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Intrinsic Motivation and the Process of Learning: Beneficial Effects of Contextualization, Personalization, and Choice

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This experiment examined the effects on the learning process of 3 complementary strategies—contextualization, personalization, and provision of choices—for enhancing students' intrinsic motivation. Elementary school children in 1 control and 4 experimental conditions worked with educational computer activities designed to teach arithmetical order-of-operations rules. In the control condition, this material was presented abstractly. In the experimental conditions, identical material was presented in meaningful and appealing learning contexts, in either generic or individually personalized form. Half of the students in each group were also offered choices concerning instructionally incidental aspects of the learning contexts; the remainder were not. Contextualization, personalization, and choice all produced dramatic increases, not only in students' motivation but also in their depth of engagement in learning, the amount they learned in a fixed time period, and their perceived competence and levels of aspiration.

Learning, every parent knows, can be fun. From the dogged dedication of the infant learning to walk and the voraciousness of the toddler first learning the names of objects to the insatiable curiosity of the preschooler wanting to know the "why" behind everything, astute observers from Plato to Piaget have remarked upon young children's intrinsic love for learning. There are, it appears, no preschool children with "motivational deficits."

Yet only a few years later, after these same children have entered school, their motivation to learn has somehow become decidedly more problematic. Many of them seem to find the instructional activities in schools to be dull and boring, and a substantial number will be quickly diagnosed as showing motivational deficits. Moreover, these motivational difficulties seem to increase steadily as children progress through school. In a variety of different settings and using a variety of measures, investigators have found children's reported intrinsic motivation in school to decrease steadily from at least third grade through high school (e.g., Anderman & Maehr, 1994; Harter, 1981; Lepper, Sethi, Dialdin, & Drake, in press).

One prominent explanation offered for this persistent decline in intrinsic motivation in school involves the widespread pedagogical practice first challenged by Dewey (1913, 1938) and later identified most clearly by Bruner (1962, 1966) as the decontextualization of instruction. That is, in schools teachers often seek quite deliberately to present new material in its most abstract or decontextualized form, presumably in the belief that learning in this abstract form will promote generalization of that learning (e.g., Lave, 1988; Perkins, 1992). In the process, settings for learning are created that are quite different from those in which young children are known to show such a zest for learning. By removing learning from the contexts in which both its practical utility and its links to everyday interests and activities would be obvious to children, teachers risk undermining children's intrinsic motivation for learning.

The implication is obvious: Presenting learning activities, even those involving abstract operations, in meaningful contexts of some inherent appeal to children should have significant beneficial effects on children's intrinsic motivation and learning. In its theoretically most ideal form, such an approach has been seen to suggest the full integration of mathematics instruction into long-term, collaborative projects involving communities of learners working at culturally authentic activities (e.g., Brown, Collins, & Duguid, 1989; Katz & Chard, 1989; Rogoff, 1990)—as has been

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recommended by several recent national commissions (e.g., National Academy of Sciences, 1990).

Unfortunately, the development of such complex projects and activities can be a difficult and costly process, and it is likely that such approaches will complement, rather than replace, traditional instructional methods for many years to come. As a result, it is of considerable interest that recent research has begun to suggest that many of the motivational and instructional benefits of contextualization can be obtained even when abstract mathematical problems are merely embedded within simple "fantasy" contexts involving topics, themes, or characters of particular interest to students (e.g., Chabay & Sherwood, 1992; Dugdale, 1992; Lepper & Cordova, 1992; Malone, 1981; Parker & Lepper, 1992).

Parker and Lepper (1992), for example, presented grade school children with a series of activities designed to teach them the basics of a simple graphics programming language for the computer. In each activity, in all conditions, students were asked to put themselves in the place of an arrow-shaped cursor and then to navigate in prescribed ways around the computer screen using the commands provided. In the control condition, these learning activities were presented in an abstract form; in various experimental conditions, these same activities were presented in the context of a simple fantasy of interest to the students. In one learning task, for instance, control students were presented with a screen displaying five circles and were asked to navigate the cursor so that it touched each of the circles in turn. In the experimental conditions, by contrast, the five circles in the display had been embellished to look like islands and the students were asked to navigate the cursor so that it touched each of the "islands" in turn, to "pick up" the "pirate treasure" that had been buried on them.

Even these seemingly minimal embellishments, which placed otherwise purely abstract learning tasks into meaningful and interesting contexts, had substantial educational benefits. Not only did students find the contextualized programs more intrinsically motivating but as a result, they became more deeply involved in the task and showed greater subsequent learning. Measures of the students' mastery of both the specific commands comprising the graphics programming language and the more general and abstract geometric concepts underlying the design of the language, such as the estimation of distances and angles or the ability to follow a series of steps in a plan, showed significant differences on classroom tests administered 2 weeks later in the absence of the computer.

In broader perspective, of course, contextualization is but one of several techniques that might be used to increase the intrinsic motivational appeal of educational activities. Indeed, previous experimental research has identified at least three other major classes of determinants of intrinsic motivation (Lepper & Malone, 1987; Malone & Lepper, 1987). Some theorists, for example, have focused on the concept of mastery or effectance motivation and the pleasure that derives from solving challenging problems (e.g., Harter, 1978; White, 1959). Other theorists have concentrated on curiosity and related epistemic motives that produce interest (e.g., Berlyne, 1960, 1965; Kagan, 1972), and still others have stressed people's need for a sense of self-determination and personal control (Nuttin, 1973; Deci, 1975, 1981; Deci & Ryan, 1985). In this study, we sought to investigate two additional strategies, derived from the literatures concerning curiosity and interest and concerning control and self-determination, for enhancing the motivational appeal of a given educational activity.

Our first strategy for increasing students' intrinsic motivation involved the personalization of several incidental features of the learning context and was designed to associate the activity with characters and objects of inherent interest to the students. Recent research on the role of topical or content variables in determining children's curiosity and interest has shown that materials are better learned and remembered when presented in connection with topics, characters, or ideas of high interest value (e.g., Hidi, 1990; Lepper & Cordova, 1992; Malone, 1981; Malone & Lepper, 1987; Renninger, Hidi, & Krapp, 1992; Schank, 1979). Indeed, on the basis of these findings, Malone and Lepper (1987) have proposed a "spreading interest" model that argues that interest will spread along links between nodes of differing interest values, as in "spreading activation" theories of memory (Collins & Loftus, 1975). Personalizing an educational activity in terms of themes, objects, and characters of high prior interest to students should, therefore, enhance intrinsic motivation.

Our second strategy for enhancing the motivational appeal of learning activities involved the provision of choice over several aspects of the activity and was designed to increase children's sense of control and self-determination. Among theorists who assign central importance to issues of self-determination (e.g., Deci & Ryan, 1985; Nuttin, 1973), the provision of choice has long been the paradigmatic procedure for manipulating intrinsic motivation, and much research has indeed demonstrated that individuals offered choice will show more enjoyment of, better performance on, and greater persistence at a variety of activities (e.g., Ayeroff & Abelson, 1976; Langer & Rodin, 1976; Perlmuter & Monty, 1977; Zuckerman, Porac, Lathin, Smith, & Deci, 1978). Moreover, these motivational effects remain apparent even when the choices provided seem trivial or completely "illusory" (e.g., Langer, 1975, 1989). In this study, therefore, we offered students choices only over instructionally irrelevant aspects of the learning activity. In this way, we sought to take advantage of the demonstrated motivational benefits of the provision of choice, without running the risk that students might make pedagogically poor choices if allowed to determine instructionally crucial aspects of the activity (e.g., Malone & Lepper, 1987; Steinberg, 1977, 1989).

