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ABSTRACT

This study tested the hypothesis that children bring specifiable expectations to their use of interactive computer programs, and that these expectations will determine, to a large extent, which features of a given program will be motivating to a child. It is also argued that the different genres of interactivity relied upon by software designers will elicit different expectations from a child. Subjects were 14 fifth-grade students. Three sets of data were collected by: (1) asking students to sort software titles into piles of "like" programs; (2) asking students to indicate on a scale of one to three how much they like to use each program; and (3) identifying the interactive elements of the favored software genre-adventures through group interviews. The groupings were recorded and children were asked to label each pile. The analysis yielded seven clusters of programs that could be differentiated according to the students' labels, and four ways of interacting in and with the world were identified. To investigate the relationship of motivation to interactive formats, the motivational strength of a program was measured by asking 22 subjects to complete a questionnaire by indicating how often they would choose to use each of the programs in their free time. Adventures and programs which generated printer output were significantly preferred to the other clusters but not to one another. It is suggested that what makes each program so successful is the fit between the reasons the child wants to use the program and the interactive environment it creates, and the similarity between the motivating goal structure for that type of activity in the real world and in the software program. (9 references) (BBM)

Title:

The Interplay of Interactivity and Motivation in Educational Software

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This work explores the interplay between various types of software interactivity and a program's motivating elements. It is our hypothesis that children bring specifiable expectations to their interactions with educational software. These expectations, to a large extent, will determine which features of a given program will be motivating to a child. Additionally, the different genres of interactivity relied upon by software designers will elicit different expectations from a child and may resonate or conflict with the motivating elements built into the program. The state of affairs for the designer of educational software is much like that for the movie director. The director of a certain genre must include the elements the audience comes to see (e.g., the scarey scenes of a horror movie) and not fully replace or confuse them with elements that work for other genres (e.g., slapstick). Similarly, the software designer must be attentive to the connections between the interactive elements upon which she relies and those elements which are appealing to a child.

The research reported in this paper represents an attempt to establish the validity of the above position prior to the development of verification oriented research. We think this is necessary as our conceptual approach is somewhat different than prior research in this area. Previous attempts to schematize or categorize software have often been done according to adult conceptualizations (e.g., Jonassen, 1985; Taylor, 1980). According to our hypothesis, it is the *child's* perception and categorization of programs, particularly the interactive aspects, which determine how we should think about designing software (c.f. Shapiro, 1987; Winograd & Flores, 1986; Turkle, 1984). Accordingly, our first research question is whether interactive formats have a strong enough influence on how children categorize software so that we may speak of *genres of interactivity*. A second way our research differs from previous approaches is that some of the best works on the motivational aspects of computer software have tended to ignore differences across software. For example, Malone (1981) writes of the role of challenge in creating motivation. Challenge, however, is not what motivates us to use a particular word processing program. Rather we choose those programs which conform to our needs as writers.* We intend to show that the motivating elements of software vary from program to program and are dependent to a large degree on the interactive premise of the software.

To begin exploring the relationship of interactive software and motivation we collected three sets of data:

1) By having fifth graders sort software titles into piles of "like" programs, we investigated how children categorize educational software.

2) We gathered information about the motivational power of programs by asking the students to indicate on a scale of one to three how much they like to use each program.

3) Through group interviews we identify the interactive elements of the favored software genre - adventures.

All of the studies were conducted with fifth graders enrolled at Royale Elementary School in Darien, Connecticut. The Darien School District has an ample computer program which is laboratory based. Children use the computer lab during free time and regularly as part of class time. The software selection and usage is closely linked with the curriculum. There are enough computers for children to work individually if they choose. And, a full 75% of the children had computers (or video games) in their household. We comment where we feel that this usage profile may impact the generality of our findings.

Genres of interactivity

If children think of software in terms of interactive format, then it is reasonable to expect them to use similarities in interactive format across programs as a basis for categorization (cf. Chi, Feltovich & Glaser, 1981). To decide if a cluster of programs coheres by interactive

*In fairness, Malone (Malone & Lepper, 1984) later added an interpersonal dimension of motivational variables which capture the interactive appeal of a larger array of software.

equivalences, without a crisp definition of interactivity, could be problematic.* However, we expected that this problem of identification would not be too great. It was our prediction that students would create and label a few categories which unquestionably suggested interactivity.

