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Accommodating Diverse Learning Styles in the Design and Delivery of On-line Learning Experiences*

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The primary purpose of this study was to incorporate principles of learning styles theory into the design and delivery of Internet-based education. Learning styles theory has long been used by educators to enhance the learning experience by individualizing it to accommodate the various ways that students perceive and process information. Although learning style principles have been widely applied to more traditional teaching-learning formats, educators have just begun exploring the potential application to asynchronous formats. This paper first describes Kolb's (1984) theory of learning styles, and then describes how principles from the theory can be adapted for use with computer-delivered instruction. Finally, we report the results of a study designed to measure the effect of customized instruction on students' perceptions of the learning process, and discuss the implications for the increasing numbers of faculty and students involved in on-line teaching and learning.

INTRODUCTION

WHILE VARIOUS forms of computer-aided and delivered instruction have been around for many years, the newest and most promising medium is the Internet [1]. The Internet is used as a platform to deliver information in the form of text, graphics, audio, video, and videoconferencing. The ability to integrate these forms of technology into one medium has prompted widespread use of the Internet by faculty engaged in on-site, as well as distance, education. The Internet is used for a wide range of educational activities, from the posting of course information and syllabi which supplement traditional site-based courses to the development and on-line delivery of entire distance education curricula. While proponents of Internet education have cited many potential benefits to instructors and students alike, many questions remain unanswered [2, 3]:

1. Do students learn differently with on-line instruction than with traditional methods?
2. Can instructors rely on the same teaching strategies, and will they be equally effective?
3. Do different students respond differently to on-line instruction, and how can individual differences in learners be accommodated?

Learning styles theory may help us begin to answer these important questions.

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LEARNING STYLES THEORY

Learning style has been described as *how* the student learns, as opposed to *what* he or she learns [4]. The dominant theory of learning styles, developed by David Kolb in 1984, conceptualizes learning as a four-part process, beginning with concrete experience, followed by reflective observation, abstract conceptualization, and active experimentation (see Fig. 1).

Learning begins with concrete experience, or the immersing of one's self in a new experience. Characteristics of this stage include a focus on the here-and-now and an active, hands-on orientation. Learners then have reflective observations, or the pondering of the experience and observing it from multiple perspectives. Immediate conclusions are not sought at this stage, rather the learner gathers and analyzes as much data as possible. This is followed by abstract conceptualizing, whereby information collected during earlier stages is integrated into logical theories and principles. Learners attempt to make sense of their experiences by fitting information into rational schemes. Finally, learners engage in active experimentation, which is the application of these theories and schemes to more complex situations.

Kolb observed that learners tend not to engage in each step of the process, but instead have a preference for certain parts of the cycle. Individual differences in the process occur on two continua, one representing how the individual prefers to apprehend information (the vertical axis in Fig. 1) and one representing a preference for processing information (the horizontal axis in Fig. 1). These