This study, therefore, involved five conditions. In a basic control condition, students engaged in two computer-based learning games in an unembellished form. In four experimental conditions, these same learning activities were embedded in simple fantasy contexts. For half of the students in these experimental conditions, fantasies were presented in a generic form; for the other students, several incidental elements in the fantasies were personalized on the basis of background information that had been elicited from the

students at the outset of the experiment. Within each of these groups, in addition, half of the students were offered a series of limited choices regarding a number of instructionally incidental features of the fantasies; the remaining students were offered no such choices.

Thus, the design of the present study was a 2 × 2 (Personalization × Choice) factorial, with an added no-treatment control condition. Dependent measures included a number of indices of children's intrinsic motivation, drawn from previous research in this area (e.g., Condry & Lepper, 1992; Deci & Ryan, 1985; Lepper, 1988; Lepper & Hodell, 1989; Tang & Hall, 1996). These included self-reports of interest and enjoyment, behavioral commitments to continued task engagement, preferences for increasingly challenging tasks, and direct measures of students' on-line involvement in the experimental activities. In addition, students' actual learning and retention of the abstract material presented in the activities was assessed 1 week after the last experimental session, using standard written tests administered outside of the computer context.

To permit us to draw inferences about the effects of variations in intrinsic motivation on the process of learning, our manipulations were embedded in a highly controlled experimental setting. Thus, we deliberately sought to design motivational manipulations so that each of them would be completely independent of the basic cognitive structure of the learning activity, such that differences among conditions could not be attributed to variations in the information, instruction, feedback, or problems students had received. Similarly, because we were concerned with the effects of variations in motivational appeal on the learning process, it was important for us to control the amount of time that students spent with the activity, to ensure that differences among groups were not simply a function of variations in "time on task" that might otherwise follow from differences in the motivational appeal of the activities. Likewise, we explicitly restricted the choices provided to students to instructionally irrelevant features of the activities, rather than an array of "pedagogically sound" options, to allow us to examine the effects of motivational variables in a more precise fashion.

Method

Participants

The sample included 31 male and 41 female fourth- and fifth-grade students from two private elementary schools in the San Francisco Bay area. These 72 children were randomly assigned, within-gender, to one of five conditions: (a) generic fantasy–no choice, (b) generic fantasy–choice, (c) personalized fantasy–no choice, (d) personalized fantasy–choice, and (e) an additional no-fantasy control condition. Two children did not complete all five experimental sessions, due to the fact that they transferred to another school, so their data were not included. As a result, the final sample consisted of 70 children, 14 per experimental condition. These 70 children in the final sample ranged in age from 9 to 11 years (M = 10.49, SD = 0.56). Their socioeconomic backgrounds, as estimated from parental occupations, ranged from working class (e.g., nurse's aide, clerk, waiter) to upper-middle class (e.g., physician, attorney, engineer). An examination of the ethnic composition of our sample revealed that 71% of our participants were Caucasian, 13% were Hispanic, 9% were African-American, and 7% were Asian-American. Children at these schools had had some prior experience working with computers. Typically, this experience consisted of participation in a weekly computer laboratory class. Nevertheless, a review of their curriculum revealed that the children had not been exposed to the types of activities presented in our experimental programs. Statistical analyses revealed that there were no significant differences among the experimental and control groups in terms of students' ability level or prior experience with computers following our randomization procedure. Parental consent was obtained, and in addition, oral assent was obtained from each child prior to participation in the initial session.

Instructional Programs

Three parallel versions of a computer game designed to teach arithmetical and problem-solving skills, most notably the hierarchy of the order of operations and the proper use of parentheses in arithmetic expressions, were created. All three versions were patterned after a commercially available software package for the Apple II computer entitled "How the West Was One + Three × Four" (Seiler, 1989), distributed by Sunburst Communications.[1] Permission was obtained from the company to use their software as a model for our computer game. All versions were presented on an Apple Macintosh computer.

Common features. For each of the versions used in this study, the underlying game structure was the same. Specifically, for all three versions, the game board consisted of a number line ranging from 1 to 50, with four "target zones" located at each multiple of 10 and two "shortcuts." The location of each shortcut differed for each game. In all three versions of the game, both the player and his or her opponent (i.e., the computer) started at 1 and took turns moving along the number line. The first one to reach 50 was declared the winner.

During a turn, three numbers between one and five were randomly generated by the computer. The child then combined these three numbers in an arithmetic expression (using the operations of addition, subtraction, multiplication, and division, as well as parentheses) with the constraints that all three numbers had to be used and that no operator or number could be used more than once. The resulting value of the expression was the number of spaces the child got to advance on the number line. If the child failed to correctly solve the arithmetic expression he or she had specified, the computer automatically provided some instructional feedback and offered the correct answer. Nevertheless, if the answer provided by the student was incorrect, he or she did not advance along the number line on that particular turn.

To make the children's task more challenging than just generating the largest possible total, several types of special moves were added. For instance, target zones occurred every 10 spaces. Whenever players landed on one of these, they were automatically advanced 10 spaces to the next target zone. In addition, there were two shortcuts along the number line. Whenever players landed at the entrance to one of these, they were automatically advanced to the other end. Furthermore, if a player landed on the same space as his or her opponent, the opponent was automatically "bumped" back two target zones.

[1] "How the West Was One + Three × Four" was originally designed at the University of Illinois as part of the PLATO project by Bonnie A. Seiler. This educational program has been utilized in other research projects as well (i.e., Burton & Brown, 1982).

In all three versions of the program, students were allowed to select the level of difficulty for each game. The program permitted them to choose between two alternatives—the computer could either play "the best it can" or "pretty well but not great." Whenever the first option was selected, the computer would always make the best possible move. On the other hand, when the student selected the second option, "pretty well but not great," the computer's objective was not to generate the best possible move every single time, but to position itself not too far ahead or behind the child. If the student was slightly behind or less than 5 spaces ahead, the computer usually made a rather small forward move which did not involve division or negative numbers. If, on the other hand, the child had a fair lead, the computer proceeded to formulate a more elaborate move. Lastly, if the child was at least 18 spaces ahead, the computer selected the same move it would have generated when playing at its best.

In all three versions of the program, two types of hints were available throughout the course of a game. The "Possible?" button allowed students to ask the computer whether or not it was possible to obtain a certain result using the three particular numbers that had been provided for that turn. It was then up to the child to try to figure out what particular arithmetic expression would yield the desired result. For example, suppose the child had obtained the numbers 3, 3, and 4 during a given turn and was interested in finding out whether or not it was possible to get the number 4 for an answer. All the child needed to do to obtain this crucial piece of information was click on the "Possible?" button and type the number 4 when prompted.

The "Form" option provided a stronger form of help. When a student requested this type of hint, the computer responded by showing the form of the expression of the best possible move for that particular turn. Suppose, for instance, that the student was at 1 and had the numbers 3, 2, and 4 with which to work with. Upon selecting the "Form" button, the child might be shown "(__ + __) × __." It was then up to him or her to try to determine which numbers corresponded to each blank.

At the end of each game, students were shown a summary of their performance. They were told the number of moves they had made, the number of problems they had solved correctly, the number of problems they had missed, and the number of times they had made use of each of the three special moves (taking advantage of shortcuts, "bumping" the computer, and landing on a target zone). If the children had missed one or more problems during the course of the game, they were subsequently shown a second display that listed each one of the problems they missed, along with the correct answer and an explanation concerning the particular mistake they had committed.

Fantasy embellishments. In the basal, unembellished version of this program, entitled simply "Math Game," the basic game board consisted of a number line ranging from 1 (the start) to 50 (the finish) with four "gray zones" and two "shortcuts." The objective of the game was for the child (represented on the game board by a triangle) to arrive at the finish line before the computer (represented on the game board by a circle).

In the various embellished fantasy versions of this program, this activity was presented within two fantasy contexts designed to heighten children's intrinsic interest in the program. In the first of these two fantasies, entitled "Space Quest," the students were encouraged to think of themselves as commanders of a space fleet. Their mission consisted of saving the Earth from an energy crisis by traveling to a distant planet in search of an alternative energy source. In the second fantasy, referred to as "Treasure Hunt," the children were asked to play the role of a ship captain in search of an ancient treasure buried on a deserted island.