Fourteen children (balanced for gender) each received a stack of 56 index cards which had an educational software title typed on one side. Children were directed to "sort the cards into piles of programs that are alike." No further instructions were given. Students were left to interpret "alike" and decide how many piles to create. The groupings were recorded and children were asked to label each pile.

A separate manipulation removed programs which a child had not actually used. We only consider the 26 programs that were known by at least half of the students in both the sorting task and the motivational ranking task below. The sortings were subjected to a cluster analysis using the Rao-Russel coefficient of similarity and a complete linkage approach. The label or labels which occur most frequently over all the programs within a cluster are used as names for the resulting cluster.

The analysis yielded seven clusters of programs which could be differentiated according to the labels assigned by the students. We give the label and our interpretation of the cluster along with the programs which were included. The order of the programs and clusters listed below replicates the ordinal positions within the final clustering. For example, *Bank Street Writer* is most closely linked to *LogoWriter* and most distant from *Path Tactics*.

Writing or Language Arts

These programs are typically seen as used for writing or typing practice.
Bank Street Writer, LogoWriter, Paws, Writer Rabbit.

Print-out Programs

This category is defined by the program's emphasis on the goal of printing something out.
Print Shop, Print Shop Companion, Time Liner.

Puzzles

One student called this type of program "mind puzzles." This category revolves around deductive style reasoning.
Gertrude's Puzzles, Puzzles & Posters.

States or Social Studies

These programs all involve learning about the 50 states. However, the titles alone may define the category.
Dataquest: The Fifty States, Game of the States, States and Traits, Coast to Coast.

Adventure/Journey/Mystery

The anchoring attribute of this category appears to be computer simulation of the physical world. One student made the astute distinction between mystery and adventure as one of solving vs. looking. These two types of programs are strong sub-clusters within this category.
Odell Lake, Oregon Trails, Goodell Diamond, Treasure Hunter.

*We take interactivity to mean something broader than and prior to a simple distinction between computer and "passive" media. As such, interactivity is a potentially unbounded concept ranging in examples from playing a game of tennis to reflecting on one's own thoughts. In attempting to define interactivity, one could easily flounder in debates over false problems: Can true interactivity only take place between two humans? Is drill and practice less or more interactive than inquiry-based software? Fortunately, our ultimate goal as researchers is not to come up with a necessary and sufficient definition of interactivity. Indeed, if there are concepts which are meaningful through the family resemblances of their examples, interactivity surely must be one. Rather, our goal is to organize discourse about those shared and differing attributes which characterize the many situations we call interactive.

Putting things together

Students have to construct something and test it.
Clock Works, Woodcar Rally.

Math

This category includes many of the programs that deal explicitly with number. Within this cluster there is a tendency for drill and practice programs to be associated with one and another.
Multiplication Puzzles, Subtraction Puzzles, Math Blaster, Circus Math, Quotient Quest, The Market Place, Path Tactics.

There are two strong dimensions used to develop the categorizations: content area and interactive model. The three content area clusters, language arts, social studies, and mathematics should not be very surprising. Given schools' strong partitioning of knowledge into curricular domains, one would expect children to bring their categorization of school experience to their categorization of software. This effect is probably heightened by Darien's use of the computer lab within class periods.

Of greater interest for our purposes are the other four groupings, especially the printer, adventure, and building programs. From this small sample of children and programs, it can be seen that children are quite attentive to interactivity in their conceptualization of software. Each of these represents an identifiable way of interacting in and with the world: using tools, navigating, searching, and creating. One might easily imagine that less interactive but more frequently tauted aspects of software, such as graphics quality or engagingness, could have been used to equate the software. Interactive models are not limited to action in the phsyical world, although this is the currently favored genre of fifth graders. There also appears to be a sub-cluster within the math grouping in which the student competes with an animated agent within the computer thus modeling interpresonal interactivity. Undoubtedly, there are many other models of interactivity upon which computer programs do or will rely.

Motivation and types of software

If programs are equally motivating but rely on different models of interactivity, it is likely that the motivation originates from different sources. To investigate the relationship of motivation to interactive formats, we operationalized the motivational strength of a program to mean how often a child likes to use the program. 22 fifth graders (balanced for gender) completed a questionnaire indicating how often (always, sometimes, never, unknown) they would choose to use each of the 56 programs in their free time. Below is the ranking, from most motivating to least, of those programs that were known by at least half of the students. A score of three would represent the most motivating program.

