student to engage in scenario operations and possesses some logical connection to the cover story. Examples of a scene might include the President's office, the loading dock at Ellis Island, or a forest service mountain-top lookout post.

### *Criteria for Designing the Cover Story*

*Role coherence.* The cover story should provide a desirable role for the student within a plausible, exciting, and accessible story. The elements of the cover story should be thematically consistent with each other; if they are not, the student is apt to become frustrated and disbelieving. If a person with a given role would ordinarily have certain tools and visit a certain locale, the setup should provide those tools, and the scenes should include that locale. Similarly, the role must ensure that the setup does not provide implausible tools and that the scenes do not have implausible settings. In other words, the GBS must reproduce the aspects of the role and setup that define them and, therefore, make them meaningful. When confronted with an implausible cover story, the student will not be able to use common-sense knowledge to help solve problems and maneuver in the world.

Similarly, the cover story should clarify the relationship between the mission and the scenario operations. For both motivational and pedagogical reasons, the cover story must explain why a certain scenario operation will be useful with respect to the completion of the mission. Students need to understand why each scenario operation is available at a given point in the GBS; otherwise, they may feel like they are jumping through hoops instead of trying to figure out how to accomplish a mission.

*Target skill density.* One danger in developing a convincing cover story is that the target skills we are interested in teaching may get lost in the details. A cover story that embeds the teaching of a few target skills within a huge scenario involving many other skills may be fun for the student, but it

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would be highly inefficient. Although it is important that the student be motivated to participate in the GBS, the cover story should emphasize the scenes that call for the use of the target skills as much as possible. Reliance on ancillary skills should be minimized.

*Frequent practice opportunities.* A related concern is that too much of the student's time and effort will be required simply to maintain and further the cover story's premise. In other words, it is easy to spend too much time simply developing the plot of a GBS. The cover story must be devised so that advancing the story line depends as much as possible on the target skills. The cover story should provide frequent and varied opportunities to practice the target skills.

*Integrated support.* Once the role has been established, it is important that the student be provided with the needed support to do the job. The GBS must provide various forms of assistance. Whenever possible, help should be provided through materials that are consistent with the cover story. It is always better to provide support than not to provide it (after all, a big part of a good learning-by-doing environment is to provide assistance that might not be present in the real world). Ideally, assistance can be presented in context for all the scenes throughout the GBS; if not, the support should be provided anyway regardless of how well it fits with the cover story.

### *Example Cover Stories*

Here is a closer look at the cover stories that are used by the example GBSs.

*Broadcast News.* The student is told at the beginning of the program that he or she will play the role of assistant producer of the evening news and will have access to newswire text and news video footage. Users also have a team of writers working for them who have already written drafts of the news stories and are available to do rewrites. Experts in broadcast journalism and political science are available to give advice and answer questions.

The *Broadcast News* cover story is thematically coherent. Everything the student can do in the system is linked to the mission of producing the newscast. The cover story is also fairly simple. Right from the start of a session with the program, the students can easily understand what their role is and what they are supposed to do. But the cover story can be made more complex in higher levels of the program; for example, the student can play executive producer and organize the entire newscast as well as editing all stories.

The student's role in *Broadcast News* requires many actions. The assistant producer needs to make decisions about the stories that go into the final

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newscast, so the student is put in a position with both authority and responsibility.

One of the greatest advantages of *Broadcast News* is its relevance to real life. The cover story sets up real-life network news situations; moreover, the student gets to play a role that sounds like a fun job to have in real life and also uses realistic resources (newswire text and video). The cover story also provides support for the student's activities. For example, it includes videos of experts that allow the student to learn more about the news events and obtain additional background information and analysis.

*Sickle Cell Counselor.* The cover story of *Sickle Cell Counselor* locates the user in an environment in which he or she can pursue activities in four different scenes: asking experts, doing lab tests, calculating risks, and advising the clients. In contrast to the conventional notion of scene, each scene in the program is available to be visited and revisited, in whatever sequence the user desires. Scenes also specify details of the cover story such as the user's function and affiliation, colleagues available for consultation, and so forth, as summarized for each scene below:

- Asking the experts is a way to engage in a conversation-like interaction with colleagues.
- The Bloodlab activity gives users the opportunity to perform tests normally done by a lab technician and thereby acquire and use knowledge in an authentic setting. The user's goal, though, is not to learn about red cells and hemoglobin, but to identify the clients' gene types. In pursuing this goal, a user acquires some level of understanding of these concepts.
- Determining the clients' risk factors involves two steps: finding out their gene types and then determining in what ways those types combine.
- Once their gene types are found in the bloodlab, the ways those types combine is presented via the Punnett Square. This part of the cover story illustrates how one scene may naturally set the stage for another.
- When the user advises the clients, how they react depends on what information the user has explored and what advice the user chose to provide. Thus, via the clients' behavior, the user recognizes the relationship between the actions he or she has taken and the observed results.