In both cases, the instantiation of the relevant fantasy was accomplished in similar fashion. First, when the program was started up, a single graphics page displayed the title of the program and various relevant icons. Second, a display containing a brief prologue introduced the characters for each fantasy, as well as a description of the mission at hand. Finally, all the basic elements present in the game board were modified in such a way that they "matched" the particular fantasy context. Thus, in the case of "Space Quest," the basic game board consisted of an "intergalactic trail" originating at the "Earth" and ending at "Planet Ektar" with four "space stations" and two "intergalactic tunnels." Similarly, in the version entitled "Treasure Hunt," the game board consisted of a "native trail" originating at a "map" and ending at the "treasure chest" with four "huts" and two "secret passages." Screen displays illustrating the major differences between the no-fantasy and fantasy versions appear in Figure 1.

Experimental variations. Within each of these two fantasy versions, then, we orthogonally manipulated two variables. The first was the extent to which the children had control over various instructionally irrelevant features of the fantasy, such as the specific icons representing the child and the computer, as well as the names of the characters. The second was the extent to which the fantasy context had been personalized for each child. The personalized fantasy contexts were created by replacing a number of generic referents in the program with personally relevant ones obtained from the personalization questionnaire. Thus, for each of the two fantasy versions of the activity, there were four different combinations: (a) generic fantasy–no choice, (b) generic fantasy–choice, (c) personalized fantasy–no choice, and (d) personalized fantasy–choice, as described in detail below.

Procedure

Session 1: Pretest. The first session was devoted to pretesting. Prior to testing, all children were told that the experimenter was simply interested in how children learn with computers, and every effort was made to minimize perceptions of evaluative pressure by enlisting the children as our "assistants" to help us find out how well our new educational software programs worked. Children were then pretested on their knowledge of the order of operations and the use of parentheses in solving arithmetic expressions, using a 15-item test that was based on assessment measures previously developed by Sunburst Communications. In addition, the children completed a brief "personalization questionnaire," asking them to provide us with some specific pieces of information about themselves, such as their nicknames, birthdates, and the names of their closest friends, as well as their favorite foods, school subjects, hobbies, television shows, books, and magazines. Finally, to examine the possibility that our experimental effects might differ as a function of prior differences in children's general motivational orientations, the children also filled out several measures of their global motivational orientations.[2] No such interaction effects with prior motivational measures were found, however.

[2] These pretest measures included abbreviated versions of Harter's (1981, 1982) Intrinsic Motivation and Perceived Competence Scales, and additional items measuring children's self-rated enjoyment of, and self-perceived competence in, various academic subjects. Scales of test anxiety (Sarason, Lighthall, Davidson, Waite, & Ruebush, 1960), locus of control for academic achievement outcomes (Crandall, Katovsky, & Crandall, 1965) and self-efficacy (A. Bandura, personal communication, July 1992) were also administered. Additional details on these measures are provided in Cordova (1993).

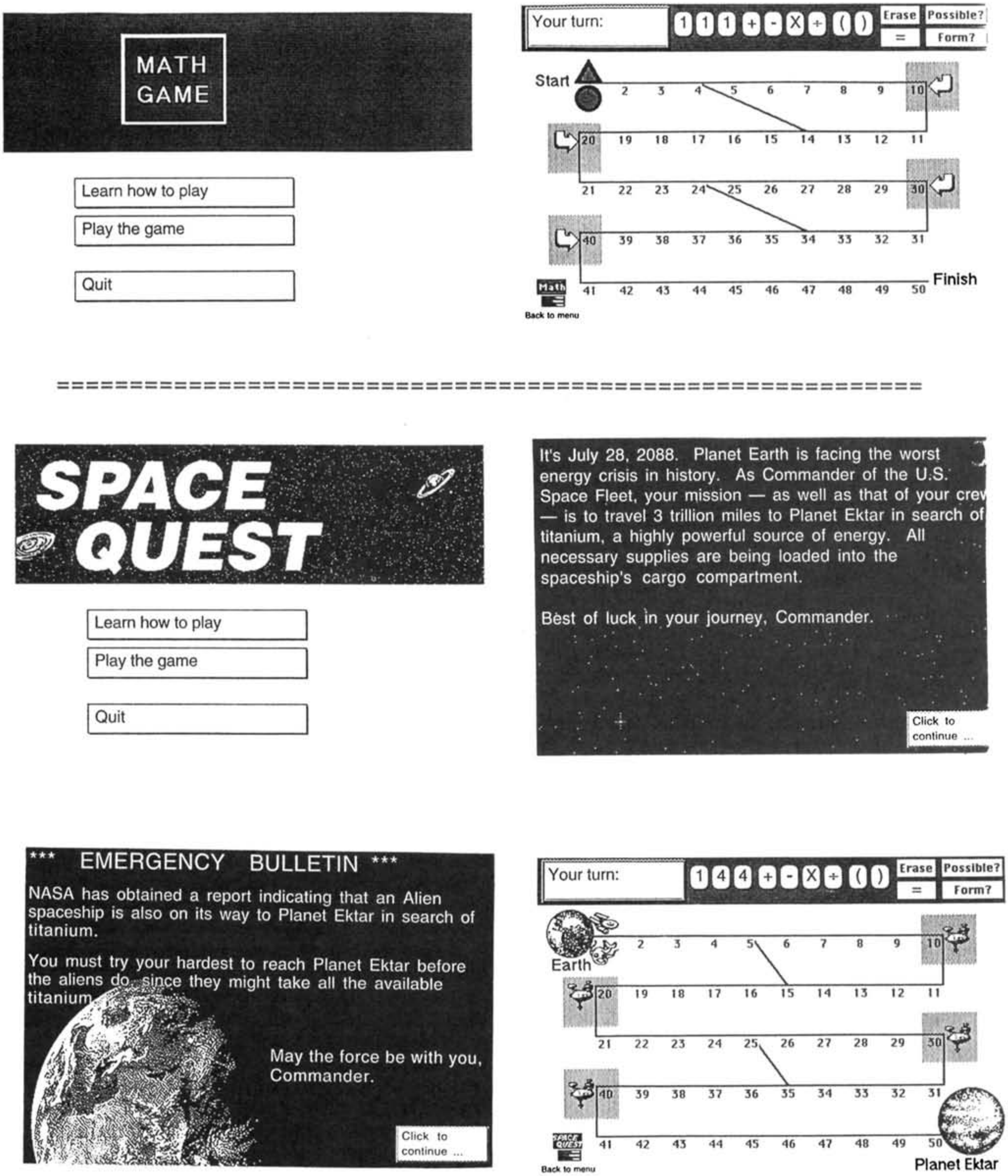

Figure 1. Sample screen displays illustrating the major aspects of the contextualization manipulation. The top panel displays the introductory screen and the opening game board from the no-fantasy control condition. The middle and bottom panels display, left to right, the introductory screen, the two screens added following the introductory screen to provide a meaningful context for learning in the four fantasy conditions, and the opening game board from the generic fantasy conditions.

Sessions 2–4: Experimental sessions. In the second, third, and fourth sessions, each child was asked to play with one randomly assigned version of the educational computer games described above. Children participated in three 30 min experimental sessions conducted approximately 5 days apart. All sessions took place in the computer room at the children's school, a setting that permitted seating of 5 children at separate work stations placed so that the children could not observe one another's work. Hence, all five conditions could be represented in each session.

Sessions 2 and 3: "Space Quest." Prior to the beginning of each session, the experimenter created a "participant data card" for each of the participants and entered the relevant personal information to be integrated into the program for those students in the personalized fantasy conditions. In the case of "Space Quest," the game played during the course of Sessions 2 and 3, this information consisted of the child's nickname, birthdate, favorite foods and toys, and closest friends.

