# Instructional Design and the Authoring of Multimedia and Hypermedia Systems: Does a Marriage Make Sense?

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## Introduction

Instructional Design (ID) deals with the systematic design of learning environments and instructional systems, which may include various facets of didactic methods and media, e.g., direct instruction, self-instructional textbooks, and instructional video, as well as computer based training, interactive multimedia, and elements of distance learning. Models of ID provide theoretical frameworks for professionals who plan, produce, and manage such instructional systems. Furthermore, they prescribe certain procedures for developing learning environments and instructional systems in order to enhance the quality of training.

A significant category of ID models explicitly links theories of learning and instruction with the actual construction of instructional materials. Such models, which are often called Instructional Systems Development models (ISD), typically distinguish a number of phases, or activity clusters, in the development of instructional materials. Typical clusters of activities concern: (1) the analysis of needs, tasks, and learning objectives; (2) the design of increasingly more detailed blueprints that specify the requirements of to be-constructed instructional materials; (3) the construction and implementation of the instructional materials; (4) the evaluation of the materials, in both a formative and summative sense; and (5) the maintenance of the instructional system.

In contrast to ID models that mainly focus on the first two stages of instructional development (analysis and design), ISD models thus include phases for the construction or production of instructional materials, the formative and summative evaluation of those materials, and their maintenance. Despite this more or less broad interest it must be concluded, however, that these systematic approaches are hardly applied in reality. The relation between ID models and practical approaches in producing hypermedia and multimedia courseware must be described as a problematic one. It is our firm conviction that most multimedia and hypermedia systems are authored without the application of an ID model.

The goal of this article is to clarify the relationship between ID and the authoring of courseware, in particular, of multimedia and hypermedia educational systems. Questions of special importance here are: Are ID models really necessary in the context of courseware authoring? If so, why? Building on the assertion that ID models can be helpful to courseware authoring, we will investigate if current ID models are suitable to reach this goal. Finally, we will indicate possible directions to better integrate a systematic design of instruction with the authoring of multimedia and hypermedia. To sum up, we will analyze the relationship between ID models and the authoring of multimedia and hypermedia educational systems, discussing possible reasons that seem to hinder a happy marriage.

## Instructional Design Models

Instructional design models have the ambition to provide a link between learning theories and the practice of building instructional systems. Research in this field aims at providing ID models that are the integrating elements of a linking science looked forward to for many years (Elen, 1994; Glaser, 1976; Reigeluth, 1983). In order to solve instructional problems, ID models make explicit which variables to consider, specify their interrelationships, and provide indications on the use of particular instructional interventions. By doing so, ID models aim at bridging the gap between (instructional and learning) theory and the development of powerful learning environments. As such, ID models are neither purely theoretical nor purely practical; they are bridges between both extremes.

Authors of ID models proclaim that the use of their model is warranted if effective instruction is to be designed and developed. ID models, it is argued, reflect

This article summarizes the main points raised by the panelists and the audience during a panel discussion concerning the role of educational theories and instructional design in the development of multimedia and hypermedia. The panel took place at the World Conference on Education and Hypermedia (ED-MEDIA '95), June 17–21, Graz, Austria. The panelists, who are also the authors of this article, are grateful for the contributions of the audience.

and operationalize outcomes of research on learning and instruction. Given their scientific background, their quality surpasses the quality of implicit models used by many developers, as these may rest on naïve, inadequate, deficient, and even 'wrong' idiosyncratic theories about learning and instruction.

ID models focus on the design phase, on the construction of a blueprint taking numerous factors into consideration. ID models, therefore, argue that any instructional development and delivery effort requires deliberate decision-making about the kind of support to be offered by instruction in view of the attainment of learning goals by learners with specific characteristics.

The ambition of ID models is to support the design of efficient and effective instruction. This goal can only be reached if they are readily used and appropriately applied. In other words, in the absence of a recognition of the value of design in general and ID models in particular by potential users, these models remain theoretical constructs no matter how practical they might be.

