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AUTHOR	Rezabek, Randy
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ABSTRACT

The intent of this study was to explore the intrinsic aspects of motivation, and to see if the design of instruction could positively affect learners' levels of intrinsic motivation toward the subject matter. The following questions were addressed: (1) Will different computer-based instructional treatments which have been designed to reflect principles of intrinsic motivation to varying degrees produce measurably different levels of intrinsic motivation in learners? (2) Can the data from this study be explained in terms of the flow model? (3) Are higher levels of intrinsic motivation associated with higher learning scores? and (4) Are prior learning and prior interest related to different levels of intrinsic motivation? The flow phenomenon is described in terms of its two parameters, challenge and skills. When these two factors are in balance, people feel that they have the skills necessary to achieve a challenging but realistic goal. Instructional materials for the study consisted of three computer-assisted instructional programs on the topic of the relationship of aperture and shutter speed to exposure, depth-of-field, and image blur. Treatment #1 utilized a linear design with a fixed sequence of topics. Treatment #2 contained the same content material, but was organized into a hypermedia style structure, giving subjects a choice over the sequencing of instruction. Treatment #3 utilized a series of camera simulators with embedded instructional sequences for both presentation of the material and opportunities for practice, and with a "Jeopardy" style game at the end in lieu of embedded questions. Measures of intrinsic motivation were gathered from 121 subjects through the use of the Experience Sampling Form (ESF) and the Intrinsic Motivation Inventory (IMI). Results suggest that attempting to increase intrinsic motivation through the design of instructional materials is more difficult than the literature would indicate. The following subdimension score results are discussed: activation (alertness, involvement, excitement); affect (happiness, sociability, relaxation); cognitive efficiency (concentration, expectation, satisfaction); motivation (sense of control; success, satisfaction, importance of activity to the subject); perceived confidence (respondent's sense of competence, skill, and confidence). Results are illustrated in eight tables. (Contains 22 references.) (MAS)

Title:

The Relationships Among Measures of Intrinsic Motivation, Instructional Design, and Learning in Computer-Based Instruction

Author:

Randy Rezabek, Ph.D.
The University of Oklahoma

1220 East Brooks St.
Norman, OK 73071
(405) 329-7771
Internet: dd8244@uoknor.edu

Why would a person want to learn? This is one of the central questions of education. Many arguments have been generated as to why learning benefits both the individual and their society. But these rationales focus on the outcomes of learning, not the process itself. For instructional designers, whose task it is to create learning environments, the key question is "what variables encourage learning for its own sake?"

The study of motivation has long been a neglected area in instructional technology. The emphasis on promoting effectiveness and efficiency in instructional design often excludes concerns about the appeal of instruction. Traditionally handicapped by the lack of theory and lack of measurements dealing with motivation, instructional designers have assumed that good quality instruction will in itself be motivating (Keller, 1983). However, motivation is such a crucial issue in education that simple assumptions are not sufficient.

Our culture tends to emphasize extrinsic motivation, that is, the use of externally supplied rewards and punishments as a means of controlling behavior. However, the use of an extrinsic reward has a hidden cost in that it has a negative effect on an individual's *intrinsic* motivation, that is, motivational states which are internally supplied or generated (Deci & Ryan, 1985). With an intrinsic motivational strategy, the reward arises out of direct involvement with an ongoing activity, which in turn, increases the participant's ability to grow in terms of personal complexity (Csikszentmihalyi, 1978).

The intent of this study was to explore the intrinsic aspects of motivation, and to see if the design of instruction could positively affect learners' levels of intrinsic motivation toward the subject matter.

Statement of the Problem

This research concerned the relationship between intrinsic motivation, differing instructional designs, and learning in computer-based instruction. Specifically, it addressed the following questions:

1. Will different computer-based instructional treatments which have been designed to reflect principles of intrinsic motivation to varying degrees produce measurably different levels of intrinsic motivation in learners?
2. Can the data from this study be explained in terms of the flow model?
3. Are higher levels of intrinsic motivation associated with higher learning scores?
4. Are prior learning and prior interest related to different levels of intrinsic motivation?

