

To Have or Have Not: An Examination of Feedback, Learner Control and Knowledge Type in Online Learning

Lin Chai

University of Southern California

chai@marshall.usc.edu

Abstract

Online course offerings have not only gained in popularity among technology-mediated training methods, but they also have produced a prominent change in the landscape of academia. It is therefore imperative to obtain a solid understanding of the important elements that contribute to effective online learning. The major contribution of this paper is to investigate a complex set of interrelated factors in the relatively new sphere of online learning. The intercombination of these particular factors appears to be important from past research, but it has never been explicitly addressed, and never in an experimental setting. Findings of this study have shown that feedback and learner control have a significant interaction effect for declarative knowledge acquisition. For satisfaction, however, feedback is only salient for declarative knowledge learning, and not for procedural knowledge learning. Other factors, such as interest and comfort level produce effects in most situations.

1. Introduction

Technology-based teaching and learning have dramatically increased in the past decade [11]. Especially, online course offerings have not only gained in popularity among technology-mediated training methods, but they also have produced a prominent change in the landscape of academia. It is predicted that by 2002, although varying in extent and scope, 80% of higher education institutions will offer some form of virtual education (Block and Dobell 1999). In spite of the emerging importance of online virtual learning, insufficient attention has yet been devoted to understanding its dynamics [10].

Expanding on the importance of understanding online learning, Alavi and Leidner [1] call for greater depth of research that takes into consideration internal psychological processes through which learning occurs. According to the authors, "... it is not the technology features, in and of themselves, that matter. It is the mutual influence of technology features, instructional strategy, and psychological

process that impacts learning outcomes in a given learning context" (p. 6).

In this study, feedback represents the primary instructional strategy being considered because "... feedback is one of the most powerful components in the learning process" [23:165]. In anticipation of Alavi and Leidner's call for greater depth of research into online learning, the present study attempts to contribute to our understanding of how an effective learning outcome can be achieved in a virtual learning environment by investigating the mutual influence of feedback, knowledge type and learner control. In particular, the following research questions are proposed and examined in this study.

1. How does the feedback mechanism influence learning outcomes in the online environment?
2. What are the interaction effects of feedback and learner control in two different online learning situations defined by the types of knowledge?

The paper is organized as follows. In the next two sections, we introduce the general theoretical background of learning and conceptual dimensions of the focus of this study. The contemporary learning theories and empirical research are reviewed. We then propose our hypotheses, followed by a description of the research method. Analysis and discussion of the results, the study limitations, implications and future research directions and our conclusion follow.

2. Theoretical Background

This paper investigates online learning based on a dichotomy of two different perspectives. These perspectives come from two fundamentally different types of knowledge: declarative and procedural. This dichotomy of knowledge types is represented by different mental models of learning and is reflected in the history of feedback research, which is set forth briefly in the following.

Most feedback research has been done from an objectivist perspective (behaviorism or information processing). [39]. Behaviorists emphasize feedback as a reinforcer, and the information processing view sees feedback as correcting errors. This objectivist view is particularly relevant for understanding the role of feedback in declarative knowledge learning.

The behaviorist movement in psychology was perhaps the earliest to explicitly examine the role of feedback in learning [15]. Behaviorists were especially interested in the impact of feedback in terms of rewards and punishments. Around the turn of the century, Thorndike [56] formulated a systematic learning theory around reinforcement theory, and his research could be called “radical” behaviorism. In a departure from radical behaviorism, and serving as a transition to cognitivist theories, Ammons [3] suggested that the most common effect of knowledge of performance is to increase motivation, and he thus included a strong affective component in the study of feedback. Setting the stage for future theorists in the constructivist tradition, Ammons also noted that feedback can come both internally and externally.

Over time, the behaviorist model was gradually replaced with a cognitive model that assumes mental processes intervene between feedback and the recipient's response [15]. Following the cognitive model, Ilgen *et al.* [29] consolidated many previous ideas on feedback into a goal-setting theory of feedback. They claimed that feedback is essential for learning and satisfaction. From their perspective, feedback acts both to inform the recipient of expected behaviors and to provide satisfaction through information about rewards from behavior. Ilgen *et al.* claimed that specific goals and specific feedback that is directly applicable to future performance lead to higher levels of performance, both in terms of learning and satisfaction.