However, it seems that in the context of authoring multimedia and hypermedia systems, ID models are hardly used and, when they are, they are regularly misapplied. The chain between theory and practice seems to be broken. In the absence of conclusive research on the actual use of ID models, the following impressions may illustrate the restricted attention paid to instructional design.

(1) An indicator of the importance attributed to a problem is the number of courses, curricula, or programs that educational institutions offer. Taking a worldwide perspective, the number of programs dedicated to instructional design is scarce. Several programs exist in the USA, but in Europe, for instance, we know of only a few such programs in higher education. Interestingly, some of them are not even located in educational departments but are offered by media or computer science departments.

(2) The development of instruction and especially courseware requires contributions by a variety of experts. They cooperate in a team. Given the ambition of instructional design, it might be expected that the instructional design experts head such teams. This seems to rarely happen. Mostly, programmers or managers take over this responsibility, arguing that they are the final product developers and responsible for project budgets.

(3) Focusing on realizing a product rather than on supporting learning, courseware developers regularly assume that authoring systems help them to design instruction. While authoring systems provide tools to develop (more or less) various aspects of instruction, they do not (and do not intend to) take over or support decision-making about the selection of learning goals, the appropriateness of approaches or methods, or the most suitable kind of evaluation. This limitation of authoring systems can be said to be one of the reasons why recently so much time and energy has been devoted to trying to automate instructional design (Spector, Polson, & Muraida, 1993).

From the perspective of instructional design, the broken chain results in poor instruction as the consequence of paying too much attention to less important elements. For instance, Zahner, Reisser, Dick, and Gill (1992) found that in evaluating the quality of courseware, teachers pay attention to surface characteristics of instruction (color, pictures, etc.) or to features that make their life easier rather than to elements that may support learning. Beck, McKeown, and Gromoll (1989) pointed to difficulties learners would experience studying social studies textbooks, given their lack of coherence and considerateness, i.e., given a lack of design. Taylor, Ellis, and Baldwin (1993) evaluated the quality of US Navy classroom training. They concluded that poor quality was mostly due to the


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absence of design prior to the delivery of the training.

On the other hand, although typically claimed, the superior instructional quality and efficiency of systems that have been constructed on the basis of a widely accepted ID model has not been proven empirically. But given the complexity of this research question, it seems doubtful that this question could ever be decided by empirical research, since possible failures can be attributed to an arbitrary number of factors independent of the tested models. The lack of application of ID models must simply be seen as a lack of professionalism. Any profession gains some of its self-confidence by establishing systematic procedures in their field. Computer science, for example, made a tremendous improvement in reputation when software production was no longer perceived as somewhat mystical art and an engineering approach was settled.

## Lack of Attention to ID Models

The question now becomes how this lack of attention paid to instructional design (and, hence, ID models) can be explained. A thorough analysis of the sources of the problem may help to overcome it. In general, a distinction can be made between reasons that are either external or internal to ID: external reasons, on the one hand, relate to deficiencies in applying existing ID models. Current ID models should enhance the quality of multimedia courseware, if only they were applied appropriately. Internal reasons, on the other hand, pertain to concepts of instructional design. Insufficiencies of current ID models might be responsible for their limited usefulness in typical multimedia projects.

### Reasons External to Instructional Design Models

Although everybody crosses bridges often in her/his life, few would claim to have the knowledge to build a bridge. When a bridge is to be built, engineers are called to do the job. With regard to learning and instruction, the situation seems to be different. Firstly, the experience of being instructed, the task of instructing itself, and the task of designing instruction all seem to be closely related. Having experienced instruction at school, everybody has acquired some knowledge of the profession of teaching simply by observational learning. This experience gives rise to the impression that instructing and, by implication, the design of instruction, is a rather obvious endeavor. When observing teachers, their activity most often appears to be a rather simple task of conveying information to others. Consequently, novices at ID who rely on their classroom experiences typically choose a rather static information delivery approach rather than a learning-support one. Presenting well-structured information in an attractive way gets focused upon, and ID is reduced to the design of mere surface characteristics. Moreover, some highly capable and reflective persons may be able to overcome their own experiences and design instruction by considering learning goals, the specific context, and learner characteristics. It should be noted, though, that the number of such persons remains restricted. For most, experience with instruction does not result in the expertise to design it. Taking into account the complexity of the relationship between learning and instruction, design requires extensive training.