Theoretical Framework

The primary theoretical framework for this study is the work of Mihaly Csikszentmihalyi (1975, 1990, 1993; Csikszentmihalyi & Csikszentmihalyi, 1988), which is generally described as "flow theory." Csikszentmihalyi's work deals with identifying and defining the structural characteristics of "optimal" experiences, that is, experiences which are perceived to be challenging, exhilarating, absorbing, and fun.

The flow phenomenon is best described in terms of its two parameters, challenge and skills. When these two factors are in balance, people feel that they have the skills necessary to achieve a challenging, but realistic, goal (Csikszentmihalyi, 1982). A challenge is perceived as an activity that has clear goals and requires an investment of effort in order for the goal to be achieved. Skills are those efforts that an individual needs to apply towards the achievement of the goal. Implicit in this model is the characteristic of feedback, which allows an individual to track his or her efforts in achieving the goal.

Csikszentmihalyi (1993) states that flow-like activities have four main characteristics:

> (1) they have concrete goals and manageable rules, (2) they make it possible to adjust opportunities for action to our capabilities, (3) they provide clear information about how well we are doing, and (4) they screen out distractions and make concentration possible (p. xiv).

Flow experiences are informative in nature, that is, they are clearly bounded by rules and goals, yet are flexible enough to allow an individual to exert effort and see the results of those efforts.

The emotional effects of attempting to achieve any goal can be classified according to the ratio of challenge to skill an individual applies to the task. These ratios are termed "channels" and are grouped into classes and defined by Csikszentmihalyi as: flow, in which the level of challenge is equal or slightly above the level of skill required to achieve the task; anxiety, in which the level of challenge is greater than the amount of skill necessary for the task; apathy, in which both the level of challenge and the level of skill is low; and boredom, in which the level of challenge is lower than the amount of skill an individual can bring to the task (Csikszentmihalyi & Csikszentmihalyi, 1988).

Flow is perceived as a positive experience because the mastery of an achievable challenge stretches an individual's capabilities by promoting the development of new skills and increasing self-esteem and personal complexity (Csikszentmihalyi & LeFevre, 1989). In addition, remaining in the state of flow requires further increases in the complexity of the challenge, thereby promoting growth.

While in a state of flow, people often report feeling more active, alert, concentrated, happy, satisfied, and creative (Csikszentmihalyi & LeFevre, 1989). Flow produces a sense of focused concentration described as the "merging of activity and awareness" which Csikszentmihalyi claims "produces harmony within the self" (Csikszentmihalyi & Csikszentmihalyi, 1988).

The traditional approach to studying flow is through the use of the Experience Sampling Methodology. The ESM randomly samples the day-to-day activities of subjects over a period of time, usually one week. These experiences are captured in a series of open-ended questions relating to what the person was doing and Likert-scale items which relate to the individual's motivational state which can then be classified and quantitatively analyzed. This methodology has been used with a wide variety of populations, ranging from adolescents to the elderly, and in a number of cross-cultural settings (Sato,1988; Allison & Duncan, 1988; Han, 1988; Carli, Della Fave, & Massimini, 1988). These studies confirm flow theory's major hypothesis: that which makes an experience enjoyable and motivating is the balance between the challenge of the activity and the skills of the individual.

Although flow activities can take many forms, and to a certain degree depend upon individual interests and tastes, the theory shows that manipulating the structural variables of challenge, skill, and feedback can increase the likelihood that an individual will find an activity to be motivating. Within the field of computer software, video games are a classic example of how structural factors in the design of the program can affect the intensity of use. Malone's research (1981a, 1981b) indicates that the two factors that most clearly distinguish popular video games are the ability of the game to provide a clear goal and to provide feedback in the form of a score. From the perspective of flow theory, the goals of these games are interpreted as an achievable challenge while the scoring mechanism provides immediate information to the user as to their skill level.

