An Interpretation Construction Approach to Constructivist Design

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Original article published: In B. Wilson (Ed.) **Constructivist learning environments.** Englewood Cliffs, NJ: Educational Technology Publications, 1995.

Study is a key concept in making design more fruitful in education. We propose that what students are doing when they construct knowledge is studying. Specifically, we think that the term *study* captures better what should be going on during knowledge construction then does the term *learn*. Thus, in designing for knowledge construction we see ourselves as designing Study Support Environments (SSEs) instead of "instructional systems" or "learning environments." Creating SSEs allows us to create "a place for study in a world of instruction" (McClintock, 1971, "Toward a Place for Study in a World of Instruction"). The core of study is the hermeneutic activity of constructing interpretations. Hermeneutics as a field focused initially on interpretation of texts, but has broadened to interpretation in general (Palmer, 1969; Gadamer, 1976). From this perspective, the basis for cognition (and being in general) is interpretation based on background knowledge and beliefs (Heidegger, 1962; Winograd and Flores, 1986). Consistent with these philosophical arguments for the centrality of interpretation in cognition are the many research results from cognitive psychology showing that understanding involves making a large number of inferences (Black, 1984; Black, 1985). Thus, the key consideration in designing a SSE is fostering the construction of interpretations based on observations and background contextual information.

Teachers College, Columbia University has been collaborating with the Dalton School (a K-12 independent school in New York City) on the Dalton Technology Plan. The general aim of this plan is to develop a digital knowledge-base and information infrastructure for all aspects of the K-12 educational experience, and to implement educational strategies designed to make use of this infrastructure, enhancing significantly an already excellent educational experience. In this paper, we describe a framework for SSE design and describe its application to three specific SSEs created as part of the Dalton Technology Plan. After describing the SSEs we report evaluations that demonstrate their effectiveness.

Interpretation Construction (ICON) Design Model

1. **Observation:** Students make observations of authentic artifacts anchored in authentic situations
2. **Interpretation Construction:** Students construct interpretations of observations and construct arguments for the validity of their interpretations
3. **Contextualization:** Students access background and contextual materials of various sorts to aid interpretation and argumentation
4. **Cognitive Apprenticeship:** Students serve as apprentices to teachers to master observation, interpretation and contextualization
5. **Collaboration:** Students collaborate in observation, interpretation and contextualization
6. **Multiple Interpretations:** Students gain cognitive flexibility by being exposed to multiple

interpretations

7. **Multiple Manifestations:** Students gain transferability by seeing multiple manifestations of the same interpretations

Some of these constructive design principles are adaptations from proposals by others. For example, the Cognitive Apprenticeship principle comes from Collins, Brown and Newman (1988), the Multiple Interpretations one from Spiro, Feltovich, Jacobson and Coulson (1992), and the Collaboration one from Johnson, Johnson, Holubec and Roy (1984). The Observation principle is a combination of recommendations by Brown, Collins and Duiguid (1989) and the Cognition and Technology Group at Vanderbilt (1990), but our focus on authentic artifacts is unique. Further, our emphasis on Interpretation Construction, Contextualization, and Multiple Manifestations is distinctive.

Three Example SSEs

To illustrate the application of this design framework, we describe three SSE programs created for the Dalton Technology Plan. Specifically, we describe how these constructive design principles apply to the *Archaeotype* program used in 6th grade history, to the *Galileo* program used in 11th and 12th grade science (particularly for students not scientifically oriented), and the *Playbill* program used in 10th grade English at the Dalton School.

In the *Archaeotype* program, students study ancient Greek and Roman history by using observations of simulated archaeological digs to construct interpretations of the history of these sites, while drawing upon a wide variety of background information. The *Archaeotype* program (implemented in *Supercard* on Apple Macintosh computers), which is the earliest and most fully-developed of the Dalton Technology Plan projects, presents the students with a graphic simulation of an archaeological site, then the students study the history of the site through simulated digging up of artifacts, making various measurements of the artifacts in a simulated laboratory (**Observation**), and relating the objects to what is already known using a wide variety of reference materials (**Contextualization**). The students work cooperatively in groups (**Collaboration**), while the teacher models how to deal with such a site then fades her involvement while coaching and supporting the students in their own study efforts (**Cognitive Apprenticeship**). The students develop ownership of their work by developing their own interpretations of the history of the site and mustering various kinds of evidence for their conclusions (**Interpretation Construction**). By arguing with the other students and studying related interpretations in the historical literature, they get a sense of other perspectives (**Multiple Interpretations**). By going through the process a number of times bringing each contextual background to bear on a number of different artifacts, the students learn and understand the many ways that the general principles behind what they are doing become manifest (**Multiple Manifestations**).