At this point, a research assistant escorted the children in groups into the computer room. After having introduced herself, the experimenter introduced the experimental programs. After the students had reviewed the opening display, which contained the title of the program as well as some relevant graphics (i.e., rockets, planets, and spaceships), the experimenter asked them to click twice on the *Continue* button, located on the lower right-hand corner of the screen. Subsequently, a menu containing three options—*Learn how to play, Play the game,* or *Quit*—appeared on the screen. At this point, the experimenter instructed all children to select the "Learn how to play" option. On selecting this option, a highly interactive, 19-screen-long tutorial section depicting the rules and objectives of the game was presented. It took children an average of 8 min to go through this section of the program.

Personalization manipulation. Once children had reviewed the instructions section, two screens depicting the fantasy scenario were presented. These screens varied depending on the experimental condition. For instance, participants in the two generic (i.e., nonpersonalized) fantasy conditions read the following prologue:

[Screen 1]

It's July 28, 2088. Planet Earth is facing the worst energy crisis in history. As Commander of the U.S. Space Fleet, your mission—and that of your crew—is to travel 3 trillion miles to Planet Ektar in search of titanium, a highly powerful source of energy. All necessary supplies are being loaded into the spaceship's cargo compartment. Best of luck in your journey, Commander.

[Screen 2]

EMERGENCY BULLETIN

NASA has obtained a report indicating that an alien spaceship is also on its way to Planet Ektar in search of titanium. You must try your hardest to reach Planet Ektar before the aliens do since they might take all the available titanium. May the force be with you, Commander.

The fantasy scenarios that were presented to participants in the personalized fantasy conditions were identical to the ones depicted above, except that several pieces of background information from their personalization questionnaires were now put into the prologue:

[Screen 1]

It's [the child's birthday], 2088. Planet Earth is facing the worst energy crisis in history. As Commander of the U.S. Space Fleet, your mission—and that of your crew—Mission Specialists ______, ______, and ______ [three of the child's closest friends] is to travel 3 trillion miles to Planet Ektar in search of titanium, a highly powerful source of energy. All necessary supplies, including ______, ______, and ______ [names of the child's favorite foods and/or toys] are being loaded into the spaceship's cargo compartment. Best of luck in your journey, Commander ______ [child's nickname].

[Screen 2]

EMERGENCY BULLETIN

NASA has obtained a report indicating that an alien spaceship is also on its way to Planet Ektar in search of titanium. You must try your hardest to reach Planet Ektar before the aliens do since they might take all the available titanium. May the force be with you, Commander ______ [child's nickname].

The display screens in the top panel of Figure 2 illustrate these variations.

In addition to this initial prologue, there were four other instances during the course of the game in which students in the personalized fantasy condition could potentially receive personalized messages. First, when it was the student's turn to generate an arithmetic expression, the computer prompted him or her by inserting the student's name into the generic referent (e.g., *Commander Tom's turn*) instead of just saying *Commander's turn,* as was the case in the generic fantasy conditions. Second, whenever the child landed on one of the "intergalactic tunnels," the following personalized message appeared on the screen: *Congratulations, Commander* ______ [name of child]. *You have found the intergalactic tunnel!* For students in the generic fantasy conditions, the message was identical, with the exception that it did not include the child's name. Third, every time a student in the personalized fantasy condition landed on one of the space stations, the following personalized message appeared on the screen: *You landed on the space station, Commander* ______ [name of the child]. *You are now resupplied with* ______, ______, *and* ______ [names of the child's favorite foods]. By contrast, for participants in the generic fantasy conditions the message read: *You landed on the space station, Commander. You have picked up some extra supplies.* Lastly, whenever the student reached Planet Ektar first, thus winning the game, the victory message varied depending on the condition in which the participant played. For students in the personalized fantasy conditions, it read: *You won,* ______ [name of the child]*! You have rescued Earth from its energy crisis.* By contrast, for students in the generic fantasy conditions, the student's name was not incorporated into the message.

Choice manipulation. The second independent variable in this study consisted of the extent to which the student had control over various instructionally irrelevant aspects of the fantasy. Thus, students in the choice conditions were given the opportunity to select the icon that would represent them on the game board from among four options; they were also asked to provide a name for their choice of space vehicle and to choose the icon that would represent the alien on the game board from among four options. Students in the choice conditions were also asked to name their opponent, as well as to select the starting point of each of the two shortcuts from within a prescribed range of values. By contrast, for students in the no-choice conditions, these decisions were randomly made by the computer. Display screens illustrating the instantiation of the choice manipulation appear in the bottom panel of Figure 2.

After all these choices had been made, the children proceeded to play their version of the game for 30 min. After the 30 min were up, the experimenter asked the children to return to the main menu and select the quit option. The children were thanked for their

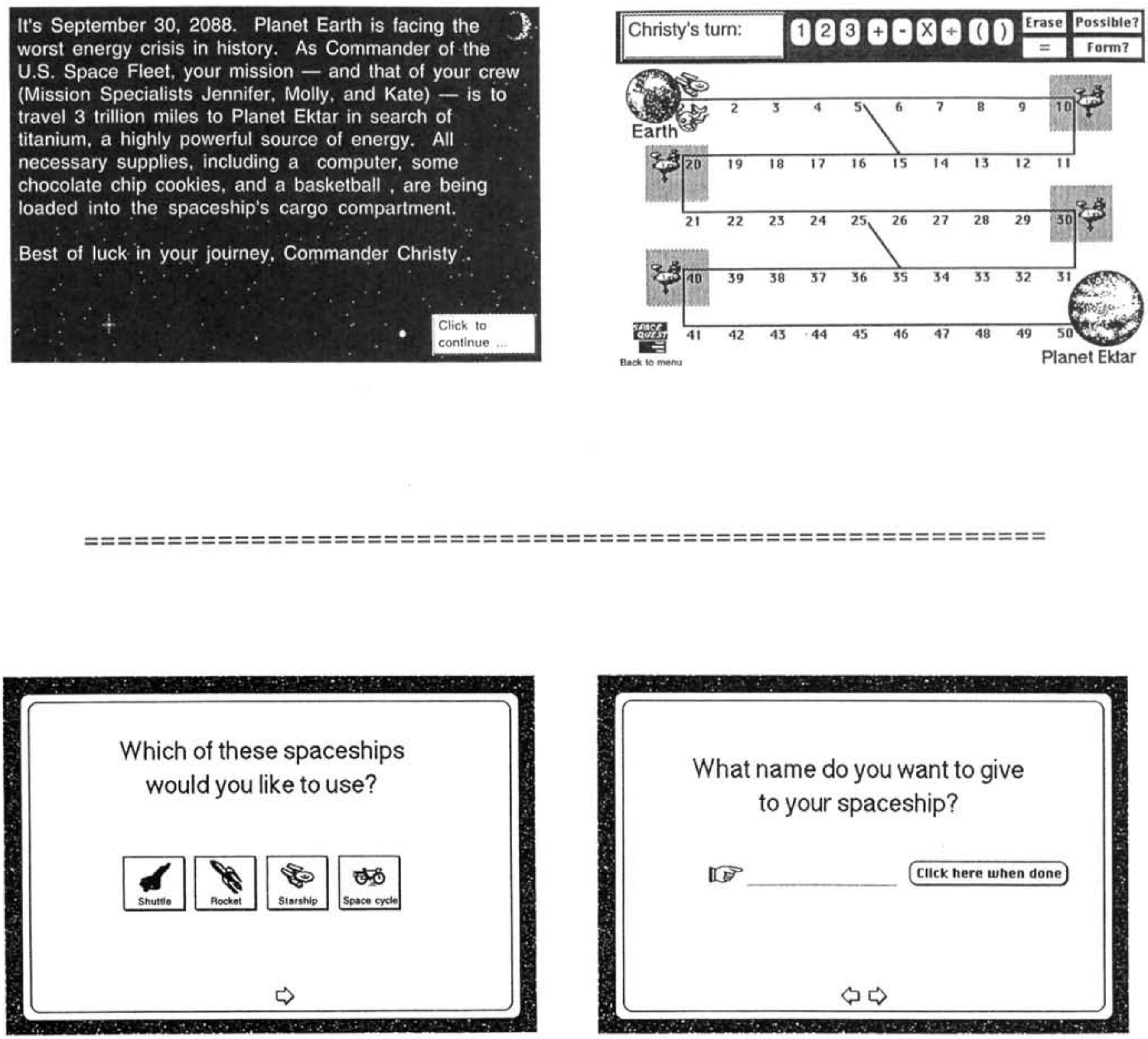

Figure 2. Sample screen displays illustrating the personalization and choice manipulations. The top panel displays two screens illustrating the introduction of individuating information into the fantasy context in the personalization conditions. The bottom panel displays two screens illustrating the sorts of instructionally incidental choices offered to students in the choice conditions.