A quite different approach to feedback is contained in the research of multiple cue probability theorists and constructivists [39]. Constructivism represents a paradigm shift in theory and incorporates the importance of complexity of knowledge, as is represented in procedural knowledge learning. The multiple-cue probability learning paradigm (MCPL), indicates that feedback can actually impede learning of complex tasks and can dampen satisfaction [8]. For the MCPL, feedback tends to divert the learner's attention away from the task itself. Constructivists focus on discovery learning that is supported by *internal* feedback [20]. Here, “Knowledge is constructed in the mind of the learner” [14]. The constructivist approach emphasizes the learner as controller and developer of knowledge and argues for minimizing external influences, at least in the case of complex tasks [24]. Constructivists claim that external feedback may be inferior to intrinsic feedback when knowledge comes through discovery, as they think it must do for complex tasks.

3. Conceptual dimensions

Technology is especially good for delivering feedback [55], and so an online course is appropriate for studying the effects of feedback on learning.

Concerning research on instructional technology, Merisotis and Phipps [37] wrote, “... although the ostensible purpose of much of the research is to ascertain how technology affects student learning and student satisfaction, many of the results seem to indicate that technology is not nearly as important as other factors, such as learning tasks, learner characteristics, student motivation, and the instructor.” Thus, the focus for this research is not on distinguishing effects of different technologies that can be employed in learning, but rather on the learning situation, and in particular, on the elements of learner control, feedback, and task type in the online learning context.

3.1. Learner Control

Field-independence/dependence is one of the most researched of all cognitive styles. It has also seemed to hold the greatest potential for application to educational problems [42]. Learner control refers to the amount of influence a person desires over the learning environment, and includes control over the content and presentation of an instructional experience. Studies have suggested that some people appear to prefer instructional situations in which they have control over media and materials, while other people prefer not to be in control [57]. Because of its persistent effects, the learner control construct of field independence/dependence has been applied to a variety of educational issues. Many learning areas are thought to be affected by learner control, including feedback [60].

The construct of field-independence/dependence originated with Herman Witkin's research on human perception of positioning [60]. The construct represents the manner in which people acquire and act on knowledge about their surroundings in solving problems. Field independent persons rely on an internal frame of reference, and field dependents rely on an external frame. In general, field-independent learners are those who learn better when they are allowed to develop their own strategies in learning and problem-solving. Field-dependent learners are characterized by wanting guidance provided from outside sources; they prefer to interact with an instructor and tend to learn better with externally-imposed structure.

3.2. Feedback

The concept of feedback originated as a basic communication systems concept in physiology and engineering [36], where it was defined as the provision of knowledge of progress to be used in adjusting subsequent behavior. Thus conceptualized, feedback is a fundamental element for any adaptive system or organism. Adaptive systems must have knowledge of

their performance, whether good or bad, in order to make appropriate adjustments to that performance. People, as adaptive systems, have a critical need for feedback in their learning [54].

Feedback for learning may be defined as information people receive about their learning processes and achievement outcomes [16]. In the present context, feedback is information obtained by students regarding the correctness of their performance in a learning task [31]. This definition is the same as the notion of extrinsic feedback [6, 26]. Extrinsic feedback can be contrasted with intrinsic feedback, which is the information a learner gets from 'within' simply by performing an activity.

Feedback for learning can have both cognitive [51] and affective [61] results. Cognitive effects relate to the amount of material learned, and affective effects relate to satisfaction of the learner. Feedback supports essential cognitive activities, and providing feedback is one of the critical elements of instruction that contribute to students' progress both through cognitive and affective channels [28, 43].

3.3 Knowledge type

As early as 1969, Annett suggested that task type would moderate the effect of feedback on learning performance. However, few feedback researchers have followed up his suggestion with actual empirical work on the matter [32].

A two-way categorization of tasks [4] has been proposed to provide a distinction between declarative knowledge and procedural knowledge. Declarative knowledge refers to knowledge about things or knowledge that something is the case. Declarative knowledge helps one to answer what and why questions. Procedural knowledge is knowledge that links goals to conditions and actions for achieving the goals. Procedural knowledge helps one take actions and make decisions in a particular situation.

