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ABSTRACT

This paper examines research on the education of women and girls from the perspectives of sex differences, gender differences, and feminist studies, with particular reference to the implications of the findings for the design of computer-assisted instruction systems. The four modules of the Ingelligent Computer-Assisted Instruction (ICAI) model--domain knowledge, student model, pedagogical knowledge, and interface--are then considered in light of the three perspectives, and a framework is developed for comparing, contrasting, and, in some cases, combining problems in instructional design with issues in the education of women and girls. (14 references) (EW)

Title:

SYMPOSIUM: Technological Equity: Issues in Ethics & Theory

Paper #2 Issues of Gender and Computer Assisted Instruction

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Issues of Gender and Computer Assisted Instruction

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The purpose of this paper is to examine strands of research on the education of girls and women, and to analyze implications for the design of computer-based instructional systems. The education of girls and women has been studied from the perspectives of sex differences, gender differences, and Feminist studies; the differences in these perspectives are important to the interpretation of findings.

The Education of Girls and Women

Research on *sex differences* is based upon an assumption of biological determinism (and often an assumption of female inferiority). These studies focus upon the measurement and genetic explanation of differences; their findings tend to be interpreted to educators as expectations for achievement, rather than as prescriptive in any sense. Current research in this tradition is typified by the work of Benbow and Stanley (1980, 1983).

By contrast to sex differences research, research on *gender differences* and education is based on a recognition that *gender* is a social construct associated with, but not identical with, the biological fact of sex. Therefore, researchers on gender differences attend not only to the manifestations of cognitive abilities, but also to social phenomena in the classroom, experiential differences between girls and boys, attitudinal and emotional differences, and the relationships between and among these phenomena. A few examples from the numerous findings of this research are: (1) overt and subtle sexism in classroom materials, (2) differences in the amount and type of teacher feedback, (3) differences in attitudes of students and their significant others, (4) differences in math anxiety, (5) differences in optimal learning setting, and (6) the description and supplantation of cognitive effects of early experience.

While researchers in the traditions of sex differences and gender differences differ in their willingness to accept ability as biological and immutable, they share a willingness to accept the content of school learning. *Feminist educational research* is based upon a rejection of this assumption; researchers working from the feminist perspective see the content of school instruction as masculine in that it has been determined by male values, experiences, and intellect. Therefore, feminist educators study biases within the selection, ordering, and interpretation of topics of instruction, the confounding of the cognitive and affective domains in instructional materials and evaluative techniques, and even the definition of fields of study (e.g., "History = What men have done in public." Bezucha, 1985, p. 84).

It should be noted that many feminists would probably consider Instructional Design, itself, to be a masculine discipline, which incorporates male values by insisting on analytic approaches, orientation towards goals rather than processes, and, in Turkle's (1984) term "hard mastery" criteria for success.

Defining Gender-Fair ICAI

Intelligent Computer Assisted Instruction (ICAI) provides a model through which to examine more carefully the issues summarized above. ICAI (also know as Intelligent Tutoring Systems (ITS) is chosen for this analysis because, at least theoretically, it incorporates both the existing models for computer instruction and the promised models of the future. Most ICAI schema show the system as composed of four modules, each communicating with the others (Rambally, 1986; Wenger 1987). These modules are:

Domain Knowledge	This module is an "expert" on the knowledge that is to be communicated. It provides both a source of knowledge and a standard against which to evaluate student knowledge. It can engage in dialogue concerning the content as well as criterion referenced measurement of student knowledge.
Student Model	Like domain knowledge, this module is an expert system. Ideally the model includes knowledge of all aspects of the student's behavior and knowledge that have implications for performance and learning. It is sometimes called the diagnostic module.
Pedagogical Knowledge	Also an expert system, this module is responsible for decisions concerning the presentation of material (e.g., branching, frames); it includes knowledge of pedagogical principles which are applied to information communicated to it from the Domain Knowledge and Student Model modules.
Interface	This module is responsible for communication between the pedagogical module and the student. It translates machine information into a form understood by the student and vice-versa.

Each of the modules gathers information from those listed before it; thus, in some sense, they are listed in order of importance to designers. The question addressed below is the implications of research on women for these modules; a comparable question can, and should be asked in relation to each of the minority groups in society.

The sex differences perspective. Research from this perspective is based upon an assumption of fixed and value-free content and yields replicated differences between the sexes in mathematical, verbal, and spatial abilities, as well as in aggressiveness; several other variables of potential difference have been explored with mixed results (Maccoby and Jacklin, 1974; Fausto-Sterling, 1985). Attention to improving the mathematics instruction of girls and women by adoption of this point of view requires that these variables be addressed in the development of ICAI as follows:

Knowledge Domain:	Sex is irrelevant to the content and to its organization.
Student Model:	Sex is relevant to student performance and must be a part of the model.
Pedagogical Knowledge:	Aggressiveness required of student may be relevant to the selection of appropriate teaching strategies.
Interface:	Use of verbal, symbolic, or spatial representation of knowledge may be differentially appropriate to students based upon sex.

The major implications for instructional designers lie in the area of needed research, and that research would appear to lie largely in the direction of "how can expert systems incorporate teaching and communication strategies which are maximally effective for girls?"