Materials for the Study

The instructional materials for this study consists of three computer-assisted instructional programs on the topic of the relationship of aperture and shutter speed to exposure, depth-of-field, and image blur. These materials were designed according to a set of prescriptions based upon the challenge, skills, and feedback structure of flow theory, with additional specific recommendations derived from the work of Keller (1983, 1987) and Vallerand, Deci & Ryan (1987) (as cited in Rezabek, 1994).

Treatment #1 utilized a linear design in which subjects were exposed to a fixed sequence of topics. This treatment contained embedded questions with feedback, illustrations and animation in support of the instructional material. It was hypothesized that this treatment would be the least motivating of the three due to its inability to vary the challenge level. Treatment #2 contained the same content material but was organized into a "hypermedia" style structure which gave the subjects a choice over the sequencing of the instruction. It was hypothesized that this treatment would be somewhat more motivating due to the increased use of learner control over the material. Treatment #3 utilized a series of camera simulators with embedded instructional sequences for both presentation of the material and opportunities for practice. This treatment provided feedback in the form of photographs whose characteristics varied according to the settings of the simulators. In addition, Treatment #3 utilized a "Jeopardy™" style game at the end of instruction in lieu of embedded questions. This treatment was designed to be the most motivating of the three, incorporating a varying challenge level, a high degree of learner control, and instantaneous feedback which was natural to the task.

A conventional multiple choice test was developed to act as both a pre-test and a post-test. A prior interest survey form was developed for the purpose of gathering sufficient data to control for the impact of prior-interest on intrinsic motivation. A number of Likert-scale type questions were utilized that emphasized interest, rather than competence, in the subject matter.

Measures of intrinsic motivation were gathered through the use of the Experience Sampling Form (ESF) and the Intrinsic Motivation Inventory (IMI). The Experience Sampling Form modified for use in this study was closely modeled after the example provided in Csikszentmihalyi & Larson (1987). The specific data pertaining to the clusters of dependent variables in this study (affect, activation, cognitive efficiency, and motivation) were provided by utilizing a number of Likert scales measuring these dimensions of the respondents experience.

A second measure of intrinsic motivation was provided through the use of the Intrinsic Motivation Inventory, a series of 18 Likert scale items designed to elicit subjects' responses along four underlying dimensions of interest-enjoyment, perceived competence, effort, and pressure-tension. The IMI used in this study was closely modeled after the example provided in McAuley, Duncan & Tammen (1989). This second scale was used to provide additional data to support the reliability and validity of the measures of intrinsic motivation used in this study.

Experimental Design

The research design employed as the primary dependent variables the Likert scale questions of ESM and the IMI which were clustered into their appropriate subdimensions. The independent variables consisted of the three computerized instructional treatments, 1, 2, and 3, which were designed to create predicted effects of low, intermediate, or high intrinsic motivation. In addition, the design employed a correlational analysis of the relationship between intrinsic motivation and learning, and explored the effects of prior-learning and prior-interest on levels of intrinsic motivation. Post test scores were used to measure the dependent variable of learning, and pre-test scores along with the prior interest survey was used as measures of prior learning and prior interest.

Procedures

Approximately 120 subjects were randomly assigned to the three treatment groups. Subjects in each treatment group interacted with a computer-based instructional program designed to teach the topic of the relationship of aperture and shutter speed to exposure, depth-of-field, and image blur in the making of a photograph. Each treatment taught the same objectives but varied as to the instructional design utilized, as described previously.

A few days prior to the experiment, the subjects took a pre-test and completed the prior-interest survey form. The pre-test and any necessary follow on interviews were used to screen out any subjects that had a high level of subject knowledge to ensure a normal distribution of prior-knowledge. Prior-interest scores were utilized later as part of the data analysis phase.

Immediately following the delivery of the instruction in the treatments, subjects were asked to fill out the Experience Sampling Form, designed to capture a quantitative measure of their level of intrinsic motivation experienced during the treatment. In addition, they were also asked to fill out the Intrinsic Motivational Inventory to provide additional data for cross checking the validity of the intrinsic motivation measures. Following this, the subjects completed the post-test.

This collection procedure yielded the following types of data: pre-test, post-test, prior-interest, and two separate measures of intrinsic motivation for each subject in each of the treatments.