Developers of instructional multimedia perceive ID models as something that make their endeavors more difficult, whereas authoring systems simplify their efforts. Authoring systems provide the necessary tools for producing multimedia. Their contribution to enhancing the productivity of courseware production thus is obvious. ID models, on the other hand, complicate the production, since they demand several activities and decision-making that do not immediately contribute to the development of instructional material. Authoring systems seem to suggest that producing instructional multimedia is something simple, a task not related to pedagogical or psychological knowledge.

It is very common (especially at the university) to find multimedia projects that are developed by one author. Obviously, for that person, the use of authoring systems is very useful. Nevertheless, ID models assume an ID team at work. The use of authoring systems gives a false idea: producing multimedia or hypermedia systems is something simple, and it is not necessary to have pedagogical and psychological knowledge—you only have to learn how to use the authoring system and organize the knowledge in a logical way; learning will then appear without effort.

At the same time, not to use ID model is impossible. There is not really a choice between using an ID model or not. The real choice is to use an explicit or an implicit model.

### Reasons Internal to ID Models

Up to now, reasons external to the field of instructional design have been mentioned. However, the current state-of-the-art of instructional design and the available ID models may also contribute to the non-use or misuse of the models. Merrill, Li, & Jones (1990) have discussed some limitations of mainstream ID models that may make them difficult to use. In our view, five aspects that make it difficult to pay attention to instructional design are as follows:

(1) There is a mismatch between the actual way in which developers work and the process-indications provided by ID models (Nelson, 1987; Pieters & Bergman, 1994; Rowland, 1991). The process descriptions are logical models not psychological ones. They 'force' developers to act in a way that seems not to suit their problems and concerns. In the absence of

clear indications of the benefits of the logical models, the indications are not followed. It must be noted that recent models avoid the problem by specifying activities to be executed or aspects to be considered, without offering a precise sequence in which to execute them (Elen, 1995; Spector, Polson, & Muraida, 1993).

(2) There is an (over) abundance of ID models. In addition to a scientific endeavor, instructional design is also a commercial one. To have a model with your own name on it is an interesting commercial strategy. The abundance of models that do not make explicit their theoretical background and/or their inherent limitations (for instance, by specifying the instructional problems they are most suited for) and use a very specific model-bound terminology creates confusion and certainly hampers sound selection. Moreover, there is no consolidation of these models. A lot of the models say the same thing, give the same advice, but use different words (Andrews & Goodson, 1980). This makes them look new and makes the author of the model appear brilliant, perhaps, but hardly contributes to the development of ID itself. Clark (1989) has pointed out that there is an urgent need for consolidation of the existing models with focused research on contradictions and disagreements.

(3) There is a problem with specificity of ID models and the negative linear relationship between specificity and applicability. ID models are confronted with the problem of providing indications on how to go about designing instruction, at a particular level of specificity. The more general the specifications the wider their theoretical applicability but the smaller their immediate practical usefulness. The more specific the specifications, the more limited their theoretical applicability but the greater their immediate practical usefulness. The problem becomes even more complex when specificity has to be further operationalized. In what respect are indications made more specific? Learning tasks, delivery systems, types of students, types of learning contexts—each provides a perspective for specification. This reveals the need for the identification of relevant dimensions in ID models' referent systems (Edmonds, Branch, & Muhkerjee, 1994). In the absence of an appropriate training that helps designers to translate general models to their particular situation, the call for more specific models will go on along with the complaint that these specific models are not widely applicable and not specifically tuned to the idiosyncratic situation of the developer.