(2.50) Oregon Trail
(2.50) Print Shop
(2.45) Odell Lake
(2.32) Bank Street Writer
(2.21) Print Shop Companion
(2.11) Wood Car Rally
(2.10) Gordell Diamond
(2.09) LogoWriter
(1.95) The Market Place
(1.94) Path Tactics
(1.94) Quotient Quest
(1.92) Dataquest: The Fifty States
(1.92) Puzzles and Posters
(1.83) Coast to Coast
(1.82) Multiplication Puzzles
(1.81) Time Liner
(1.80) Gertrude's Puzzles
(1.79) Game of the States
(1.72) Clock Works
(1.69) States and Traits
(1.68) Paws
(1.65) Circus Math
(1.58) Treasure Hunter
(1.55) Math Blaster
(1.46) Writer Rabbit

560 A

Attitudes towards software programs appear to be fairly well defined across the population as there is a highly significant effect for program type ($F = 6.9$). There is a significant effect on motivation when clusters are treated as groups within an anova ($F = 7.75$). Adventures and the programs which generated printer output were significantly prefered to the other clusters (Scheffe test at $p < .05$) but not to one and another. We will discuss the source of this preference in the next section. Interestingly, there is an interaction between gender and program type ($F = 1.7, p < .03$) but not between gender and cluster type ($F = 1.45, p > .22$). This suggests that it is not math or writing per se to which girls and boys object, but rather specific, and perhaps prototypical, implementations of the category of software. However, the sample is too small to be confident in a failure to find effects or to begin parceling out interaction effects.

Oregon Trail and Print Shop are representative programs from the highly motivated clusters of adventure and print-out. These two programs are extremely different in the sorts of interactions, goals, and sources of satisfactions a student can expect. Although one might wish to claim that the same sorts of design elements make each motivating (e.g., an appropriate level of complexity or challenge), this seems to be the wrong level of analysis. We suggest that what makes each program so successful is the fit between the reasons the child wants to use the program and the interactive environment it creates. A program which includes navigational goals should create a spatial environment. Being able to jump from menu to menu in Oregon Trail (as is the case in Print Shop) would destroy the interactive premise of travel. It would undermine our expectations of interactions within a spatial environment. The program would loose much of the motivational power it gains by relying on our enjoyment and knowledge of navigating in the world.

The source of interactive expectations.

If a child perceives a program as an adventure game, she prefers to see a first-person surrogate carry out her actions within the program's environment.* On the other hand, in a math, drill and practice setting, no such surrogate is expected (perhaps to move numbers around on the screen), nor does it seem to provide motivational enhancement beyond the temporary effects of novelty. Why might this be the case? In simplest fashion, much of what is enjoyable in software borrows from what is recognized as an enjoyable activity in the real world. Children have a prior model of interaction which includes surrogates (e.g., dolls) for fantasies. On the other hand, the activity and feedback involved with worksheets - animated or not - have never included the notion of a surrogate. There would be a mismatch between their expectations of the worksheet genre of interactivity and its delivery with fantasy elements.

Our central tenet is that children's motivation towards educational software can be understood to a large extent through the specifiable expectations children bring to the different genres of software. These genres of software are created and identified on the basis of the interactive models which rest upon the child's experiences in the world. We maintain this position because children bring previous real-world interactive experiences to their understanding of the various formats of educational software. It is easy to see how they analogize or equate software to various real-world activities. (E.g., This program is like going on a trip; this one is like taking a test; this one helps me make something.) They must import the goals of interactions in the world to find satisfaction within software. Software does not create goals and lasting motivation out of a vacuum - the computer is not *that* inherently motivating. Rather, a piece of software will borrow the motivating goal structure and the attendent interactive environment which supports a particular type of interaction in the world. The two most highly motivating clusters of programs, adventures and printing software are notable in their close linkage with the world. One facilitates interaction within a simulated physical world, the other assists social interaction through the creation of signs and cards. They each borrow their appeal through their different connections to real world interactions. Further, they each appear to be the most successful within their genre of software because they maintain fidelity to the previously experienced goals and environment of their interactive premise.