Results

The first hypothesis studied the effects of differing instructional treatments on subjects' levels of intrinsic motivation. It was expected that treatment #3, which utilized the greatest number of prescriptions, would have the strongest effect on intrinsic motivation.

Data for the three treatments were analyzed by using Dunn's planned comparison procedure in order to find differences between the groups on measures of intrinsic motivation. Only one comparison, between treatments 2 and 3 on the Perceived Competence subdimension of the IMI, was found to be significant (see table 1). The comparison of this subdimension, which measures respondents' sense of competence, skill and confidence toward the activity, showed that the mean scores for the treatment #2 group were greater than the mean scores for treatment #3, counter to the predicted direction. Since the distinguishing characteristics of treatment #2, the non-linear hypermedia structure, was also present in treatment #3, it is possible that the significance of this comparison is a statistical fluke, and would disappear in subsequent replications of the study. For the ESF data, no comparisons were found to be significant. The hypothesized superiority of treatment #3 over the other treatments on the other measures of intrinsic motivation was not supported by the data.

The second part of the study looked at an aggregate of the data to explore the validity of flow theory within an instructional context, and to establish a link between intrinsic motivation and achievement. A multivariate analysis of variance (MANOVA) was used to determine if subjects who fit the "flow" condition (both challenge and skill reported in the upper end of the scale) differed from subjects who reported a "no flow" condition.

TABLE 1:
IMI Planned Comparisons - Differences Among Means

Interest-Enjoyment Subdimension:

Treatment	2	1	3
2 ($\bar{x}$ = 5.49)	–	.115	.229
1 ($\bar{x}$ = 5.38)		–	.115
3 ($\bar{x}$ = 5.26)			–

Perceived Competence Subdimension:

Treatment	1	2	3
1 ($\bar{x}$ = 5.50)	–	-.383	.736
2 ($\bar{x}$ = 5.88)		–	1.119*
3 ($\bar{x}$ = 4.77)			–

Effort-Importance Subdimension:

Treatment	2	1	3
2 ($\bar{x}$ = 5.38)	–	-.457	.191
1 ($\bar{x}$ = 5.84)		–	.648
3 ($\bar{x}$ = 5.19)			–

Tension-Pressure Subdimension:

Treatment	1	2	3
1 ($\bar{x}$ = 6.11)	–	-.303	.787
2 ($\bar{x}$ = 6.41)		–	1.091
3 ($\bar{x}$ = 5.32)			–

* Significant at the 0.05 level

For the Experience Sampling Form, this distinction was found in two of the four subdimensions: Cognitive Efficiency and Motivation (see table 2). For the Intrinsic Motivation Inventory, the distinction between the "flow" and "no flow" conditions was found in the two subdimensions of Interest-Enjoyment and Perceived Competence (see table 3). These results were in the hypothesized direction, that is, the means of the "flow" group were greater than the means of the "no flow" group. In general, there is evidence to support the perceived relationship between flow and measures of intrinsic motivation, as predicted by the theory.

TABLE 2:
MANOVA : ESF subdimensions by Flow - No Flow condition

	Source	df	Type III SS	MS	F
Affective					
	FLOW/NO FLOW	1	0.0002	0.0002	0.00
	Error	99	47.446	0.479	
Activation					
	FLOW/NO FLOW	1	1.101	1.101	2.37
	Error	99	45.946	0.464	
Cognitive Efficiency					
	FLOW/NO FLOW	1	1.722	1.722	8.19 *
	Error	99	20.818	0.210	
Motivation					
	FLOW/NO FLOW	1	3.649	3.649	16.59 *
	Error	99	21.779	0.219	

* p< .05

TABLE 3:
MANOVA: IMI subdimensions by Flow - No Flow condition

	Source	df	Type III SS	MS	F
Interest-Enjoyment					
	FLOW/NO FLOW	1	5.240	5.240	4.78 *
	Error	104	39.699	0.992	
Perceived Competence					
	FLOW/NO FLOW	1	13.314	13.314	10.35 *
	Error	104	133.783	1.286	
Effort-Importance					
	FLOW/NO FLOW	1	2.502	2.502	2.38
	Error	104	109.519	1.053	
Tension-Pressure					
	FLOW/NO FLOW	1	3.013	3.013	2.00
	Error	104	202.211	1.944	