(4) There is an absence of validation studies. In the above, the ambition of ID models has been said to support the design of efficient and effective instruction. This remains a theoretical statement insofar as attempts to empirically test the indications provided by ID models are scarce. The complexity of such an endeavor should not be underestimated (Gros & Spector, 1994). Especially problematic is the validation of combinations of indications. While each specification can be tested separately, how they interact remains unknown. In the absence of positive evidence about the added value of ID models, arguments to use them sound idle.

(5) There is an apparent problem with the linear character of ID models. A common approach in the authoring of multimedia and hypermedia, as well as in the authoring of other software systems, is rapid prototyping. Small prototypical parts of the system are built in order to allow user tests, which immediately have an impact on the design and construction of the next prototype. This cycle typically iterates through many loops. However, it would be a misunderstanding to pose a rapid prototyping approach against a more linear ID approach. Instead, rapid prototyping approaches might be used in all phases of an ID model. For instance, rapid prototyping is useful while analyzing a subject matter domain. Then, small prototypes of the domain may be built (e.g., as concept maps, pattern notes, flowcharts) and repeatedly validated by experts or teachers in the domain.

## Towards More Powerful ID Models

From the previous section, it may be concluded that ID models may be helpful to make the authoring of courseware more efficient, and ultimately, to make the developed courseware more effective. However, the question remains if current ID models are useful in reaching this goal, or if another type of model is necessary. We believe that some desired characteristics of ID models that are suitable to be used for multimedia and hypermedia development are:

- they must allow a more flexible design and rapid prototyping in several design phases;
- they must be sensitive to the characteristics of hypermedia and multimedia systems;
- they must clearly link knowledge acquisition and skill acquisition;
- they must provide support to the authoring process; and
- they must provide guidelines for principled and effective use of advanced technologies.

Another problem might be that current ID models usually focus on the skills domain, or, in terms of Gagné, on cognitive skills. They typically follow some hierarchical or information processing approach in analyzing the skill-to-be-taught (e.g., by making a hierarchy of prerequisite skills, by analyzing the skill in its subskills), and only analyze information that should be presented or made available to the learners insofar as this is relevant to the learning and performance of the cognitive skill. According to this ID approach, the presentation of information is thus always subordinate to practicing a skill. This seems to be in clear contrast with the ideas underlying many multimedia or hypermedia systems. In most of those systems, the acquisition of knowledge instead of the acquisition of skills is at stake. Their hyperlinked structure allows for a rich, multi-perspective view on a knowledge domain, and learners are free to explore the domain by browsing and navigating through it. Moreover, the richness, interlinkedness, and multi-perspectivedness may be argued to lead to a deeper understanding of the domain.

Indeed, there seems to be a discrepancy here. But the arguments may also be reversed. Multimedia and hypermedia systems that merely present information tend not to be truly effective in building a rich mental model of a domain by a learner—unless they are used in an educational context requiring the learners to use it to reach some (non-trivial) goal. For instance, not many people study encyclopedias for fun, and after the novelty effect has disappeared, not many people will study multimedia encyclopedias for fun; they use them, and acquire knowledge about a domain, because they need this knowledge to perform some task, solve some problem, or confront some situation.

New ID models that integrate those views are needed—and are now beginning to appear. Usually, those models combine classical approaches from ID with more recent constructivistic approaches. For instance, the Four-Component Instructional Design model (4C/ID model; Merriënboer, Jelsma, & Paas, 1992) starts with an analysis of both skills and knowledge in order to find a set of non-trivial problems, cases, or scenarios that provide the primary basis for an instructional system. Coupled to either individual cases or problems or sets of them are subsystems that might provide practice in basic subskills, present information that is relevant to performing particular procedures (e.g., electronic performance support systems, job-aids, on-line manuals), or provide highly integrated networks of supportive knowledge (e.g., multi- and hypermedia systems, but also classical textbooks). While the model provides guidelines for designing and integrating all subsystems, the actual construction of each individual subsystem has to be supported by more specific authoring models or systems. The main advantage of such an ID model is that it yields one integrated learning environment, in which there is a clear link between all components of an instructional system—including multi- and hypermedia.