*This was revealed through the group discussions discussed in the next section.

What might an interactive genre look like?

If children are given an opportunity to create a program, they will create one which is consistent with, and motivating because of, the interactive genre which serves as its premise. To explore whether students would emphasize a coherent set of interactive elements an^ what those might be, the two authors conducted group interviews with two different sets of five children. The question which anchored the discussion was, "If you were to make a computer program, what would it be like and what sorts of things would you include?"

The responses of both groups were strikingly similar in their preference for adventure games. Each group distinguished these from mysteries and puzzles. These results are in accordance with the distinctions uncovered by the clustering task and the motivational rankings. By looking at the different suggestions the students made, we get a better sense of the coherence of the interactive model and collect evidence for an extensive definition of the adventure genre of interactivity.

The children stated that they wanted an impactable environment. We might call this a *causally coherent* model of interactivity in which consequences must reveal themselves through changes in the environment. All actions, student and computer, must be similarly constrained by the environment. Decisions that are made within the program should change the environment in a causal fashion. The legacy of these changes remain in play throughout the course of the interaction. For example, forgetting to plant the corn will become a damning mistake only when the food stores run out. Students pointed out several times that they did not want the program to give disengaged, omniscient, or external feedback; all consequences and computer reactions should be a natural result of the causal environment the program creates.

A second interactive model prefered for the adventure game is a spatio-temporal model. For example, they liked an ability to move in any direction spatially. This can be contrasted with programs in which the child always moves forward. However, complete freedom of movement and choice is not a superordinate principle of interactive design. The children explicitly stated that they did not like the capability of going back in time to correct a mistake. Ideally, an adventure environment will replicate the advantages and constraints of a spatio-temporal world.

Students repeatedly stated that they liked to explore and learn from their options and mistakes. They liked having to discover the sub-goals and emergent goals that must be satisfied to achieve the larger goal of the adventure. They wanted the program to be somewhat unpredictable but in a fashion consistent with the laws which govern the program's environment. They wanted optional levels of difficulty and novelty. In other words, they wanted to learn through interactions within a rich causal environment.

The adventure game relies on three basic interactive models which are derived from the child's interactions with the physical world: causality, spatio-temporality, and exploration.* The discovery or immersion learning style they have chosen finds a natural model within their own lives (Papert, 1980). However, it is important to note that this is only one genre of interactivity and a style of learning which grows from it. It is important to imagine what sorts of social interactivity and learning styles will become supportable as computer power becomes more available in the classroom.

Directions and conclusion

The methods of enhancing motivation within different interactive settings will differ depending on the goals the user generally attributes to certain types of interaction. Although the goal is ultimately to learn something, the use of interactivity can bring a much larger set of goals and expectations to bear. It is central to any interactive design that these expectations are played

*There were other elements of adventure games which the children mentioned such as codes, fantasy, and being able to choose the characteristics of their surrogates. There were also things which the children claimed were unimportant: graphics, high action, points, winning, and, sound. It is worth noting that some of the things excluded are precisely those things which are mandatory for the success of other genres of interactivity. It would have been interesting to have asked the students to design the ideal drill and practice program as a source of contrast.

upon. As a first step in delineating the nature of these expectations, it is worthwhile to think of the different types of interactions a user might expect within a given genre of interactivity. A practical way for a designer to follow this prescription is to ask herself what sort of interaction does this computer instruction seem most like and what sort of role does the computer play in the interaction (e.g., partner, adversary, game board, world, referee, reference tool, museum, etc.). Subsequently, the designer can consider what things make this sort of interaction most satisfying and work onward.

The unique features of the new and highly plastic interactive technologies have not been fully explored, either theoretically or empirically. Designers currently rely on models of development which are often out-dated or prematurely reductionistic. Much of the literature on motivation in instructional technology attempts to include all designs within large matricies and continuums of factors. They do not take into account the qualitative differences of children's expectations in their encounters with instructional technologies. Much like film, there are genres of software (in use and developing) which capitalize on the child's motivations in fundamentally different ways. Our future research will attempt to prove the interrelation of interactive format and motivation through an experimental design. However, the next step is to continue the discourse with children about the different interactive elements and their groupings into genres. It is here that we will find the best ingredients for coherent and motivating design recipes.

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