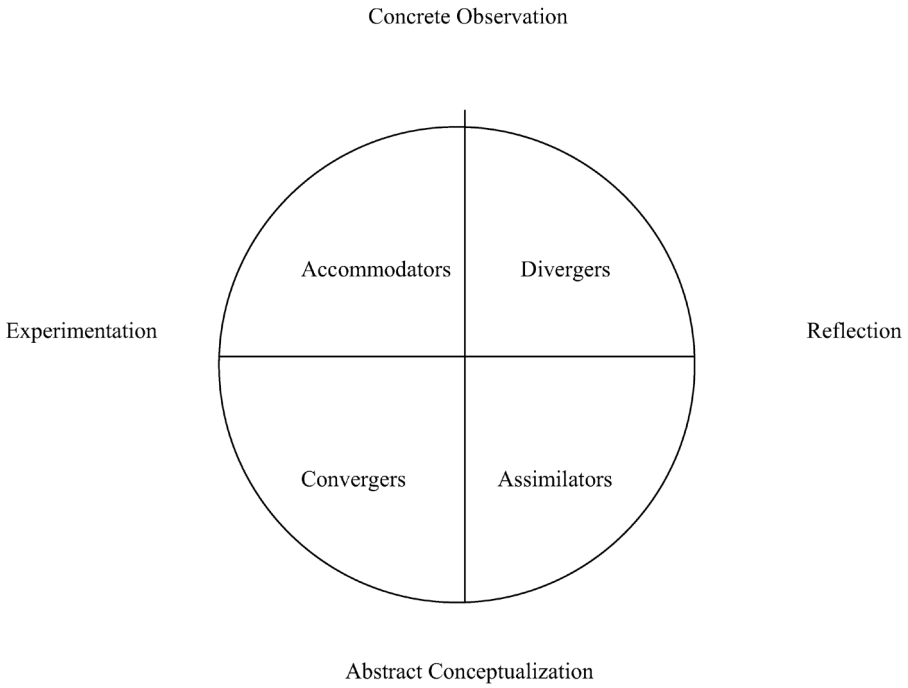

Fig. 1. Kolb's experimental learning circle.

preferences develop naturally over time, and are solidified through continuous learning experiences. In 1985 Kolb developed the Learning Styles Inventory (LSI) to assess these preferences, which it labels accommodators, divergers, convergers, and assimilators.

Convergers prefer abstract conceptualization and active experimentation and enjoy finding singular uses for ideas and implementation. Divergers prefer concrete experience and reflective observation and enjoy generating multiple solutions without implementation. Assimilators, who prefer abstract conceptualization and reflective observation, enjoy grasping a wide array of information and placing it into a logical and concise form. Finally, accommodators prefer concrete experience and active experimentation and enjoy applying new information to novel experiences.

This theory has been used successfully by engineering educators [5]. For example, the College of Engineering at Brigham Young University has found that using LSI scores as a basis for assigning students to learning teams can enhance performance in engineering courses [6]. One study [7] reported improved performance of female engineering students, and another [8] reported improved retention rates and satisfaction of engineering students when instructional strategies were adjusted to accommodate different learning styles. In spite of such evidence, most faculty do not adjust their instructional strategies to accommodate the learning styles of their students [7]. For instance, it has been estimated that while 67% of today's students prefer active learning, the lecture remains the primary teaching strategy used in higher education today [9]. Interestingly, technology is often used to recreate the traditional teaching-learning process [10]:

- videotapes are usually recordings of classroom lectures;
- satellite instruction is usually a broadcast of a live lecture;
- on-line instruction is often no different than having students read from a textbook.

Yet, through its unique ability to interact directly with the individual learner technology can also be used as a means to create a new teaching-learning paradigm. Thus, our primary goal in this study was to use technology to create 'individualized' instruction based on learning styles theory and deliver it on-line.

APPLYING LEARNING STYLES THEORY TO ON-LINE INSTRUCTION

The educational literature tells us much about the instructional preferences of students with different learning styles. Research has shown that divergers like to engage directly in a learning experience and then reflect on the experience from a variety of perspectives. Divergers have been shown to enjoy and benefit from several specific instructional strategies:

- laboratories and observations [11];
- simulations [12];
- brainstorming [11, 13];
- rhetorical questions and log entries [11].

One study [12] reported that divergers find value in vicarious experiences. It follows these findings that an Internet-based interactive exercise might

be constructed to match divergers' preference for active apprehension and an on-line brainstorming session could be developed to help them process the material.

Other research suggests that convergers, the opposite style to divergers (refer again to Fig. 1) prefer different strategies for apprehending and processing information. Convergers prefer structured, yet abstract presentations of information via lectures and reading. They enjoy active processing by applying what they have learned to new situations, such as case studies and homework problems [4]. Convergers are generally not risk takers and prefer to learn in an environment that allows them to fail safely, learn by trial-and-error [4], and generate singular solutions to problems [13]. These findings suggest that on-line information could be presented to convergers via a well-defined, systematic, and theoretical tutorial. The web site might also aid convergers in the processing of information by requiring them to complete a case study with singular answers and immediate feedback.