We can also find some examples of integration of ID and authoring in the field of automation of ID. In this section, we will discuss two examples. Both fall into Goodyear's (1994) category of weak systems, as they are not intended to replace human activities with automated solutions; rather, they are intended to complement the activities and processes of courseware development. We do believe that research emphasis should also be given to strong systems, as designing, evaluating, and implementing such systems will very likely result in new and deeper knowledge about instructional design. One such strong system (XAIDA, or the Experimental Advanced Instructional Design Advisor) is currently being evaluated in field settings with promising results (Spector, Arnold, & Wilson, in press). XAIDA is a generative system (Halff, 1993) in that it generates courseware based on information input by a subject specialist according to well-established (pre-programmed) instructional strategies customized dynamically for the specific instructional circumstances involved at that point in the development. We are basically in agreement with Halff (1993) that advisory systems which create entirely new strategies are not likely to be developed any time soon.

Recall the general thesis of this paper, namely that it is possible to provide a useful link between learning theories and instructional design practices. The two systems discussed below involve two different learning perspectives. The Guided Approach to Instructional Design Advising (GAIDA) is tied directly to Gagné's (1985) theory, whereas Guidance for Open-ended Learning Designs for Instructional Environments (GOLDIE) is linked to Hannafin *et al.*'s (1994) constructive theory. GAIDA is a lesson-planning support system which makes use of completely worked examples or cases to elaborate Gagné's nine events of instruction. The cases are validated (known to be effective in facilitating learning) and can be viewed independently (completely from the learner's perspective) or from the design point of view. Targeted users are inexperienced courseware developers. **Figure 1** indicates a sample of the kind of assistance available in GAIDA.

While this figure appears to be quite text-intensive, its utility with the targeted users is well established. Users may easily choose to pass from this screen to a view of the lesson described in the lower right quadrant by pressing the GO TO SAMPLE LESSON button. Doing so actually puts the user into the lesson at the point being described. The ICW button provides additional guidance specific to multimedia situations. The NOTES button allows users to keep notes and create an initial lesson plan. The nine numbered buttons were added at the request of users to enable them to proceed to any event. Thus, users are allowed to proceed in a non-linear fashion through this hypertext, case-based tutorial on lesson design.

GOLDIE is a course and curriculum planning support system which makes use of an on-line tutorial and various planning aids, including a syllabus planning tool, a course calendar, etc. These planning support tools are provided from an overtly constructivist perspective but are not inconsistent with the lesson planning guidance provided in GAIDA. In fact, the two systems are being integrated by the Consortium for Courseware Engineering (Armstrong