More specifically, Schunk [50] defined declarative knowledge as facts, beliefs, opinions, generalizations, theories, hypotheses, and attitudes. Procedural knowledge is defined as understanding how to perform cognitive activities. Anderson [4] defines declarative knowledge as explicit knowledge that we can report and of which we are consciously aware. Gagné (cited in [53]) distinguished procedural knowledge from declarative knowledge by stating that procedural knowledge reflects "knowing how," whereas declarative knowledge involves "knowing that." Papert [40] noted that the two types of knowledge can be distinguished in terms of the dualities of facts vs. skills, propositional knowledge vs. procedural knowledge, and knowing that vs. knowing how.

3.4. Satisfaction

According to Bloom [12, 13], affective learning, or satisfaction, focuses on the development of a positive or negative attitude toward the learning subject. Feedback has been found to influence satisfaction [30] in learning situations. Satisfaction is thus considered to be a major element underlying the affective experience [45]. Empirical results have upheld the connection between feedback and satisfaction. For example, a test of a job-characteristics model showed that feedback has a weak relationship with performance but has a stronger effect on overall job satisfaction [27].

3.5. Knowledge acquisition

Technology can influence learning through the direct support of underlying psychological processes. Technology can facilitate cognitive information processing activities such as search, scanning, transformation, or comparison of information [34]. In particular, computer-aided instruction can facilitate the provision of immediate feedback. In this study, the dependent variable of knowledge acquisition has two levels, corresponding to the learning of declarative knowledge and the learning of procedural knowledge. Declarative knowledge learning focuses on facts, names, and lists; it involves "what" and "which" types of questions. Procedural knowledge learning emphasizes higher level cognitive activities such as employing algorithms and rules, identifying concepts, solving problems, and applying, analyzing and evaluating learned knowledge [47]. Procedural knowledge also includes reasoning, associating, and skills for distinguishing.

A positivist approach to knowledge acquisition is taken for this study; tests are designed to objectively measure the amount of knowledge that a student has acquired, and that knowledge is assumed to exist separately from the learner [52].

4. Hypotheses

According to Kluger and DeNisi [32], "Although there are strong and consistent findings that feedback improves immediate performance under some circumstances, it is also clear that in some situations feedback is irrelevant and sometimes even harmful." The authors conducted a meta-analysis of the feedback-in-learning literature and found that in one-third of the studies, the feedback condition had worse performance than the group who was given no feedback. Other researchers indicated that students often retain and apply what they have learned more effectively with less feedback [49, 48].

While early literature on feedback in learning generally regarded feedback as invariably useful, contemporary approaches bring in learner characteristics and task type as moderator variables.

However, the nature of the relationship between those moderator variables and feedback is still an open question [18]. In particular, the relative effect of declarative and procedural knowledge for online learning has not been adequately examined in past research [53]. In particular, the question is unanswered as to whether feedback has a differential effect on online learning for the two kinds of knowledge.

Azevedo's [7] meta-analysis of research on the effectiveness of feedback in computerized instruction found that feedback is regarded as one of the most critical components of computer-based instruction, because its function is to provide students with information to help them either to reinforce their knowledge or to correct mistakes. However, Azevedo [7: 111] also reports that feedback's effects on learning vary with the type of learning task. The two task types of declarative and procedural knowledge seem to be particularly important in distinguishing the effects of feedback.

In addition to knowledge acquisition, satisfaction is widely used to evaluate learning situations [2]. For declarative knowledge, feedback allows people to feel a sense of mastery learning and thereby increases their satisfaction with it [58]. Ilgen *et al.* [29] proposed a goal-setting theory of feedback. For them, feedback is essential for learning and satisfaction. Feedback acts both to inform the recipient of expected behaviors and to provide satisfaction. Ilgen *et al.* claimed that specific goals along with specific feedback lead to satisfaction, at least for relatively simple tasks. Allowing students to engage in the learning activity that suits their own cognitive process will result in a higher level of satisfaction. Most importantly, the learning activity should not cause frustration that could potentially hinder the learning process. Thus, feedback, if used constructively, should relieve the possible frustrations that are most likely to arise from online learning without direct access to the instructor.

H1: For declarative knowledge, feedback will have a positive effect on *satisfaction* for both dependent learners and independent learners.