## Scenario Operations

The final component of a GBS that must be specified is the scenario operations—the actual activities the student will be performing while engaged in a GBS. The nature of the scenario operations has a significant impact on the ultimate achievement of the pedagogical goals. If the actions required are irrelevant, incoherent, pointless, or too complicated, the student's motiva-

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tion and interest will wane, and the desired skills will not be learned. In this section we consider the discrete, individual operations that the student is required to perform, rather than classes of activity described at an abstract level. When we use the term scenario operations, we mean activities such as adjusting a parameter with a dial, issuing a directive in a social simulation, answering a question, using a tool to shape part of an artifact, searching for a piece of information, and deciding between alternatives.

### *Criteria for Designing Scenario Operations*

*Responsiveness.* The causal connection between actions and outcomes should be clear to the student. In addition to the requirement that the connection between actions and outcomes be plausible in the broad sense, this connection should also be visible and obvious to the student. The clarity of this connection will depend both on the nature of the actions that are made available and the way these actions are interpreted by the system. Gibson (1979), for example, noted that the role of environmental features suggesting potential actions in problem solving in his theory of "affordances." Sometimes designers of a simulation will take for granted certain causal connections of which the student is not aware. In such cases, the student may end up wondering, "Now how in the world did my action result in this outcome?" Or worse, the student may not even ask the question at all.

Sometimes we may want the student to infer or induce the relevant causal relations from the behavior of the system; in other cases, we may prefer to explain the causal relations at the beginning of the activity, so the student can get on with the activity and manipulate the world in a coherent way. This must always be a conscious decision on the part of the GBS designer.

In any event, students must receive feedback that allows them to evaluate the efficacy of their actions. It should never be the case that the student makes a suboptimal selection without subsequently seeing (by virtue of the outcome or other means) the undesirable consequences of that selection. Similarly, students should know when their actions or choices have been successful.

Depending on the nature of the scenario, it is often desirable to provide feedback as early as possible. If the delay between the action and the feedback is too long, the impact of the feedback could be diminished. There is a trade-off here between allowing the student to fail and giving him or her quick feedback, but all other things being equal, the feedback should be given when the context is still fresh in the student's mind.

*Expressivity.* The GBS should enable students to express their ideas. It should provide enough operations to encompass the range of possible stu-

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dent directions. Students should feel they have done what they think is right rather than settled for someone else's idea of what should be done. Settling for another answer would mean the student's own idea could never be tried. In general, having a wider choice of operations available increases the realism and provides the student with a greater feeling of control.

Of course, at the opposite end is the danger of bombarding the student with so many options that he or she becomes intimidated, confused, or paralyzed, though in practice this problem is less likely to occur than the problem of having too few options. Also, operations should not be placebos; that is, they should be meaningful to the system. For example, users usually quickly discover the limitations of computer programs that accept but do not process natural language.

*Causal consistency.* The scenario operations and their effects on the system should be consistent with the cover story and mission. It is through the scenario operations that the student will practice the target skills and engage in the simulation. If the operations or their effects are not consistent with the mission or cover story, the student will not see the relevance of the target skills.

*Facilitation of strategies.* The operations available to the student should not accomplish goals on behalf of the student; rather, they should present students with the opportunity to exercise strategies to accomplish goals on their own. Anderson (1990), for example, noted the importance of changes in the strategies learners use during skill acquisition. Collins and Ferguson (1993) proposed a variety of generic strategies they call epistemic forms that apply across a large variety of tasks. Many of these forms, from making lists and comparing entities, to functional and procedural analyses, constitute valuable strategies that would be appropriate scenario operations for many GBSs.

### Example Scenario Operations

*Broadcast News.* Operations in *Broadcast News* center around editing text and video for broadcast. For example, the student can ask the writers for a revision of a news story with instructions, if desired, as to the specific type of rewrite (e.g., "Emphasize the U.S. involvement more"). Video clips in news stories can be edited or replaced at any time. The student can also ask questions about the news and its content. The expected form of the outcome of every operation in *Broadcast News* is clear (e.g., if you ask for a revision, you will get one). On the other hand, though the operations themselves are simple, putting together a series of operations that leads to a high-quality

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finished newscast is not easy at all. There is no trick, no way to guarantee getting a better story from the writers; the student must pay attention to the stories he or she is working on.