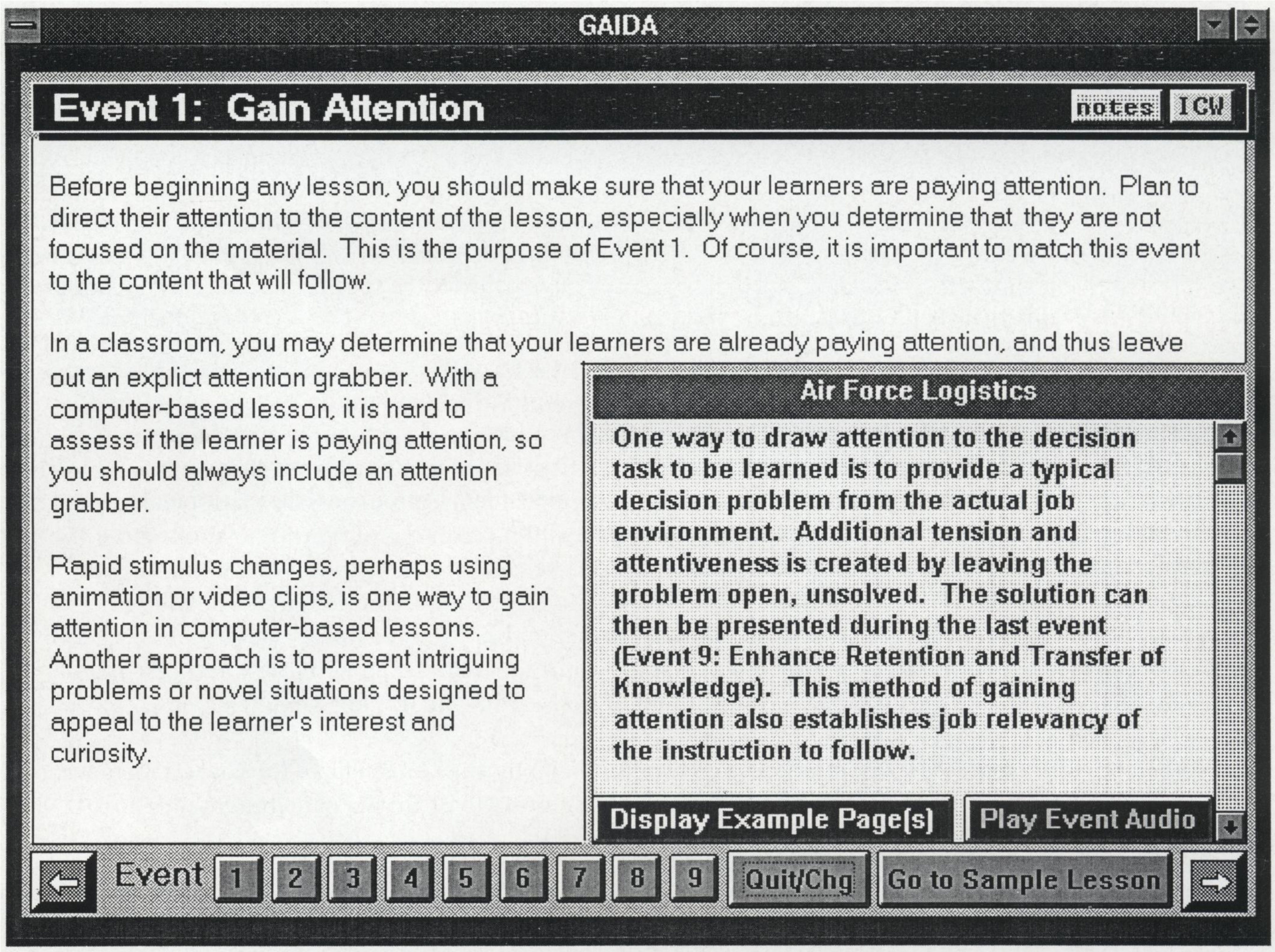


**Figure 1.** GAIDA: Event one guidance screen.

Laboratory, CYBER Learning Corp., and the University of Minnesota) into a single tool called GUIDE (Guidance for Understanding Instructional Design Expertise). **Figure 2** depicts a typical screen from GOLDIE. The organizing metaphor behind GOLDIE is that a course can be conceived of as a trek or journey, which might contain phases, milestones, and stepping stones. Each step along the journey can be viewed from an enabling perspective (what is needed to make this step successful), from a processing perspective (what is needed to support taking this step), and from a resolving perspective (what is needed to provide for learning lessons from having taken this step). Moreover, each of these perspectives can be organized in terms of four factors: context, facilitation, activities, and discussion. The supporting guidance in GOLDIE for elaboration of the component steps makes an overt attempt to encourage users to view the journey from the traveler's (i.e., the learner's) point of view.

The GOLDIE depicted here is also text-intensive. This is consistent with the targeted users (inexperienced courseware developers), the specific context (tutorial on course planning), and the supporting tools and activities provided (a syllabus construction tool and a course calendar). Users can proceed in a non-linear fashion through this tool, as was possible with GAIDA. Text-based guidance can be ignored or easily passed over in favor of more specific examples.