Feedback can aid in declarative knowledge learning and may increase the speed with which learning occurs for that type of learning [5]. Students report higher satisfaction for declarative knowledge learning when feedback is relevant and timely [9]. In an empirical study of the interaction of feedback and cognitive style, Khine [31] was supportive of the view that feedback enhances the performance of students in learning verbal information, regardless of learner type.

Field independent individuals are relatively good at giving order to unstructured information [60]. On the other hand, field dependents rely more on whatever structure is present in the information. Because field dependents have relative ease in imposing structure in

an organized situation, Witkin, et al. claim that field-dependents and field-independents will perform the same when presented with highly-organized learning materials, as would be the case in declarative knowledge learning.

Further, the goal-setting theory of feedback of Ilgen *et al.* [29] suggests that feedback is essential for learning performance, particularly in cases of non-complex knowledge acquisition. Specific goals along with specific feedback lead to higher performance.

H2: For declarative knowledge, feedback will have a positive effect on *knowledge acquisition* for both dependent learners and independent learners.

Procedural knowledge (learning "how") is more sophisticated than declarative knowledge in terms of cognitive level. According to Schunk [50], procedural knowledge consists of internalizing concepts, rules, and algorithms. It is the knowledge of how to perform cognitive activities, and it is often implicit. Examples of procedural knowledge are solving mathematical problems and proving geometric theorems.

Matching learner control to knowledge type and feedback type has been proposed as a link to a variety of positive affective outcomes, such as motivation, increased level of engagement, positive satisfaction, and decreased anxiety [32]. When an instructional experience is effectively self-managed, it may add to an individual's sense of competence and self-efficacy, which, in turn, can enhance ongoing satisfaction.

Constructivist theory suggests that feedback functions differently than in an objectivist view of learning [39]. Constructivists incorporate the notion of complexity of learning process and contend that learners are more satisfied when they can discover knowledge on their own. The constructivist approach reflects field-independent learners' natural preference. Field-independent learners should show no important effects when presented with different kinds of outside influence in the form of feedback [22]. On the other hand, field-dependent learners are thought to be more reliant on outside influence and guidance in producing positive affective results. Therefore,

H3a: For procedural knowledge, feedback will have a positive effect on *satisfaction* for dependent learners.

H3b: For procedural knowledge, feedback will have no effect on *satisfaction* for independent learners.

While feedback does provide some affective element in the case of procedural knowledge, at least in the case of dependent learners, it is not necessarily helpful in improving procedural *knowledge* [48]. Withholding feedback may actually be more effective for cases of procedural learning.

The constructivist approach focuses on situated, context-dependent, discovery learning, supported by learning from self-explaining and reflecting on internal feedback [20]. The constructivist approach [24], places emphasis on the learner as controller and developer of knowledge and argues for minimizing external influences in the case of complex tasks such as procedural learning. Even when performance would seem to benefit from feedback, learning through external feedback may be inferior to learning through discovery, with intrinsic feedback. Learning through discovery is learning based on feedback from the task itself (intrinsic feedback), rather than on feedback from an external source. For procedural knowledge, intrinsic feedback allows the participant to learn better [26], whereas external feedback can be used as a crutch, circumventing real learning [4].

According to the multiple-cue probability learning paradigm (MCPL), feedback impedes learning of complex tasks and subsequently, task performance [8]. Empirical studies on computer-aided learning of complex tasks have shown that feedback either impairs learning relative to non-feedback [17, 35] or has no effects on learning [59]. The reason for feedback's lack of positive effect seems to be that it diverts the learner's attention away from the learning itself; for complex tasks, maximal attention is necessary for attention to the task, and internal feedback functions to give the learner requisite information about performance without diverting attention.

Feedback intervention theory [32] comes to much the same conclusion: providing feedback in complex tasks changes the locus of attention from the task to the feedback and so is not always helpful, as it usually is for simple tasks. Therefore, we present this hypothesis:

H4: For procedural knowledge, providing feedback will have no effect on knowledge acquisition for either dependent learners or independent learners.