Students also always have the flexibility to choose whatever action they want to take at any time. They decide when to edit text, when to edit video, when to ask for a rewrite, when to ask background questions, and so forth. The system responds immediately to such operations. Each operation is also clearly relevant to the mission as well as to the real-life job of news producer. All *Broadcast News* operations are in service of the student's mission—to put together a newscast.

*Sickle Cell Counselor.* In *Sickle Cell Counselor,* the scenario operations include talking with experts, performing blood tests, viewing samples, predicting outcomes, and advising clients. These activities are carefully linked with the pedagogical goals and with the mission. Asking questions of the experts, for example, is an activity that both supports specific content objectives and furthers the user's mission of providing clients with useful information. The linkage is not always this direct, but each action possesses some plausible relation to the mission (a relation that the guide can be asked to explain in many cases).

## DISCUSSION AND FUTURE WORK

Well-designed GBSs should be able to teach an extensive body of material, equivalent, for example, to a semester-long course. Developing educational software of this magnitude presents formidable pragmatic and economic challenges. Even with the aid of tools, the development of such software seems prohibitively expensive for most courses. Much of the problem lies in the fact that traditional tools do not address the most difficult aspects of developing such software: the proper coverage and representation of the content to be used, and the appropriate way to package this content in an instructionally effective manner. General-purpose tools allow editors to facilitate the entry of content and drivers for using and presenting the entered content (e.g., Murray & Woolf, 1991). However, they largely ignore the issues of determining the content to be included or actually providing some of the content that may be needed. Because the bulk of development time is spent performing tasks related to the analysis, such as specification and entry of content, facilitating these tasks seems to hold the greatest promise of rendering the development of GBSs economically viable. Consequently, we are presently developing two broad classes of tools: "content rich" tools that allow the actual material in a GBS to be reused, and tools that allow templates for scenarios to be defined and reinstantiated.

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## Content Rich Tools

GBSs, we argue, should focus on teaching a set of target skills. One concern we have is that GBS designers who want to teach a set of facts or cases will simply generate contrived target skills that incorporate them, such as the skill of understanding the importance of July 4, 1776. It is not a question of simply stating the goal as a skill. The point is that July 4, 1776 is not the kind of thing we should want to teach. Only the desire to teach skills and processes should motivate the development of a GBS. It is important to reiterate that we do not object to students learning facts and cases. On the contrary, we expect GBSs to provide resources that will present facts necessary to accomplish the mission and cases that illustrate points along the way. We simply maintain that they are not the class of material that should constitute the pedagogical goals of educators. If the facts are really that crucial, there is no reason to worry. Students will inevitably encounter them while pursuing a GBS. Otherwise, we must question why we believed those facts were so important to begin with.

Content rich tools, therefore, will need to enable existing content to be reused in a way that promotes the acquisition of different skills. Proposing the reuse of content may appear to imply that we are implicitly advocating teaching the same things over and over again. This is assuredly not the case. Instead, we intend to exploit existing regularities that occur across domains. For example, it should not be controversial to suggest that a simulation of chimpanzees competing for food and mates, and a simulation of corporations competing for money and market share, will both employ content theories describing agents competing for resources. If they did not, something would be terribly wrong.

We are, in fact, presently developing a GBS that builds upon Hughes' basic architecture in *Chimpworld* (Hughes, 1993)—a simulation of a small chimp society—to teach economics by having a student run a company that is in competition with others. This GBS is being developed in the context of building a tool with a generalized agent model and simulation driver that will allow GBS developers to specialize agents to simulate a variety of social phenomena. Building tools that facilitate the reuse of content such as agent models simply keeps us from reinventing the wheel. In addition to facilitating the development of GBSs, reusing content has the added benefit of promoting the application of content that has been effective in the past. Other content rich tools we are working on include the *teaching executive,* which monitors student actions in client programs and suggests appropriate tutoring response types to the client program.

## Scenario Template Tools

It is not enough to provide students with a learn-by-doing task if what they are doing is not relevant to them. We believe that anything we would want to

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teach can be taught in such a way that students learn it while pursuing an interest of their own. In addition to incorporating an interest, it is also important to give students something to work towards. People learn things when they need to know them. Providing students with the opportunity to achieve a goal they find interesting is a good way to make them need to know what we want to teach. Therefore, we are presently building tools that allow developers to create GBSs by instantiating abstract scenario templates that promote a sense of investment on the part of the student. One such template is the Decision Motivated Investigation template, in which students are put in a situation where they must make decisions without data and knowledge needed to make an informed judgment. Students then investigate their environment and perform the actions necessary to generate or retrieve the needed information. The *Sickle Cell Counselor* program exemplifies this approach. Other templates will focus on the design or artifacts needed to avert impending problems, or assembling artifacts with constrained resources to achieve a goal.