cooperation and told that they would have a chance to play again with the computer in 5 days.

Session 4: "Treasure Hunt." During the course of the final experimental session, the children played with a second fantasy version of the program entitled "Treasure Hunt." As in Session 2, the experimenter created a data card for each one of the participants and entered the relevant pieces of background information to be incorporated into the basic fantasy for those children in the personalized fantasy conditions. In the case of "Treasure Hunt," this information consisted of the child's name, birthdate, the name of his or her school, the name of his or her best friends, and his or her favorite name for a boat, as well as his or her favorite foods and desired toys.

Once the children were brought into the classroom by a research assistant and assigned to a particular computer by the experimenter, they were told that they would have 30 min to play with this new version of the computer game. They were also told that they could skip the "learn how to play" section if they remembered all the rules and objectives of the game. At this point, all the children were presented with a two-screen fantasy prologue. For participants in the generic fantasy conditions, this prologue consisted of the following:

> [Screen 1]
> Treasure Hunt
>
> Many years ago,
> a treasure was buried
> on the island of Esperanza. . .
>
> [Screen 2]
> On July 12, you and some friends decide to set sail from your school aboard a small fishing boat, in order to look for the hidden treasure. But wait! A pirate ship is rapidly approaching the island. Good luck, Captain.

Personalization manipulation. For participants in the personalized fantasy conditions, on the other hand, several pieces of background information were incorporated into the second screen of the prologue:

> On [child's birthday], you and ______, ______, and ______ [three of the child's best friends], decided to set sail from ______ [name of the child's school], aboard the ______, [child's favorite name for a boat], a small fishing boat, in order to look for the hidden treasure. But wait! A pirate ship is rapidly approaching the island. Good luck, Captain ______.

As in "Space Quest," there were four other instances during the course of the game in which the students in the personalized fantasy conditions could potentially receive personalized messages. For example, when it was the student's turn to generate an arithmetic expression, the computer prompted him or her by inserting the student's name into the generic message (i.e., *Captain Tom's turn*). In addition, whenever the child landed on one of the "secret passages," a personalized message of congratulations appeared on the screen. Third, every time a student in the personalized fantasy conditions landed on one of the "huts," the message appearing on the screen contained the names of the child's favorite foods or snacks; whereas for students in the generic fantasy conditions no mention of any specific food items was made. Finally, whenever the students arrived at the treasure site before the pirate, thus winning the game, the victory message varied depending on experimental condition. For participants in the personalized fantasy conditions the following message appeared on the screen:

> "You have found the treasure, Captain ______ [child's name]! The chest contains ______, ______, and ______ [names of 3 toys which the student would like to get for his or her birthday]!"

In contrast, for participants in the generic fantasy conditions the message read: *You have found the treasure, Captain! The chest contains some toys.*

Choice manipulation. Similarly, as in the first variation of the program, students in the choice conditions were given the opportunity to select the icon that would represent them on the game board from among four options. In addition, these participants were also given the opportunity to provide a name for their icon and to choose the icon that would represent their opponent on the game board from among four options. Lastly, students in the choice conditions were also given the opportunity to name their opponent, and to select the starting point for both secret passages, from within a specified range. By contrast, for students in the no-choice conditions, these decisions were automatically made by the computer.

No-fantasy control condition. As noted earlier, this study also included a fifth, no-fantasy control condition. Students in this condition played with a generic, unembellished version of the program, entitled simply "Math Game," during the course of all three experimental sessions. In this unembellished version of the program, the game board consisted of a number line ranging from 1 (the start) to 50 (the finish) with four gray zones and two shortcuts. The objective of the game was for the child (represented on the game board by a triangle) to reach the finish before its opponent, the computer (represented on the game board by a circle). As in "Space Quest" and "Treasure Hunt," every time the student made a special move, a congratulatory message appeared on the screen. In the case of "Math Game," however, these messages were extremely generic in nature (e.g., *Congratulations! You have found the shortcut!*). Similarly, whenever the child reached the finish before the computer, the victory message consisted of: *You won! You reached the number 50 first!*

Session 5: Posttesting. During Session 5, held 1 week after the last game-playing session, children were tested on their knowledge of the order of operations and the use of parentheses in arithmetic expressions outside the computer context. The test developed for this purpose consisted of 20 problems similar to those used in the pretest. This standard paper-and-pencil test constituted our measure of direct learning.

In addition to this learning measure, several additional attitudinal measures were administered. Children in all conditions were asked to answer, using 7-point Likert scales (1 = *not at all* and 7 = *very, very much*), how much they liked the computer games they played, how willing they would be to stay after school one day to play with the computer game, how useful they thought the games were in helping them to learn math, and how strongly they would recommend that other children try these computer games. In addition, using similar scales, children were asked to rate their perceived competence (i.e., how good they thought they were at the computer game) and their subsequent level of aspiration (i.e., how challenging they desired a future game to be). Finally, two additional questions asked for relative evaluations of how the computer activity compared with children's favorite board games and with their favorite subjects in school. On both of these last items, children were asked to indicate if the computer activity was (a) a lot less fun, (b) a little less fun, (c) almost as much fun, (d) as much fun, (e) a little more fun, or (f) a lot more fun.

Results

General Analysis Strategy

Our general strategy for examining the effects of personalization and choice on each of the dependent measures involved a general one-way analysis of variance (ANOVA) with four orthogonal planned contrasts. The first contrast compared the no-fantasy control condition with the remaining four experimental conditions and tested whether the addition of a fantasy context, in general, made a significant difference on our outcome measures. The second and third contrasts examined whether or not there were main effects for personalization and choice, respectively, within the 2×2 (Personalization $\times$ Choice) design formed by the four experimental conditions. The fourth contrast assessed whether or not there was a significant interaction between these two independent variables.

Preliminary Analyses

Preliminary analyses were performed to determine whether there were any interactions between experimental condition and students' gender or grade at school. In neither

analysis was there any evidence of a significant interaction of these variables with experimental condition (all Fs <1). Therefore, these two variables were not included in any further analyses. In addition, no significant differences were found among the experimental groups with regard to their scores on the 15-item arithmetic pretest (all Fs <1). Thus, all experimental groups had an equivalent knowledge of the order of operations and the use of parentheses to begin with.

Effects on Intrinsic Motivation

A first question, then, concerned the effects of the addition of a meaningful context, personalization, and choice on children's actual enjoyment of the experimental program—whether these embellishments had indeed made the instructional program more intrinsically interesting for the students. To investigate this issue, we asked children two types of questions. The first focused directly on participants' liking and enjoyment of the different versions of the computer program, whereas the second involved comparative judgments assessing participants' liking for their version of the program relative to their liking for their favorite board games and their favorite school subjects.