* p< .05

The results of this analysis generated evidence to support the basic assumption of flow theory, that is, the ratio of a subject s challenge level to their skill level can be used as an indicator of intrinsic motivation. It should be noted that the use of the ESF in this study differs in certain regards from the original instrument designers' intention. The ESF was originally used in time series studies where each subject reported their responses to a wide variety of experiences over a fixed period of time. This use of the instrument was in a controlled setting where a subject reported a single response to the experimental stimuli. This study showed that the ESF instrument can be useful in an instructional setting and is capable of distinguishing between the "flow" and "non-flow" states among subjects.

The hypothesis of a positive relationship between measures of intrinsic motivation and achievement was generally confirmed. The ESF had a small to moderate overall correlation on the various measures with significant correlations in the Cognitive Efficiency and Motivation subdimensions. The IMI data also showed moderate overall correlations on all of the four measures, with significant correlations in the Interest-Enjoyment, Perceived Competence and Effort-Importance subdimensions. This link between intrinsic motivation and achievement has often been assumed in the literature, but until now little empirical evidence has been presented (see tables 4 and 5).

TABLE 4:
Correlation between ESF subdimensions and Post Test:

Subdiminsion	N	Pearson *r*	Pr rho ≥ 0**
Overall:			
Affective	100	0.072	0.47
Activation	97	0.175	0.08
Cognitive Efficiency	91	0.438	0.0001 *
Motivation	98	0.374	0.0001 *

* Significant at the 0.05 level
** one-tailed test

TABLE 5:
Correlation between IMI subdimensions and Post Test:

Subdiminsion	N	Pearson *r*	Pr rho ≥ 0**
Overall:			
Interest-Enjoyment	91	0.381	0.002 *
Perceived Competence	106	0.4470	0.0001 *
Effort-Importance	106	0.259	0.007 *
Tension-Pressure	105	0.112	0.25

* Significant at the 0.05 level
** one-tailed test

The third part of this study was exploratory in nature and was concerned with discovering the influence of prior interest and prior knowledge on intrinsic motivation. A common sense assumption underlying this part of the study is that prior interest is a direct measure of an individual's motivation toward a subject. In addition, since photography is rarely taught as a required topic, it was assumed that any prior knowledge of this subject was voluntary on the part of the individual, and hence an indirect measure of intrinsic motivation.

In order to explore the relationship between prior interest, prior learning, and intrinsic motivation, analysis of variance and multiple regression analysis were used.

An ANOVA procedure was designed to see if subjects who reported a high level of prior interest and/or a high level of prior knowledge would report higher levels of intrinsic motivation. Results showed that high prior interest subjects did report higher scores for the Affective and Cognitive Efficiency subdimensions of the ESF (see table 6), and high prior knowledge also resulted in higher scores for the Perceived Competence subdimension of the IMI.

TABLE 6:
ESF: ANOVAs for Exploratory Data Analysis
(Treatment, Prior Interest and Prior Knowledge)