5. Methods

A 2 x 2 x 2 between-subjects factorial design was employed for this study. Factors were knowledge with 2 levels (declarative and procedure), learner control with 2 levels (field-dependent and field-independent) and feedback with 2 levels (feedback and no feedback). Subjects were randomly assigned to a specific online course depending on knowledge type and feedback intervention. The entire experiment was orchestrated in an online format.

A pilot study was conducted with 12 subjects randomly selected from the student group prior to the actual experiment. On the basis of the pilot results, the experimental materials were modified to bring them into alignment with the study's requirements.

In the actual experiment, participants were drawn at random from two sources. Student names were gathered from a random sampling of college student directories. A total of 600 email addresses were obtained from student online sources, and a message was sent to these people inviting them to participate in the study. The remaining names were drawn from a random selection of email addresses available through Amazon.com. These people were also sent a message inviting them to participate. A total of 200 addresses were obtained for this group. A total of 254 people returned the pretest questionnaire, which is 32% of the number of original invitations sent out. 166 people returned the posttest questionnaire, for a final rate of return of 21%. Of the posttest responses, 96 subjects participated in the online declarative knowledge course and 70 subjects participated in the online procedure knowledge course. Returns consist of approximately 80% student data and 20% non-student/consumer data.

The experiment consisted of administering four online learning scenarios, depending on the combinations of feedback and types of knowledge. The final online course involved the use of text, still pictures, graphics and video animation.

The experiment was set up in two main stages. The first stage administered the pre-quiz, and the second stage administered the actual course and the post-quiz. At the beginning of the experiment, a brief introduction of the online course was given to all subjects. Then subjects completed the course, with or without feedback. One set of subjects was given a declarative knowledge course of instruction, and the other set was given a procedural knowledge course. The declarative knowledge portion consisted in learning various facts about famous paintings. The procedural knowledge subjects were given instruction on how to score a bowling game.

The art history course for declarative knowledge was chosen because art is inherently interesting and yet many people do not know the details of its history. The bowling scoring course for procedural knowledge was chosen because it refers to a game that most people have heard of and yet contains details of which many are unaware; it therefore serves as a good candidate for learning how to perform a moderately complex procedure.

Learner control was measured by having the participants self-select into learner type: field-dependent or field-independent. A series of 4 questions was designed for this purpose, and participants were presented with these questions at the outset of the experiment. Questions were based on research by Rosenberg et al. [44]. Participants were then randomly separated into two groups. One group was given feedback during their online course. When executing the learning phase of the experiment, the feedback group was told whether they were right or wrong concurrently with their progress. If they were

wrong, they were also told why they were wrong and how to produce a correct answer. The second group was given no feedback in that their performance was evaluated only by telling them how many answers they got right at the end of the instructional sequence.

In this study, participant satisfaction with the learning process was assessed at the end of the experiment, based on a self-reported post-experimental questionnaire. Five items were created to measure satisfaction, based on an instrument developed by Phillips and Peters [41].

According to Bloom [12, 13], cognitive learning refers to comprehension and retention of knowledge. At the end of this study's experimental treatment, the achievement quiz that initially served as a pre-quiz was given again to participants in all groups as a post-quiz. The difference between pre-quiz and post-quiz scores was used as a measure of knowledge acquisition. The achievement test had eight questions for both the declarative knowledge groups and the procedural knowledge groups. The declarative knowledge quiz had questions relating to specific paintings in art history, and the questions for procedural knowledge had a variety of questions on scoring a bowling game.

In addition to the main independent variables described above, covariates were also considered for this study. Research shows that when students expect that a new medium will make learning easier and more entertaining, they like it. However, there is also evidence that their liking does not lead them to work harder [20, 46]. On the contrary, the more students think a medium makes learning easy, the less effort they will invest to learn [33, 38, 47]. There is additional evidence that students will not invest effort if they believe a medium to be very difficult. These findings suggest that interest level, comfort level and ease of use are important covariates that need to be included in the study. Interest level, comfort level and ease of use were each measured by using two item 7-point Likert scales.

6. Results

A multivariate analysis of covariance (MANCOVA) was initially conducted to account for the influence of covariate variables in hypothesis testing. After the results of multivariate analysis showed that there were significant differences attributable to feedback and learner control in each learning situation, univariate analyses for each of the dependent variables were then carried out.