We have already argued that there are a variety of reasons for the apparent lack of integration of instructional design theories and instructional design practices. We listed five factors which make this integration difficult: (1) a mismatch between various ID models and the way developers actually work; (2)

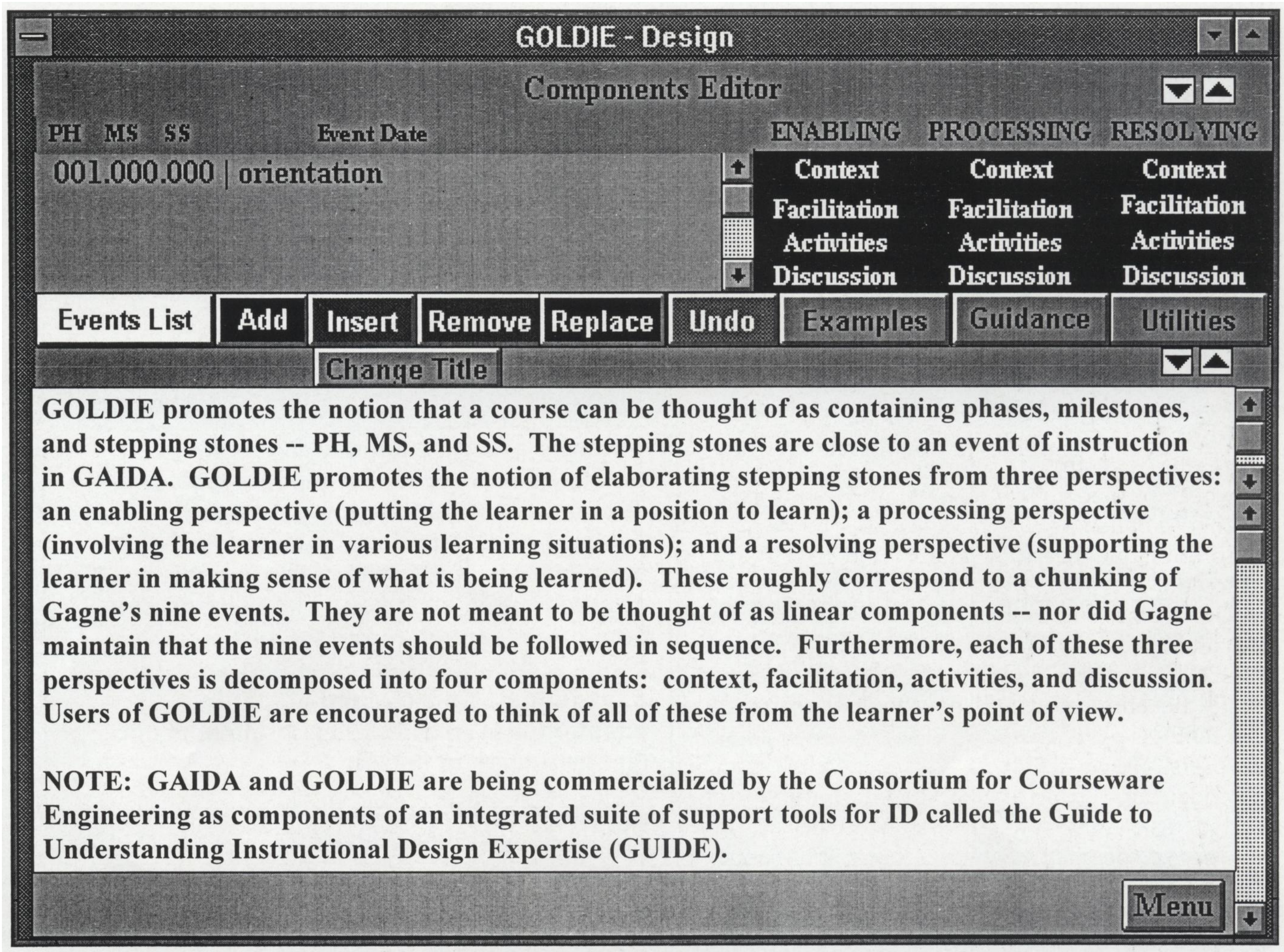


**Figure 2.** GOLDIE: Components editor screen.

proliferation of ID models; (3) lack of specificity and the linearity of ID models; (4) absence of validation studies; and (5) the apparent linear character of ID models