Accommodators prefer apprehending information by engaging themselves in an experience, and processing the information actively by applying their discoveries to new situations. Accommodators often ask the question 'what if?' and prefer independent discovery. Accommodators grasp information through the use of simulations, observations, examples, and laboratories [11]. Information processing can be enhanced by allowing accommodators to actively integrate information through case study problems, homework, or simulations. Thus it seems that an on-line lesson consisting of an interactive exercise for apprehension and a case study allowing them to process the material through application might be well suited for accommodators.

Assimilators prefer the delivery of accurate and organized information, and value it more when delivered by a highly credible source, or subject-matter expert. Assimilators process information by solving problems, conducting experiments, or following demonstrations that do not deviate too much from what was initially presented [11]. Thus, a logical step-by-step Internet tutorial, based on research by subject matter experts, might be used to assist assimilators in the grasping of information. Information processing might be enhanced for assimilators through an Internet demonstration allowing reflection on the original information, rather than its application.

THE CURRENT STUDY

The first purpose of the study was to build a website that would incorporate the learning style principles described above. This of course would require the development of four different lessons—one designed specifically to match the different preferences of each of the four learning styles.

The second purpose was to test the web site to discover if the use of customized instruction would affect students' learning, and their perceptions of the learning experience. Specifically, it was predicted that students receiving customized lessons would rate the learning experience as more enjoyable than would those students receiving lessons not individualized to their own learning style. Similarly, the students receiving customized lessons would report that more learning had occurred than would students receiving lessons not individualized to their own learning style.

Finally, it was predicted that students receiving customized lessons would score higher on a learning post-test than would students receiving lessons not individualized to their own learning style.

METHOD

Participants and materials

Sixty-one students enrolled in psychology and education courses participated in this laboratory study in exchange for course credit. The Kolb Learning Styles Inventory (LSI) was used to determine students' learning styles. The LSI (1985) is a 12-item inventory asking respondents to rank order their preferences for different learning strategies. Scoring results indicated that 31% of participants were divergers; 21% were assimilators; 23% were convergers; and 25% were accommodators.

A 40-page HTML website was developed to deliver four lessons on *The Process of Evolution*. Each lesson was intended to match one of Kolb's four styles, and was developed according to the principles described above. Specifically, the lesson designed to match the preferences of accommodators consisted of an interactive exercise containing text, graphic and various opportunities to interact with the computer. While apprehending the lesson, students were afforded the opportunity for independent discovery through the use of various image and arrow options. Accommodators, who process information actively, were then presented with a case study about a hypothetical evolutionary situation, and then asked to solve several evolutionary dilemmas using the information acquired in the interactive exercise. A large text box was included for active and immediate response.

The lesson designed to match the preferences of assimilators began with a theoretical tutorial on evolution. Because assimilators do not enjoy active participation, pages were kept to an interactive minimum; the only required interaction was the pressing of a page-forward button. Names of scientists and researchers were used to appeal to the assimilators' appreciation of expert opinion. Because assimilators prefer to process information through reflective observation, the exercise was followed by a visual review of the concepts presented in the exercise. No written responses or

any generation of ideas was required because answers to the problems were integrated into the review.

The lesson developed for convergers included the same theoretical tutorial described above for assimilators. (Remember, both convergers and assimilators prefer to apprehend information through abstract conceptualization.) Unlike assimilators, however, convergers prefer to process material actively. Thus, the same hypothetical case study used with accommodators was presented to convergers. However, because convergers prefer processing that is low-risk and involves singular solutions, the questions they received were multiple choice (as opposed to the open-ended ones presented to accommodators). To match convergers' preference for trial-and-error learning, students could view the correct answers only after entering their own answers.

Divergers, like accommodators, prefer to apprehend information through concrete experience, and so received the same interactive lesson as that described above for accommodators. However, divergers process information quite differently. They prefer reflective observation and especially enjoy brainstorming solutions to thought-provoking questions. Divergers also enjoy thinking about how material applies to themselves. Thus, divergers were first asked to reflect on the information presented in the exercise, and were then presented with a series of thought-provoking questions and asked to generate open-ended solutions that were personally relevant. Finally, they were prompted to record responses in an on-line text box.