In the *Galileo* program, students study astronomy and science in general by using observations of telescopic plates and a computer simulation of the sky to construct and test interpretations of astronomical phenomena. Students examine and make measurements on photographic plates from observatory telescopes and computer simulations of the sky (**Observation**), then relate these analyses to reference materials (**Contextualization**) containing what is know about astronomical objects (i.e., stars, planets, etc.). The teacher initially talks through how he would analyze and interpret examples of such astronomical data (**Cognitive Apprenticeship**) then the students form groups to work on some data (**Collaboration**), while the teacher coaches and advises them as they proceed. The students develop their own hypotheses and test them against the astronomical data (**Interpretation Construction**). Students defend their hypotheses using their analyses and reference materials both within and between the groups, and such argumentation together with background readings exposes them to various ways to interpret the data (**Multiple Interpretations**). As they proceed through the course, the students see how basic principles of astronomy, physics and chemistry can be used to make sense of different sets of astronomical data (**Multiple Manifestations**).

In the *Playbill* program, students study Shakespearean drama and English literature in general by using the text of the play and two or more videos of performances of the play. *Playbill* provides the students with highly indexed access to the text of Macbeth, two videos of performances of Macbeth and written commentary on Macbeth. Using this multimedia indexing system (implemented in *Supercard* on Apple Macintosh computers), students can read a portion of Macbeth (e.g., a scene) and then immediately jump to see one or two performances of what they have read (**Observation**). The students can also use this indexing system to jump to commentaries on the same portion of the play (**Contextualization**). Using portions of the play, the teacher models how to integrate reading the play, watching the performance and reading the commentaries (**Cognitive Apprenticeship**) and the students work together in groups (**Collaboration**) to develop their own interpretations of the play and how it should be performed (**Interpretation Construction**). Comparing their interpretations of the play with the other students both within the same group and then in different groups gives the students a sense of the many different reactions that people can have to a play like Macbeth (**Multiple Interpretations**). The multimedia indexing system also facilitates the students jumping around in the text and videos to see how the same entities (e.g., characters, themes, etc.) can be manifested in many different ways in the text and performances (**Multiple Manifestations**).

As these programs spanning history, science and literature show, while the basic material or data observed is widely different in different fields of study, our design framework is applicable to all. Another perspective on these programs is provided by the five facets of learning environments proposed by Perkins (1992). Specifically, Perkins proposed that one can analyze any learning environment from traditional classroom settings to futuristic technology-based settings according into how they implement the following five facets: information banks (traditionally encyclopedias and dictionaries), symbol pads (traditionally notebooks and blackboards), construction kits (traditionally TinkerToys and Legos), phenomenaria (traditionally aquariums and terrariums) and task managers (traditionally the teachers scheduling of classroom activities). The *Archaeotype*, *Galileo* and *Playbill* programs focus mainly on the information bank and phenomenaria facets. In particular, the archaeological site simulation, the sky simulation and telescopic plates and the multimedia play text and video indexing system are all phenomenaria designed to give the students the basic observational information they need to do their interpretation construction. However, to make these interpretations intelligently and to defend them well, the students in all three of these programs also make extensive use of various kinds of information banks varying from background texts, to on-line databases, to individual experts (including teachers), to videodisks (e.g., the National Gallery videodisk) and to museums (e.g., the Metropolitan Museum of Art). The symbol pads used are mostly standard word processing programs, although there has been some use of Hypercard as a more advanced form of symbol pad. There are no particular construction kits in the three programs we have covered here and the task managers are a combination of the traditional teacher scheduling (for the overall class scheduling) and the time management within the student groups. Another interesting distinction that Perkins (1992) makes is between BIG (Beyond the Information Given) constructivism and WIG (Without the Information Given) constructivism. Our focus is on WIG constructivism since we give the students the raw material for their observations but they have to analyze this raw material, come up with interpretations, present the interpretations and defend them.