Direct enjoyment measures. First, we asked the children how much they had liked the computer games they had played with during the course of the study, how much they had enjoyed working with their version of the computer program, and the extent to which they would recommend the computer program to their friends. Because all of these measures of liking and enjoyment were highly intercorrelated (average r = .76), they were averaged into a single measure of overall liking for the game. All relevant means and standard deviations are presented in Table 1.

As predicted, the results of the one-way ANOVA yielded a highly significant overall treatment effect, $F(4, 65) = 15.85$, $MSE = 0.857$, $p < .0001$. To clarify the precise nature of this effect, we performed four planned orthogonal contrasts. The first compared the control condition with the four experimental conditions. In this case, participants in the no-fantasy control condition reported liking the program significantly less than participants in the remaining four experimental conditions, $F(1, 65) = 33.02$, $p < .0001$. The second contrast tested whether there was a main effect for personalization. As an examination of the top row of Table 1 suggests, participants in the personalized fantasy conditions reported liking the program significantly more than participants for whom the fantasy had not been personalized, $F(1, 65) = 21.79$, $p < .0001$. Likewise, a third contrast tested for a main effect for choice and revealed that participants in the choice conditions reported liking the program significantly more than those in the no-choice conditions, $F(1, 65) = 8.36$, $p < .005$. Finally, the fourth contrast tested for the presence of an interaction between personalization and choice. None was found, $F(1, 65) = 0.24$.

Finally, as a more stringent motivational test, we asked our participants how willing they would be to stay during recess or perhaps after school one day to play with the computer games. Once again, the one-way ANOVA revealed a strong effect of experimental conditions, $F(4, 65) = 5.11$, $MSE = 3.0$, $p < .001$. In general, as shown in the middle row of Table 1, children in the no-fantasy control condition were less willing to spend some of their free time playing with the computer game than were participants in the fantasy conditions, $F(1, 65) = 6.69$, $p < .01$. Similarly, students in the generic fantasy conditions were significantly less willing to stay after school playing the computer game than students for whom the fantasy had been personalized, $F(1, 65) = 3.72$, $p < .05$. Finally, students in the no-choice conditions were also less likely to stay after school to play the game than those in the choice conditions, $F(1, 65) = 9.99$, $p < .005$. No interaction effect was obtained for this measure either, $F(1, 65) = 0.05$.

Relative enjoyment measures. Two additional questions asked participants for their relative evaluations of how their version of the computer game compared with both their favorite board games and with their favorite subjects in school. The two measures proved highly correlated (r = .78) and were averaged into a single "relative enjoyment" measure. The means and standard deviations for this combined measure are presented in the bottom row of Table 1.

As predicted, a one-way ANOVA revealed a strong effect of experimental conditions on these relative judgments, F(4,

Table 1
Means and Standard Deviations for Direct Enjoyment Measures

	Conditions				
Variable	No fantasy	Gen–no choice	Gen–choice	Pers–no choice	Pers–choice
Overall liking for game					
M	3.97	4.58	5.44	5.89	6.50
SD	0.81	1.33	0.88	1.04	0.46
Willingness to stay after class					
M	3.00	3.21	4.57	4.00	5.57
SD	1.11	2.19	1.34	2.18	1.55
Relative enjoyment composite					
M	2.75	2.90	3.82	3.93	5.42
SD	0.86	1.58	1.66	1.16	0.76

Note. Measures were presented by means of 7-point Likert scales ranging from 1 (*not at all*) to 7 (*very, very, much*). Gen = generic fantasy; Pers = personalized fantasy.

65) = 10.02, MSE = 1.81, $p < .0001$. Again, four orthogonal contrasts were computed. The first showed that relative to participants in the experimental conditions, students in the no-fantasy control condition thought that their version of the computer activity compared less favorably with their preferred board games and school subjects, $F(1, 65) = 11.24$, $p < .005$. The second contrast revealed that relative to those participants in the generic fantasy conditions, those in the personalized fantasy conditions thought that their version of the computer game compared very favorably with their favorite board games and subjects at school, $F(1, 65) = 15.26$, $p < .0005$, and the third contrast showed the same pattern to hold for those students in the choice conditions, $F(1, 65) = 12.89$, $p < .001$. Finally, the fourth contrast showed that there was once again no significant interaction effect, $F(1, 65) = 0.71$.

Effects on Task Involvement

Do differences in intrinsic motivation influence task involvement? To answer this question, we examined the students' records during the game-playing sessions in search of differences in the manner in which children in the various experimental conditions had approached the computer game. Our on-line recording system provided us with several measures regarding what transpired during the course of all three game-playing sessions—namely, the number of spaces along the number line the players advanced per turn, the number of times the players made use of the two types of hints, the difficulty level for each game selected by the students, the number of times the students made use of complex operations, the percentage of problems they solved correctly, and any evidence of strategic play on the part of the players. All relevant means and standard deviations for these measures are provided in Table 2.

On the simplest on-line performance measures, there were no differences among the conditions. For example, there were no significant differences among the experimental conditions in the number of spaces the player advanced per turn or in the number of times students in the different conditions solicited hints from the computer or on the percentage of problems they answered correctly.

Significant differences did emerge, however, with respect to the number of times the children made use of complex operations, such as the use of parentheses, negative numbers, or division, in the generation of arithmetic expressions during the course of each game. A one-way ANOVA revealed a significant effect of experimental conditions on this measure, $F(4, 65) = 3.19$, $MSE = 1.08$, $p < .02$. More specifically, children in the no-fantasy control condition used these operations significantly less often than students in the fantasy conditions, $F(1, 65) = 7.23$, $p < .01$. In addition, children for whom the fantasy had been personalized used these operations significantly more frequently than those children for whom the fantasy had not been personalized, $F(1, 65) = 5.17$, $p < .05$. No significant effects were obtained, however, for the choice versus no-choice conditions, $F(1, 65) = 0.24$. Nor was there any

Table 2
Means and Standard Deviations for On-Line Performance Measures

	Conditions				
Variable	No fantasy	Gen–no choice	Gen–choice	Pers–no choice	Pers–choice
Spaces per turn					
M	7.15	7.78	7.36	6.92	7.58
SD	0.99	1.08	1.64	1.10	1.53
Use of hints					
M	0.55	0.49	0.84	0.80	0.20
SD	0.80	0.89	1.27	1.08	0.25
% of problems solved correctly					
M	91.4	89.9	91.5	92.2	93.6
SD	5.35	7.50	5.33	4.63	4.58
% of times more challenging version of program selected					
M	29.00	80.00	80.00	64.00	82.00
SD	0.12	0.22	0.24	0.23	0.19
Use of complex operations					
M	0.80	1.33	1.30	2.06	1.83
SD	0.61	0.96	1.43	1.15	0.91
Strategic play					
M	0.63	0.77	1.09	1.15	1.39
SD	0.24	0.36	0.61	0.85	0.57

Note. The number of spaces per turn was calculated by dividing the numerical value of the player's location at the end of the game by the number of turns the player had in that game. The use of hints was calculated by dividing the total number of times the player solicited hints by the total number of games he or she played. The use of sophisticated techniques was calculated by adding the number of times players made use of parentheses, division, and negative numbers in their arithmetic expressions. Gen = generic fantasy; Pers = personalized fantasy.

evidence of an interaction between personalization and choice, $F(1, 65) = 0.12$.[3]

Similarly, we also examined the number of times the students made strategic moves such as "bumping" their opponent, or landing on a shortcut or a target zone. A one-way ANOVA revealed significant differences among the experimental groups, $F(4, 65) = 4.16$, $MSE = 0.32$, $p < .005$. Specifically, students in the no-fantasy control condition made significantly fewer moves of this caliber than students in the fantasy conditions, $F(1, 65) = 7.91$, $p < .01$. In addition, children in the personalized fantasy conditions generated a significantly higher number of strategic moves relative to those children for whom the fantasy had not been personalized, $F(1, 65) = 5.15$, $p < .05$, and there was a marginally significant effect due to choice, $F(1, 65) = 3.52$, $p < .065$. Again, there was no significant interaction effect, $F(1, 65) = 0.07$.