Each of the tools we are building attempts to enforce the relevant design criteria we have outlined in this article. To review briefly, the target skills that a GBS teaches will be of value to students if it is evident to the student that they can be used to achieve a desirable goal. The tools in question will help ensure the presentation of skills, as opposed to facts, by making available abstract environments designed to present certain classes of skills in context. Achieving the mission, however, will only be meaningful if it takes place within a plausible context. To promote this sense of accomplishment, it is important to develop a cover story that provides the student with a realistic role to assume while pursuing the mission. By reusing many of the same abstract scenario types, we will be able to exploit existing resources required to convey a rich environment.

We believe the underlying principles of GBSs are founded on a sound theory of memory and learning. Nevertheless, GBSs must prove their worth over time by demonstrating a capacity to teach skills effectively. We are encouraged by our preliminary experiences. As we develop a variety of GBSs, we will be exploring a variety of issues, including, among others, the ability of students to transfer skills learned in a simulation to real-world situations, student willingness to assume roles and missions over extended periods of time, and minimization activities included only to maintain and further the cover story.

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# APPENDIX:
# Summary of GBS Components and Design Criteria

The four main components of a GBS—the mission, cover story, scenario operations, and mission focus—along with the criteria each should meet are summarized in the following tables.

Mission: The Primary Goal the Student Pursues Within the GBS

| *Criteria* | *Definition* |
|---|---|
| Goal distinction | The goal should be clear, plausible, and consistent with the cover story. Progress towards the goal as well as its accomplishment should be obvious to the student. |
| Goal motivation | Much of the motivation to work through the GBS will come from the desire to complete the mission. The mission should be a goal that the students already have, or one that there is reason to believe the students will enthusiastically adopt. |
| Target skill dependence | Completion of the mission should require mastery of the target skills and knowledge. |
| Empowerment | Completing the mission should demonstrate to the student that he or she is now capable of achieving a wide class of goals. |
| Flexible achievement | A mission should be selected that can be achieved many different ways, yet for which no single solution is guaranteed to work every time. |

*Example*

The student's mission in *Broadcast News* is to produce a new broadcast by editing text, selecting video footage, and reading the copy.

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Mission Focus: The Overall Organization of the Student's Activities Within a GBS

| *Criteria* | *Definition* |
| --- | --- |
| Task consistency | The overall focus of the student's activities should be suggested by the mission and cover story. Possible mission focuses include explanation, control, discovery, and design. |
| Student investment | The mission focus should promote a student's sense of personal investment in the mission. |
| Process emphasis | Pedagogical goals should depend principally on the process of trying to complete the mission. |
| Artifact dependence | The "artifact" of the mission focus, be it a design, an explanation, or otherwise, should reflect the student's understanding of the domain and embody a solution to the problem at hand. The properties of the artifact and its performance within the cover story should reflect the strengths and weaknesses of the solution. |

*Example*

The mission focus in *Sickle Cell Counselor* is explanation: the task structure can be characterized as generating a predictive theory of sickle cell disease.

Cover Story: The Premise Under Which the Mission Will Be Pursued

| *Criteria* | *Definition* |
| --- | --- |
| Role coherence | The cover story should provide a desirable role for the student within a plausible, exciting, and accessible story. |
| Target skill density | The cover story should be designed to lead to situations that maximize the need to apply the target skills and minimize the need for others. |
| Frequent practice opportunities | Advancing the cover story should require minimal time and effort relative to that spent on acquiring target skills and knowledge. The cover story should provide situations that allow the target skills to be practiced in a wide variety of contexts. |
| Integrated support | Additional assistance required by students should be provided using materials consistent with the cover story when possible. |

*Example*

In *Yello* (Kass, Burke, Blevis, & Williamson, 1993/1994), the student plays the role of a Yellow Pages ad salesperson. A simulation lets students move from the local sales office, where they design prospective advertising, prepare sales presentations, and contact clients by phone, to their client's place of business where they make sales calls.



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Scenario Operations: The Activities the Student Performs in Pursuit of the Mission

| *Criteria* | *Definition* |
|---|---|
| Responsiveness | Students should be able to observe the causal effects of their operations. |
| Expressivity | Students should be provided with a sufficient number of operations to allow them to pursue the mission as they see fit. The operations available should include those that can lead to a failure in achieving the mission. |
| Causal consistency | Operations and their outcomes should be consistent with the cover story and mission. |
| Peripheral support | The student should be relieved of operations that are not central to the pedagogical goals of the GBS. |

*Example*

In *Sickle Cell Counselor,* the scenario operations include talking to experts, viewing samples under a microscope, and predicting genetic outcomes.



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