Evaluation of Study Support Environments

Since we believe that interpretation is central to cognition and learning, we evaluated whether the *Archaeotype* and *Galileo* SSE programs would increase students' interpretation skills. Specifically, we tested whether the students who had been through these programs could make observations and interpretations in a completely new area better than students who had not been through the programs. For these studies, we chose an area unlikely to be familiar to precollege students -- namely, experimental psychology.

In the *Archaeotype* evaluation study, 6th grade students who had participated in the *Archaeotype* program and a comparable group of students that had not participated were each given a booklet describing four psychology experiments examining how people remember lists of words. The students had to examine the basic observations report on the results of the studies, find patterns in the results, devise explanations and argue for those explanations. They were also given some background readings in the psychology of memory. The reports the students wrote were then scored for how many they got of the 60 possible points they could have gotten for recognizing the patterns in the data, representing the data in insightful ways, explaining the patterns of results and arguing for the explanations. The students who had been through the *Archaeotype* program were able to get 42% of the possible points after 4 hours work, whereas the non-*Archaeotype* students were only able to get 32%. Most striking, almost all of this superiority was due to the *Archaeotype* students getting 45% of the possible points on the explanation and argumentation part of the scoring, while the non-*Archaeotype* students only got 26% on this portion (these two differences are highly significant statistically). Clearly, in addition to learning about archeology and ancient history, the *Archaeotype* students were acquiring a general ability to interpret and argue in new areas of study.

Similarly, the 11th and 12th grade students who had been through the *Galileo* program were compared to a comparable group on how well they could interpret and link three related cognitive psychology studies and their underlying principles. The students were given booklets containing descriptions of basic observations made in these three psychology studies together with various informational resources including relevant and irrelevant background material. The students were given three hours to perform the task and write a final report. As in the previous study, these reports were scored for the possible points that could be covered recognizing patterns in the data, representing the data insightfully, interpreting the data, and arguing for the interpretations. Here again the students who had been through the *Galileo* program were much better than students who had not -- with the *Galileo* students getting 44% of the possible points whereas the non-*Galileo* students only got 32% (this difference is highly significant statistically). In fact, the *Galileo* students showed this superiority in all the areas we scored for -- namely, pattern recognition, data representation, interpretation and argumentation. Clearly, the *Galileo* program like the *Archaeotype* one teaches students general interpretation skills in addition to specific content.

While we designed the evaluation studies as appropriate for what we were trying to accomplish with the SSEs, it is instructive to examine them in terms of the constructivist learning evaluation criteria proposed by Jonassen (1992). Our evaluations are goal-free since we did not look for particular interpretations by students but merely how well formulated and argued their interpretations were. Our evaluations also met

Jonassen's criteria of using authentic tasks (the students interpreted actual psychology experiments and results), involving knowledge construction (the students constructed the interpretations and argumentation), being context-driven (students were evaluated in the context of making sense of psychological observations), involving multiple perspectives (different interpretations were proposed and argued by different students) and involving socially-constructed meaning (the students worked in groups to make sense out of the observations).However, Jonassen also proposed three criteria that our evaluations did not meet -- namely, that the evaluations should be process oriented and multimodal (for simplicity we merely evaluated the end-product report of the students' deliberations), and that the goals of the evaluation should be set by the learners (we were looking for whether these programs fostered interpretation construction and argumentation skills). Our evaluation studies could probably be improved by including process data and multimodal products (although that would have made it much harder to conduct the studies), but we are unsure how letting the learners set the goals of the evaluation would apply to our situation.

Conclusions

We have proposed an approach to constructivist design (ICON) that makes interpretation construction of authentic artifacts in the context of rich background materials the central focus. We have shown how this approach can be applied to Study Support Environment programs in widely different fields of study -- namely, history, science and literature. We have also shown that in addition to learning specific content, students using these programs acquire generalizable interpretation and argumentation skills. Thus, our constructivist design framework is useful both for guiding design and for producing valuable learning results.

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