Finally, we also examined the selected level of difficulty for each game. A one-way ANOVA revealed that there were significant differences among the groups, $F(1, 65) = 3.67$, $MSE = 0.93$, $p < .01$. Specifically, students in the no-fantasy control condition chose the less challenging version of the activity significantly more often than those students in the fantasy conditions, $F(1, 65) = 7.36$, $p < .01$. For this measure, however, the main effects for personalization and choice were not significant, $F(1, 65) = 1.60$, $p > .21$, and $F(1, 65) = 2.71$, $p > .10$, respectively.

In general, then, participants in the contextualization, personalization, and choice conditions exhibited significantly higher levels of task involvement, as evidenced by their preference for more challenging versions of the game, their greater use of complex operations, and their emphasis on strategic play relative to participants in the no-fantasy, nonpersonalized, and no-choice conditions.

Effects on Learning

Given these differences in the motivational appeal of the various versions of the educational program and in the degree of task-involvement, it is of central importance to ask how students' learning was affected by our experimental manipulations. Thus, we examined the students' performance on the mathematics test that had been administered during the posttest session.

To examine the effects of personalization and choice on students' learning, we conducted a one-way analysis of covariance (ANCOVA), using the pretest score as a covariate, on children's scores on the 20-item math test that had been administered during the posttest sessions 1 week later, in the absence of the computer. This analysis yielded a significant effect of experimental treatments on the learning measure, $F(4, 65) = 13.80$, $MSE = 0.86$, $p < .0001$. The relevant means and standard deviations for this measure are presented in Table 3.

Once again, a series of orthogonal contrasts was performed to test the specific predictions of the study. First, students for whom the educational activity had been presented in an unembellished, no-fantasy context exhibited significantly lower levels of learning than students for whom the activity had been embedded in a fantasy context, $t(65) = 5.00$, $p < .0001$. Second, children in the personalized fantasy conditions showed significantly higher levels of learning than those in the generic fantasy conditions, $t(65) = 4.89$, $p < .0001$. Last, the provision of some degree of choice over various instructionally irrelevant aspects of the game also had beneficial effects on students' learning, as children in the choice conditions scored significantly higher on the math test than those in the no-choice conditions, $t(65) = 2.02$, $p < .05$. Again, no interaction effect was found, $t(65) = 1.11$, $p > .27$.

Effects on Perceived Competence and Level of Aspiration

Finally, we examined the possibility that there might be subsequent motivational effects due to our experimental manipulations. To this end, we examined the students' responses to two additional measures. The first of these measures focused on children's perceptions of their ability at the computer games used in this study, whereas the second measure examined their subsequent level of aspiration for a future version of the educational computer game.

Perceived competence measure. Our first measure asked participants to rate, on a 7-point Likert-type scale, how good they thought they were at the experimental computer games. The one-way ANOVA revealed a significant effect of experimental conditions on the perceived competence ratings, $F(4, 65) = 4.38$, $MSE = 1.01$, $p < .005$. As shown in Table 4, there were distinct variations among the experimental conditions. The orthogonal contrast comparing students in the no-fantasy control condition with those in the remaining conditions once again proved significant, $F(1, 65) = 5.10$, $p < .05$, indicating that children in the control condition perceived themselves as being worse at playing the computer game than those in the fantasy conditions. In addition, students for whom the relevant fantasy context had been personalized exhibited higher levels of perceived competence relative to those for whom the fantasy had not been personalized, $F(1, 65) = 3.98$, $p < .05$. Similarly, students who had been provided with the opportunity to exert some control over several noninstructional features of the game reported significantly higher levels of perceived competence relative to those students who had not been provided with such options, $F(1, 65) = 7.79$, $p < .01$. No interaction was found, $F(1, 65) = 0.64$.

Level of aspiration measure. Our second measure assessed students' subsequent levels of aspiration. In particular, we asked our participants to vote on the desired level of difficulty for a future game to be brought to the school the

[3] Given that the children in the personalized conditions were generating more elaborate expressions, we examined the possibility that they might have committed a significantly higher number of mistakes relative to participants in the remaining conditions. A one-way ANOVA showed that this was not the case, as there were no significant differences between the conditions with respect to the percentage of problems solved correctly.

Table 3
Means and Standard Deviations for Posttest Learning Measure

Variable	No fantasy	Gen–no choice	Gen–choice	Pers–no choice	Pers–choice
Order of operations test					
M	9.21	10.36	10.64	12.79	14.36
SD	1.71	2.09	2.53	2.08	2.30

Note. Order of operations test consisted of 20 items. Gen = generic fantasy; Pers = personalized fantasy.

following week. Once again, the same pattern of results was obtained. In general, there was a robust effect of experimental conditions on the desired level of difficulty ratings as indicated by a one-way ANOVA, $F(4, 65) = 10.45$, $MSE = 1.04$, $p < .0001$. As shown in Table 4, children in the no-fantasy control condition expressed a strong preference for a significantly easier version of the game than did participants in the fantasy conditions, $F(1, 65) = 21.35$, $p < .0001$. Furthermore, relative to students in the generic fantasy conditions, those for whom the relevant fantasy had been personalized expressed a preference for harder, more challenging versions of the computer game, $F(1, 65) = 7.54$, $p < .01$ and, relative to students in the no-choice conditions, those who were provided with an opportunity to exert some degree of control over various aspects of the game also expressed a preference for more challenging future versions of the game, $F(1, 65) = 12.47$, $p < .001$. No significant interaction effect was obtained, $F(1, 65) = 0.43$.

Discussion

Taken together, the findings from the present study provide strong evidence of the potentially powerful educational benefits that can result from the appropriate use of strategies designed to increase the intrinsic motivational appeal of learning activities for students. For each of the three specific strategies examined in the current investigation, as predicted, students exposed to motivationally embellished activities displayed higher levels of intrinsic motivation. As a result, they became more deeply involved in the activities, attempting to use more complex operations, and thereby learned more from the activities in a fixed period of time. Finally, they also showed higher subsequent levels of aspiration and feelings of perceived competence than their counterparts who were exposed to the unembellished versions of these same activities.

Thus, as in previous studies, students for whom the abstract learning activities had been embedded in meaningful and appealing fantasy contexts generally showed substantially greater motivation, involvement, and learning than those for whom the activities had not been so contextualized. These educational benefits were further heightened, moreover, when incidental aspects of these contexts were personalized for students or when students themselves were allowed choices regarding incidental aspects of these contexts. Thus, students for whom the learning contexts had been personalized, through the incorporation of incidental individualized information about their backgrounds and interests, displayed larger gains in motivation, involvement, and learning than their counterparts for whom the contexts had not been personalized.

Likewise, students who were offered a modicum of choice over instructionally incidental aspects of the learning contexts showed greater increases in motivation and learning. It is worth noting that the success of the present choice manipulation may be contrasted with the failure of the choice manipulation in the Parker and Lepper (1992) study to influence motivation or learning. In that study, however,

Table 4
Means and Standard Deviations for Perceived Competence and Level of Aspiration Measures

Variable	No fantasy	Gen–no choice	Gen–choice	Pers–no choice	Pers–choice
Perceived competence					
M	4.71	4.64	5.60	5.40	5.93
SD	1.07	1.13	1.07	0.97	0.73
Desired level of difficulty for future game					
M	3.79	4.43	5.21	5.00	6.14
SD	1.12	1.28	0.98	0.88	0.77

Note. Measures were presented by means of 7-point Likert scales ranging from 1 (*much, much easier*) to 7 (*much, much harder*). Gen = generic fantasy; Pers = personalized fantasy.

only a single choice (of general fantasy context) was offered, whereas in the present study, and in others in which choice has had demonstrable educational benefits (e.g., Perlmuter & Monty, 1977), a series of six or more discrete choices was offered. In addition, within the present study, the effects of the choice manipulation were not always as strong as those of the personalization manipulation.