Source	df	Type I SS	MS	F
Affective Subdimension				
Treatment	2	0.095	0.047	0.12
Prior Interest	1	2.161	2.161	5.24 *
Treatment X Prior Interest	2	0.000	0.000	0.00
Prior Knowledge	1	0.052	0.052	0.13
Treatment X Prior Knowledge	2	0.514	0.257	0.62
Treatment X Prior Interest X Prior Knowledge	3	3.411	1.137	2.76 *
Within (error)	88	36.294	0.412	
TOTAL	99	42.530		
Activation Subdimension				
Treatment	2	0.761	0.381	0.89
Prior Interest	1	0.608	0.608	1.41
Treatment X Prior Interest	2	0.991	0.496	1.15
Prior Knowledge	1	0.119	0.119	0.28
Treatment X Prior Knowledge	2	0.070	0.035	0.08
Treatment X Prior Interest X Prior Knowledge	3	1.314	0.438	1.02
Within (error)	85	36.560	0.430	
TOTAL	96	40.424		
Cognitive Efficiency Subdimension				
Treatment	2	2.173	1.087	5.23 *
Prior Interest	1	1.361	1.361	6.55 *
Treatment X Prior Interest	2	0.141	0.017	0.10
Prior Knowledge	1	0.119	0.071	0.34
Treatment X Prior Knowledge	2	0.070	0.035	0.08
Treatment X Prior Interest X Prior Knowledge	3	0.625	0.208	1.00
Within (error)	75	15.587	0.207	
TOTAL	86	20.432		
Motivation Subdimension				
Treatment	2	0.296	0.148	0.72
Prior Interest	1	0.770	0.770	3.77
Treatment X Prior Interest	2	0.658	0.329	1.61
Prior Knowledge	1	0.012	0.012	0.06
Treatment X Prior Knowledge	2	0.028	0.014	0.54
Treatment X Prior Interest X Prior Knowledge	3	0.328	0.109	0.54
Within (error)	86	17.581	0.204	
TOTAL	97	19.673		

* $p < .05$

In addition, the generative verses supplantive approach to learning strategies (Smith & Ragan, 1993) prescribes that individuals with high prior interest and high prior knowledge would benefit from a more generative strategy, whereas low interest/low prior knowledge individuals would require a more supplantive strategy. Generative strategies are more motivating, whereas supplantive strategies tend to be less challenging and less motivating. In this study, treatment #3 was designed to be more generative while treatment #1 took a more structured, supplantive approach. This ANOVA was able to test the predictions of the generative-supplantive hypothesis by adding a third dimension and testing for a treatment x prior interest x prior knowledge interaction. This interaction was found in the Affective subdimension of the ESF. A post hoc analysis revealed that the direction of the prediction was generally confirmed, with the high prior interest/high prior knowledge group in treatment #3 reporting the highest affective scores. However, the low prior interest/low prior knowledge group also reported its highest mean scores for treatment #3, with treatment #1 having the second highest score.

The results of this interaction produced evidence supporting the generative-supplantive hypothesis while also linking it to a theoretically grounded methodology for studying intrinsic motivation. It is notable that this interaction was found in results which earlier could not find the generalized superiority of one strategy over another.

In the stepwise multiple regression analysis, prior interest acted as a significant predictor in all four subdimensions of the ESF, with prior knowledge acting as a significant predictor in the Activation and Cognitive Efficiency subdimensions. However, the total variance accounted for by a combination of these two factors was never greater than .10 (see table 7). Analysis for the IMI resulted in prior knowledge as a significant predictor in the Perceived Competence and Tension-Pressure subdimensions; however only a maximum of .06 of the variance could be accounted for by this factor (see table 8). Overall, the amount of variance accounted for by the predictor variables was very small.

TABLE 7:
ESF: Multiple Regression for Exploratory Data Analysis
(Prior Interest and Prior Knowledge)

Source	Beta	Stepwise Multiple Correlation (R)	Stepwise R^2	R^2 Increment
<u>Affective</u>				
Prior Interest	0.27	0.27	0.07	
<u>Activation</u>				
Prior Interest	0.21	0.17	0.03	
Prior Knowledge	0.21	0.27	0.07	0.04
<u>Cognitive Efficiency</u>				
Prior Interest	0.27	0.23	0.05	
Prior Knowledge	0.21	0.31	0.10	0.05
<u>Motivation</u>				
Prior Interest	0.24	0.06	0.06	

<u>Note.</u> Table includes only those variables that met the .15 level of significance

TABLE 8:
IMI: Multiple Regression for Exploratory Data Analysis
(Prior Interest and Prior Knowledge)

Source	Beta	Stepwise Multiple Correlation (R)	Stepwise R^2	R^2 Increment
Perceived Competence				
Prior Knowledge	0.25	0.25	0.06	
Tension-Pressure				
Prior Knowledge	0.19	0.19	0.04	

Note. Table includes only those variables that met the .15 level of significance

The lack of variance accounted for by prior interest and prior knowledge was surprising since it was anticipated that these two factors would have a strong predictive effect on intrinsic motivation. These results may be due to measurement error, the prior interest inventory and the pre-test were both researcher designed instruments and have not been extensively validated. However, it is doubtful that poor instrumentation could completely account for the extremely low variance found in the multiple regression. It is likely that other, unknown variables account for much of the variance in the intrinsic motivation scores.