The findings first draw attention to the absence of some of the important effects that were hypothesized. First, the positive effect of feedback on knowledge acquisition for independent learners and declarative knowledge is not evident. On the contrary, the data show that giving feedback to independent learners in this learning situation has a negative effect on their

knowledge acquisition, compared to the no feedback condition. Therefore, H2 is not supported for independent learners and declarative knowledge.

Second, for procedural knowledge, there is no positive feedback effect on satisfaction for dependent learners. That is, giving feedback in procedural knowledge learning has the same effect as no feedback on satisfaction for dependent learners, showing H3a is not supported.

Hypotheses H1 and H2 were tested in the domain of a declarative knowledge learning situation. Analyses of variance of feedback and learner control showed significant interaction effects on *knowledge acquisition*, while feedback alone showed a significant main effect on *satisfaction* for both learner types.

Results showed that learner satisfaction in the declarative knowledge learning situation depends on feedback (H1). When feedback is present, subjects, categorized as both dependent and independent learners, achieved higher level of satisfaction on learning. Statistically, the positive effect of feedback on satisfaction is suggested by comparing difference scores across conditions. Subjects were significantly more likely to have a higher satisfaction level when given feedback ($M = 18.3918$) than when given no feedback ($M = 16.8939$). Hence, there was a main effect for feedback, $F(1, 89) = 4.135$, $p = 0.045$. This result is consistent with H1.

In terms of knowledge acquisition, as noted earlier, feedback exhibited a negative effect for independent learners. However, feedback showed a positive effect on dependent learners. In other words, dependent learners acquire more knowledge with feedback, and independent learners acquire less knowledge with feedback, compared to the no feedback condition. This relationship was detected by the significant interaction effects of feedback and learner control, $F(1, 77) = 4.236$ and $p = 0.043$. Thus, H2 is supported for dependent learners but not for independent learners.

The data showed that independent learners with no feedback ($M = 2.4545$) and dependent learners with feedback ($M = 2.4211$) are likely to acquire more knowledge than otherwise. Without feedback, dependent learners have mean scores of 1.5238, which results in the lowest knowledge acquisition. However, data further indicate that with feedback, independent learners learn less than dependent learners in the same condition, with mean scores equal to 1.6429 and 2.4211 respectively. Because the means are statistically similar, it can also be concluded that knowledge acquisition of the two specific conditions of independent/no feedback and dependent/feedback are the same.

To examine the effects of feedback effect and learner control on learning outcome, H3a, H3b and H4 were proposed and tested. As noted earlier, providing feedback did not result in significant impact on *satisfaction* for dependent learners. Statistically,

feedback has no main effect on satisfaction, with $F(1, 58) = 1.664$ and $p = 0.202$. Thus, H3a is not supported. In addition, H3b was proposed to test the effect of feedback on independent learners. Data also show that feedback has no significant impact on satisfaction with respect to independent learners. Thus, H3b is supported.

With respect to *knowledge acquisition*, it was postulated that feedback has no effect on knowledge acquisition for either dependent or independent learners. Consistent with this conjecture, the data revealed neither a main effect nor an interaction effect, $F(1, 55) = 1.474$, $p = 0.23$. Thus, H4 is supported.

7. Discussion

The results showed that most hypotheses were supported in this study. It was hypothesized that for declarative knowledge, feedback will have a positive effect on satisfaction for both dependent learners and independent learners. This hypothesis was supported. Research has shown that feedback increases the speed with which learning occurs in cases of declarative knowledge learning [5]. Students also report higher satisfaction for declarative knowledge learning when given feedback [9]. Thus, we would expect that for declarative knowledge situations, feedback would give people increased satisfaction.

Hypothesis 2 stated that for declarative knowledge, feedback would have a positive effect on knowledge acquisition for both dependent learners and independent learners. This is partially supported. Feedback is regarded as one of the most critical components of declarative knowledge instruction, because its function is to provide students with information to help them either to reinforce their knowledge or to correct mistakes [7].