The gender differences perspective. The implications of gender differences research for ICAI are considerably more complex, in part because they affect the Knowledge Domain. This research has implications for both the selection and organization of information, and for other elements of ICAI as follows:

Knowledge Domain:	(1) Expand the content domain to include information relevant to women's learning. (2) Contract the content to exclude sexist examples. (3) Organize the content to allow more diverse modes of querying.
Student Model:	Sex of student is a relevant variable and has interactions with attitudes, anxiety, motivation, encouragement from significant others, which are also relevant variables.
Pedagogical Knowledge:	Include strategies for cooperative learning, at least at the level of concept development. Eliminate sexism from examples.
Interface:	No clear implications.

The findings from research on gender and ethnic differences in learning are quite complex in their implications for construction of a Knowledge Domain and a Student Model. Different lines of gender research suggest the addition of spatial information, historical information, metacognitive strategies, and metamathematical advice to the Knowledge Domain; addition of these types of information would require different, and perhaps conflicting, organizations of knowledge.

An argument can be made that (human) teachers call upon at least two content relevant Knowledge domains: knowledge *of* the content and knowledge *about* the content. The latter domain includes such information as the prevalence of particular errors, a typology of errors, referents to knowledge outside the given domain, useful analogies, miscellaneous motivational ideas, jokes, etc. The logic

underlying access and use of Knowledge *about* mathematics is entirely different from the deductive logic *of* mathematics. Perhaps, if ICAI is to be made responsive to issues raised by researchers on gender and mathematics, it must be conceptualized as having two Knowledge Domains: *Knowledge of Mathematics* and *Knowledge about Mathematics.*

Regardless of whether and how information *about* mathematics is included in ICAI, there remains the question of how the information *of* mathematics should be organized in a Knowledge Domain. Researchers on children's play suggest that boys and girls build different cognitive structures based upon their play activities, and that these structures are differentially useful for organizing mathematical information. Studies of Native American children (Garbe, 1973) and of Oriental graduate students (Damarin and West, 1979) indicate the existence of cultural differences in the relative importance of particular concepts to students in full or partial command of a body of mathematics. Damarin (in prep.) provides a rationale for expecting some similar differences between male and female children as they study fractions. The implication of these studies is that the organization of concepts in ICAI must be fluid rather than fixed, giving learners the opportunity to structure their own knowledge in a manner consistent with their own linguistic and cognitive structures.

The challenges posed for ICAI designers by research on gender differences are fundamental to the design of the Knowledge Domain. Gender differences research also has implications for the Student Model and the Pedagogical Knowledge modules. Some of these implications are demands for research; little is known, for example, about how math anxiety interacts with subject matter specifics, nor about how one would use anxiety information to modify instruction. The finding that girls learn initial concepts more effectively in cooperative learning settings (Fennema and Peterson, 1986), raises a constellation of questions for ICAI.

It should also be noted that, because the computer can be dispassionate, ICAI could be quite useful in correcting some gender-based inequalities in education. Girls and boys should expect equal amounts of task relevant feedback, and both should work with examples which are not laden with sexist connotation.

The Feminist Perspective. The attempt to bring together ideas from feminist educational theory and an advanced model for instructional design is, perhaps, tantamount to heresy in both fields. Nonetheless, the generality claimed for the ICAI model by educational computing enthusiasts, and the ubiquity of male influence, as elaborated by feminist researchers, invites a joint analysis of these positions. A preliminary summary of implications of feminist theory for the elements of the ICAI model is as follows:

Knowledge Domain:	Knowledge is never value-free: content and organization of this domain should allow querying of values. Content and its organization should reflect variety in the ways of knowing.
Student Model:	All students are products of a patriarchal society. Rules for behavior (including cognitive behavior) are gender-related and relationships between knowledge and behavior are knowledge-variant. Students vary in

	their acceptance or rejection of the values inherent in the Knowledge Domain.
Pedagogical Knowledge:	Each teaching strategy embodies elements of an educational philosophy; selection of strategies also reflects a philosophy of learning and of the teacher role. These philosophies must be articulated and allow querying.
Interface:	Natural language, itself, has masculine connotations. These connotations often preclude the translation of machine information in such a way as to communicate neither more nor less than the meaning of the machine language. Such translation should, however, be the goal.

The issues raised in this summary are many and they are related to all components of ICAI; the depth of these issues is illustrated by a single example. Sherry Turkle's (1984) analysis of adolescents working with Logo leads her to discuss the concepts of "hard mastery," a kind of technical mastery of Logo which is associated with the masculine, and "soft mastery," a more intentional mastery of the language. At the same time, Wenger (1987, p. 149, p. 425) observes that Logo provides a good paradigm for some aspects of ICAI. Bringing this work together implies that criterion referenced evaluation within a Logo Knowledge Domain should not be based solely upon technical proficiency with the language, but must also reflect the individualistic and creative work done by those in "soft mastery" of Logo. These same considerations have implications for the Student Model, and for the design of ICAI well beyond the Logo environment.

Conclusion

This paper provides a framework for comparing, contrasting, and in some cases, combining problems in instructional design with issues in the education of girls and women. The framework serves to structure several issues for further analysis. It is important to note that some issues of importance both to the design of computer-based instruction and to the instruction of girls and women fall outside this framework. For example, there is mounting evidence (Collis, 1987; Hawkins, 1987) that girls transfer mathematics anxiety to computer anxiety. One implication of this finding might be that ICAI is less appropriate for those girls than it is for boys; an alternate implication, and one that is more difficult to pursue, is that ICAI must become more responsive to the needs of girls and women than traditional mathematics instruction has been. The analysis above points out how complex a task this would be.

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