Discussion of Findings

The results of this study suggest that attempting to increase intrinsic motivation through the design of instructional materials is more difficult than the literature would indicate. Investigating the data for the ESF leads to some general conclusions about the difficulties of integrating intrinsic motivational prescriptions into the practice of instructional design.

It was surprising that the Activation subdimension scores, containing questions on alertness, involvement, excitement, etc. did not distinguish between the treatments. It was expected that treatment #3 would have a stronger impact on subjects in this dimension because of its simulation and gaming strategies. However, mean scores for all three treatments on these questions were at or below the midpoint of the scale, indicating that these treatments did not generate a very active sense of engagement in the task. It is possible that the design of treatment #3 may not be challenging enough for this particular group of subjects. Defining the optimal challenge requires a careful analysis of the audience, and probably varies widely from one individual to another, thereby greatly compounding the problem for the designer.

However, the Affect subdimension scores were above the midpoint of the scale, indicating a positive sense of happiness, sociability, and relaxation among the subjects. These questions probably reflect a general orientation more strongly influenced by the subject's self perception or world view than a reaction to a specific activity.

Cognitive Efficiency was another subdimension where theory would have predicted a strong effect for treatment #3. This subdimension contained questions on concentration, expectation and satisfaction. It was expected that the simulation elements of treatment #3, which provided a greater amount of problem solving, would have contributed to greater levels of concentration by the subjects. In addition, the gaming element could have contributed to a greater sense of satisfaction. However, results show that subjects in treatment #3 had the lowest means for any of the comparison groups on this subdimension, although this distinction is not significant. Again, it could be concluded that the gaming and simulation elements of treatment #3 were not challenging or extensive enough to make a difference among the subjects.

The motivation subdimension had mixed results. For questions relating to the subject's sense of control, success and satisfaction in all three treatments, respondents scored above the midpoint of the scale. But for the questions relating to the importance of the activity to themselves or to their overall goals, respondents scored at or below the midpoint. It is possible that, although the subjects found the activity to be satisfying, they did not find it to be very relevant to the larger context of their overall goals.

The only significant comparison was between treatments 2 and 3 on the Perceived Competence Subdimension of the IMI. The comparison of this subdimension, which measures respondents' sense of competence, skill and confidence toward the activity, showed that the mean scores for the treatment #2 group were greater than the mean scores for treatment #3, counter to the predicted direction. Since the distinguishing characteristics of treatment #2, the non-linear hypermedia structure, was also present in treatment #3, it is possible that the significance of this comparison is a statistical fluke, and would disappear in subsequent replications of the study.

This study points out the complex, interactive nature of intrinsic motivation. If it is assumed that variables affecting any type of psychological phenomena can be classified into environmental, social, and intrapersonal factors, then it can be seen that this study controlled for only environmental factors, that is, the design of the treatments. Therefore it can be hypothesized that social factors, such as group interaction, and/or intrapersonal factors, such as cognitive styles, probably have a stronger impact on intrinsic motivation than environmental factors alone. As found in the investigation of the interaction between treatments and the factors of prior interest and prior knowledge, it is likely that these social factors will be seen to operate in interaction with critical environmental factors such as instructional strategies.

Conclusion

This study develops evidence that the design of instruction can have an effect on intrinsic motivation, and that intrinsic motivation has an effect on achievement, and that methodologies derived from flow theory are of practical use in an instructional setting. However, the relationships are not clear, and there appear to be many other variables affecting learners' intrinsic motivation. Further research should be conducted to both refine the motivational appeal of instructional materials and to identify those social and interpersonal factors that impact motivation.

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