It is important to note that while the presentation format was customized to match the preferences of each learning style (as described above), the content apprehended and processed was the same for all students.

Procedure

Students completed and self-scored the LSI. The researcher interpreted the score and assigned the student a code representing his or her learning style. Students then went on-line and were instructed to double-click on their assigned code. This determined which lesson they were presented. Approximately half of the students received the lesson which matched their learning style (called the matched group) and the others received a lesson designed for the learning style most unlike their own (the unmatched group). After completing the lesson (approximately 25 minutes), students received an 11-item multiple choice post-test of the material presented in the on-line lesson. Finally, students completed a questionnaire developed by the researchers to measure student perceptions of their learning experience. Five-point Likert scale items measured student satisfaction with the Internet lesson, perceptions of how much the lesson helped them learn, and enjoyment of specific design features. Level of prior experience in using the Internet, and prior knowledge of evolution were also rated. Additional items were included as 'manipulation checks' to determine the extent to which design features were perceived as intended by users.

RESULTS AND DISCUSSION

Adapting learning styles theory for on-line instruction

Although most earlier work with learning styles has been done in traditional classroom settings, we were able to translate the findings from previous research and practice into Internet design. However, we found this translation process required some 'creative guess-work'. For instance, the literature has shown that convergers enjoy keeping journals, an instructional strategy that is straight- forward and obvious in the traditional educational setting. But, it is less obvious how to translate this preference into an online instructional strategy. Our use of text boxes to approximate the traditional journal experience is an example of the process we employed in adapting previous research and practice for use with the Internet.

While more research is needed to determine the best ways to apply what is known about learning styles in traditional educational formats to on-line instruction, our results suggest that it is possible to customize the learning experience to individual learning styles by the manipulation of delivery and design options. Student ratings of the manipulation check items on the questionnaire indicate that students perceived these design and delivery options as intended. Students receiving the lesson designed to be highly interactive rated it significantly ($p < 0.05$) more interactive ($M = 3.64$) than those students receiving the lesson designed to minimize interaction ($M = 2.93$). Similarly, students receiving the lessons designed to require active processing rated it significantly ($p < 0.05$) more active ($M = 3.72$) than did students receiving the lessons designed to require reflective processing ($M = 2.10$).

Additional support for our success in translating learning style theory and research to on-line instruction was obtained by asking students to rate specific features of the lesson in terms of their effects on enjoyment and perceived learning. Although the small number of students in each group prevented statistical comparisons, a comparison of means revealed some differences in students receiving matched and unmatched lessons. Specifically, accommodators and convergers (matched group) enjoyed the online case study significantly more than did the assimilators and divergers (unmatched group). Also as expected, accommodators (matched group) enjoyed answering questions in online text boxes more than did the assimilators (unmatched group), while convergers (matched group) enjoyed following links

to problem solutions significantly more than did divergers (unmatched group), who preferred to generate their own solutions in text boxes. Accommodators and divergers (matched group) rated the interactive exercise significantly higher on both enjoyment and perceived learning than did assimilators and convergers (unmatched group). Similarly, accommodators and divergers (matched group) enjoying clicking on pictures to move around the lesson significantly more than did convergers and assimilators. And, as expected, divergers (matched group) rated the brainstorming exercise higher on both enjoyment and perceived learning than did the other learning styles (unmatched group).

Student ratings of the tutorial suggested that we were less successful in creating an on-line lesson that appeals to the information apprehension preferences of assimilators and convergers. These learners indicated less enjoyment and perceived learning with the tutorial than did the mismatched students (accommodators and divergers) receiving the tutorial. However, matched students (assimilators and convergers) did rate learning from expert opinion in the tutorial as more enjoyable than did unmatched learners.