We first want to indicate that the fourth area remains problematic. Although there have been validation studies conducted for GAIDA, ID Expert (see Merrill *et al.*, 1990), and XAIDA, these all suffer from two characteristic flaws: lack of sufficiently large samples of controlled subjects, and lack of independently conducted evaluation studies. We believe these flaws are endemic to virtually all of the systems currently under development. Until institutions and organizations are willing to really undergo rigorous and completely independent evaluation, little progress is likely to occur in this arena.

This should not be taken as a fatal criticism of the systems mentioned above or of others. At least those cited here have attempted some evaluation studies to determine likely causes of effects, as have others. Moreover, those systems which have not [yet] been evaluated may offer much of value to actual practitioners. Indeed, one kind of independent evaluation involves observing the use of instructional design support systems by actual developers, given our earlier comments that developers mostly disregard instructional design theories and authoring support systems built explicitly around instructional design principles and theories (Perez & Niederman, 1992; Rowland, 1992). Against this criterion, both GAIDA and GOLDIE are receiving wide acceptance in their targeted user populations (United States Air Force inexperienced courseware developers).

One of the reasons for the easy and widespread acceptance of GAIDA is that it has been partially designed by the targeted users (Spector, Polson, & Muraida, 1993). This same practice of participatory design is being used with XAIDA.

With regard to the proliferation of ID models, we can only say that this is a problem for the entire community. We cannot be expected to resolve it here. We can suggest, however, that progress is not likely to occur when there is such serious polarization within the instructional design community. Progress in refining and winnowing ID models can occur only in the spirit of collegiality and cooperation.

The problems concerning specificity and linearity can be and have been addressed. Both GAIDA and GOLDIE offer varying degrees of specificity, and both offer users the chance to make progress with their own developments in a non-linear fashion. GAIDA's approach to specificity is to allow the users to adjust all of the guidance as well as the cases to their needs, according to what they know works well in their instructional design environments. All of the guidance in GAIDA exists in ordinary text files which can easily be altered by knowledgeable users. In addition, GAIDA's case base is extensible. Existing cases can be easily be eliminated and new cases can be added. GOLDIE's level of specificity is not presently adjustable by users. However, the processes of creating course calendars and course syllabi are reasonably open-ended tasks that can be accomplished in varying degrees of specificity, which is completely under the control of users.

## Final Remarks

Contrary to common practice (or belief) it is impossible not to use a model of instructional design. Even if one does not refer to such a model explicitly, every developer of instructional multimedia does apply some assumptions about learning and instruction implicitly. Some authors have suggested solving this problem by raising the "intelligence" of future authoring environments. These environments could support the developer with instructional design decisions and integrate them with customary authoring tools. With such a system, the author will be forced to make design decisions deliberately before starting to produce actual materials. However, such an electronic support system for instructional design will only yield acceptance if authors understand the underlying concepts and realize the usefulness of the approach (which means authors perceive them as an aid to improving instructional quality and efficiency), and, if the provided ID models prove as appropriate for the relevant projects. Therefore, our problem will not be solved by simply implementing a current ID model into an electronic support system or other even more demanding approaches of automating instructional design. Future directions will consequently have to deal with two directions, one dealing with raising awareness of ID as an essential, but separate professional activity, the other with the development and validation of ID models that answer some of the outlined critics.

We remain convinced that a marriage of instructional design and multimedia authoring not only makes sense: it should be approached with enthusiasm and optimism. □

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## Comments/Suggestions?

The Editors of *Educational Technology* welcome your feedback on the articles in this issue of the magazine and on all aspects of our coverage of the field.

Similarly, the Editors welcome Letters to the Editor and/or less formal communications regarding general trends and issues in educational technology.