Both of these variables may also be viewed as manipulations tending to increase the self-relevance of the activity. They do so, however, in a way that makes the self intrinsic or "endogenous" to the task, so that motivation, performance, and learning are enhanced. Such strategies may be contrasted with those in which increased relevance to the self is purchased at the expense of threats to self-esteem, such as in the typical ego-involvement manipulations, in which focus on the self becomes extrinsic or exogenous to the activity itself and in which intrinsic motivation tends therefore to be undermined (e.g., Deci & Ryan, 1987; Lepper, 1988; Sansone, 1986).

Significantly, these findings were obtained under circumstances in which all aspects of the cognitive demands and structure of the activities were carefully controlled. Not only were the instructions provided and the problems presented to students identical across groups but even the choice of learning contexts was specifically designed to minimize alternative cognitive interpretations. For instance, previous studies in the cognitive literature have demonstrated "context-availability" effects (e.g., Anand & Ross, 1987; Ross, 1983), showing that learning can be enhanced when problems are presented in familiar concrete contexts that could allow learners to draw on their experiential knowledge from those contexts (e.g., that students might be more effective in solving problems involving fractions in the context of dividing up pizzas among friends than in the context of abstract questions regarding the sectioning of circles). In the present study, on the other hand, all three contextual manipulations were selected to be entirely incidental to the learning task at hand. Hence, it would be hard to imagine a purely cognitive explanation of the importance of the names of one's spacecraft, the purported identity of the crew, or the types of fictional provisions stashed aboard on children's ability or willingness to use more complex equations. Indeed, even the choice of "difficulty level" provided in this study did not involve the presentation of different problems; instead, it involved only variations in the success of the student's "opponent."

By contrast, the motivational effects of our manipulations were both manifest and immediate. At the first appearance in the personalization conditions of individuating information, for example, squeals of delight could actually be heard from many of the students, even before they had encountered a single problem.

Despite the strong effects obtained in this study, it would be an unwarranted extrapolation to suggest that the use of motivational embellishment strategies of the sort used in this study will always, or even typically, have such beneficial effects. For instance, these techniques might well not be as effective with older children or with adults, given that interest in such fantasies may decrease with age. Similarly, these motivational embellishment strategies might prove to be much less beneficial for children who are already highly motivated and task-oriented. For these highly goal-directed students, such motivational embellishments may be seen more as a distraction, or a time-wasting nuisance, than as an aid. Finally, there are issues of novelty and habituation. It is quite possible that if these sorts of techniques were overused, their positive effects might dissipate over time.

Other potential difficulties with the present findings can be more directly gainsaid. Thus, although we deliberately used instructionally irrelevant choices in this study to rule out more purely cognitive explanations for our findings, we would not expect the motivational benefits of choice to be restricted to such "trivial" choices. Indeed, previous literature would suggest that the motivational effects of the provision of more substantial choices will, if anything, prove more powerful (Deci & Ryan, 1985; Nuttin, 1973). Nor do we believe the present findings to be restricted to learning in nonevaluative settings or to the learning of simple algorithms. At least with respect to our basic results concerning the benefits of fantasy contextualization, previous experimental findings by Parker and Lepper (1992), as well as more informal reports on the design of educational computer games (e.g., Chabay & Sherwood, 1992; Dugdale, 1992), would seem to demonstrate that such techniques are equally applicable to the more competitive and evaluative context of most classrooms and to the learning of more complex and conceptually oriented materials.

In addition to these obvious possible limitations, Lepper and Malone (1987; see also Baker, Herman, & Yeh, 1981) have also identified a number of situations in which increases in the motivational appeal of specific computer-based learning activities failed to produce corresponding increases in learning or other desired educational outcomes. The most general principle determining whether increased motivational appeal will also lead to increased learning, Lepper and Malone suggested, concerns the match between the actions required for students to learn the material being presented in an activity and the actions required for students to enjoy that activity. When these actions are identical or mutually reinforcing, the effects on learning should be positive; when these actions are mutually exclusive or otherwise at variance with one another, the effects on learning should be negative.

In the specific case of instructional games, for example, one may examine the relationship between the goals of winning the game and learning the material. In the best of circumstances, these two sets of goals are congruent and mutually supportive; under such conditions, the added motivational value of presenting instruction in a game format should result in increased learning. In other circumstances, these two sets of goals may be completely independent of one another; here the consequences on learning should depend heavily on the extent to which the motivational activities take up time that would otherwise have been devoted to learning. In the worst of circumstances, however,

these two sets of goals are directly at odds with each other; under such circumstances, learning will suffer from the addition of motivational embellishments of this sort. In the present study, of course, considerable pains were taken to ensure that learning and enjoyment would be mutually congruent.

Having recognized these potential limitations, however, it seems equally important to note the potentially general applicability of effectively designed motivational embellishments within today's classrooms (cf. Lepper, Woolverton, Mumme, & Gurtner, 1993). In fact, effective teachers have long used the techniques discussed in this article to motivate and instruct students. One may recall from years ago the efforts of that English teacher who sought to teach proper spelling and grammar by setting up her classroom as a newspaper office or that science teacher who introduced basic concepts of measurement and analysis in the context of an actual weather station set up and staffed by students. Indeed, some researchers have argued that most of the elementary curriculum could be more effectively taught through the use of these sorts of meaningful project-based contexts for learning (e.g., Edwards, Gandini, & Foreman, 1993; Katz & Chard, 1989).

Moreover, the procedures used in the present study suggest that such strategies can be quite cost-effective, with a set of minimal modifications of instructional materials apparently producing quite substantial effects on students' learning from those materials. Thus, in terms of standard effect-size measures (e.g., Glass, McGaw, & Smith, 1981), the difference in learning between the most effective condition (high choice and high personalization) and the control condition in this study yields a sizable d of 3.17.[4] This figure compares very favorably with the average effect sizes reported in recent meta-analytic reviews on the effects of computer-assisted instruction in general, which have ranged from $d = .24$ (Fletcher-Flinn & Gravatt, 1995) and $d = .30$ (Kulik & Kulik, 1991) to $d = .42$ (Niemiec & Walberg, 1987). Indeed, in terms of McGraw and Wong's (1992) common language effect size statistic (CL), there is a probability of .96 that any random student in the personalized–choice condition will perform better than any random student in the control condition.

Finally, although there is no reason to believe that the present findings are dependent on the use of the computer, it is certainly the case, as has often been noted, that the introduction of computers into the classroom has provided a truly unprecedented opportunity for the increased individualization of instruction (e.g., Bork, 1985; Kleiman, 1984; Papert, 1980, 1993; Schank, 1984). Interestingly, the obvious possibilities that computers afforded for individualization of instruction along cognitive lines were central to even the very first forms of computer-assisted instruction (e.g., Atkinson, 1972; Suppes, 1966). By contrast, the comparable possibilities for individualization of instruction along affective and motivational lines have received surprisingly little attention (Lepper, 1985; Lepper & Chabay, 1988). We hope that the present findings will help to make clear the potentially powerful educational dividends to be reaped from greater attention to such affective and motivational issues.

[4] Effect size (d) was computed here using the "preferred" formula for pretest–posttest designs (e.g., Fletcher-Flinn & Gravatt, 1995; Glass, McGaw, & Smith, 1981), in which the effect size (computed as the difference between the mean of the experimental group and the mean of the comparison group divided by the standard deviation of the comparison group) at pretest was subtracted from the comparable effect size measure at posttest. The simpler d, however, based purely on the posttest means and the standard deviation of the comparison group, would be an equally impressive 3.01.

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