Student learning and perceptions of the learning experience

It was hypothesized that students receiving a lesson that matched their learning style would enjoy the learning experience more and perceive that they had learned more than those students receiving an 'unmatched' lesson. We found interesting support for this prediction. The results of the questionnaire showed that students who received lessons that were matched to their learning style reported significantly more enjoyment of the learning experience and also perceived that they had learned significantly more than did those students whose lessons were not customized for their learning style. However, this significance was only obtained when the analysis controlled for level of previous Internet experience, and for level of previous knowledge of evolution.

A MANOVA revealed no significant differences on lesson enjoyment or perceived learning for the entire sample, but significance was obtained when the analysis included only individuals with little knowledge of evolution (below 4 on the rating scale) or only individuals with little experience using the Internet (below 4 on the rating scale). Follow-up ANOVAs, as shown in Table 1, revealed that students receiving matched lessons reported greater lesson enjoyment and perceived learning than those receiving mismatched lessons only if they also reported limited experience using the Internet. For those students rating themselves as experienced Internet users, neither effect was observed. This suggests that as students gain more experience, and thus are more comfortable using the Internet for self-directed learning, they may benefit less from customized lessons. However, for those students new to Internet-based learning, taking learning style into account in lesson design may pay off both in terms of greater enjoyment and perceptions of learning. Having positive early experiences with nontraditional delivery modes is very important, since it can influence both decisions to choose that mode in the future, as well as students' satisfaction with future learning experiences with that mode [14].

The other factor shown to influence the effects of matching lessons to learning style was prior knowledge of the lesson's subject matter. As shown in Table 1, a significant difference ($p < 0.05$) between matched and unmatched groups' levels of perceived learning was found only for students reporting little prior knowledge of evolution. This finding suggests that customized lessons may be most appropriate for subject matter novices, or for introductory courses or material.

Finally, similar analyses of post-test scores found no significant differences in the two groups (matched and not matched) in terms of actual learning, regardless of prior knowledge or Internet experience. (See Table 1.) This finding has two possible interpretations. First, it may suggest that customizing lessons may impact students' confidence in what they have learned more than the amount of actual learning. Or, it may simply reflect our failure to control for the effects of prior knowledge of evolution. Although the lesson topic and content was designed to minimize

Table 1. ANOVA results comparing matched and unmatched students on lesson enjoyment, perceived learning, and knowledge post-test

Dependent variable	N	Matched mean	Unmatched mean	F value
ANOVA for students with limited Internet experience				
Lesson enjoyment	42	3.12	2.71	3.82*
Perceived learning	42	3.58	2.53	5.76*
Knowledge post-test	42	8.3	7.8	1.09
ANOVA for students with limited pre-lesson knowldege of evolution				
Lesson enjoyment	38	3.52	2.60	5.33*
Perceived learning	38	3.63	2.90	5.15*
Knowledge post-test	38	7.9	7.8	0.09

*$p < 0.05$

pre-test differences, and was piloted with college students, our design did not control for this confound.

CONCLUSIONS

This research has implications for the increasing numbers of faculty and students involved in on-line teaching and learning. It suggests that learning styles theory can be adapted for use with Internet-based instruction, and that doing so can positively impact the learning experience. The study also identified particular on-line strategies to use with particular learning styles. In general, divergers and accommodators seem to benefit most from a highly interactive session containing many links, buttons, and icons, while assimilators and convergers prefer less interaction and may be content to simply read the material. When it comes to processing information, it seems that assimilators and divergers both benefit from reflective review, while accommodators and convergers prefer an opportunity to apply the material to a new situation, as provided by a case study.

Educators concerned about the cost of developing customized lessons might consider the option of allowing the students to self-customize by combining on-line lessons for information apprehension with off-line assignments for information processing. Or, different learning preferences might be accommodated over the course of a semester by designing some on-line lessons to match the preferences of divergers, some for convergers, some for assimilators, and some for accommodators. Probably the most important thing to remember is that students differ in how they learn on-line, just as they do off-line. The learning process can be enhanced further by helping students understand their own learning preferences and suggesting ways they might adjust their learning style to better match the instructional styles they are presented.

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