The finding conflicts with Khine's [31] view that feedback enhances the performance of students in learning verbal information, regardless of learner type. Knowledge acquisition was lower for independent learners, as compared with dependent learners, with feedback in declarative knowledge. Apparently learner independence takes precedence over external feedback in declarative knowledge learning, which is contrary to the literature, which indicates that feedback acts as a reinforcer and corrector for everyone. Perhaps independents are relying on a kind of internal, self-generated feedback to guide them. Dependent learners, on the other hand, rely on external structure, and they habitually absorb feedback. Independent learners are used to ignoring external influences, and so even if the feedback is present, it might not be attended to.

Hypothesis 3a was proposed for procedural knowledge; however, feedback was not found to have a positive effect on satisfaction for dependent learners. It was originally thought that dependent people would be inclined by that very characteristic to rely on and be

more satisfied with external reinforcement in the form of feedback. Here, it seems that knowledge type takes precedence: learning a procedural task is more salient than learner type. Dependent learners appear to get the feedback they need from internal sources, and that is satisfying to them. The covariates of interest and comfort level were found to have a significant impact on dependent learners' satisfaction. Although feedback is not a major force in producing satisfaction, other elements appear to be important.

Hypothesis 3b stated that for procedural knowledge, feedback will have no effect on satisfaction for independent learners. This hypothesis was supported. Research has indicated that people learning a procedural task tend to rely on intrinsic feedback; external feedback is not as helpful. Independent learners also rely more on intrinsic than extrinsic cues and are even distracted by external feedback, which would negate its effect on satisfaction [17].

Hypothesis 4 stated that for procedural knowledge, providing feedback will have no effect on knowledge acquisition for either dependent learners or independent learners. This hypothesis was supported. Most research has found that procedural knowledge takes precedence over learner type with respect to feedback's effect on knowledge acquisition. Regardless of learner type, people will rely on internal cues to acquire procedural knowledge [17, 21, 48].

8. Implications

Some tentative recommendations can be made for instructional designers and classroom teachers concerning the use of varying levels of feedback to enhance learning.

Results of this study imply that educators should design their online courses to reflect deeper cognitive processes. In particular, the distinction between courses that involve declarative knowledge and those that involve procedural knowledge should be taken into account because cognitive processes are not the same for the two kinds of learning.

Educators should also use feedback based on their teaching objectives. If their objective is to teach facts and rules, then external feedback is appropriate and should be used liberally. However, if their objective is to teach know-how, then reliance on students' intrinsic feedback is relatively more important. In any event, the combination of knowledge type and learner control must be matched with the appropriate provision of feedback.

Most importantly, design should reflect knowledge type differences. Instruction should be adapted to the learner rather than the learner to the instruction. Decisions regarding which students need more or less support for cognitive processing in a given program are important because students who do not need support may learn less when the instructor attempts to replace

learners' idiosyncratic and successful cognitive strategies with less familiar competing strategies. When the instruction strategies match a student's own strategies, learning is increased. Thus, interventions supporting cognitive processing should only be given to those who need them and should not conflict with a student's own propensities.

9. Limitations and future research

This study is not without limitations. The material presented to participants here was not an actual online course; it was devised for the purposes of the present study. Although attempts were made to devise realistic material, it still was considerably shorter than actual courses. Future research could examine online issues in a real-world setting. For example, one factor relates to grading. These courses had people complete a quiz, but they did not receive grades in any sense. Future research could be conducted more realistically if it investigated situations in which students had to work for grades.

There was a dropout rate between the pre- and post-test portions of the experiment, and this reduced the final data available for analysis. This could be corrected in future research by combining the two sections together into a single stage. Another limitation is that the results of this study might not generalize to courses quite different from art history and bowling scoring. Future studies should include very different types of courses, although the distinction between declarative and procedural knowledge should be preserved. Also, there could be a combination effect of feedback and interactivity, which was not examined in this study. Future research could distinguish these elements.

These factors pertain to the present study, but there are others that go beyond it that should be studied in future research. For example, there is evidence suggesting that student and teacher perceptions of online learning change over time, sometimes radically [47]. This would suggest that we should evaluate the student's perceptions on a longitudinal basis.

Future research could also examine the effect of feedback, learner control and task type on new dependent variables of knowledge retention and transfer. This would reflect a deeper level of learning and should be investigated.

Finally, the hypothesized was supported that external feedback would not affect procedural knowledge acquisition. Yet, this finding does not tell us what *does* affect procedural knowledge acquisition. Presumably the effect comes from intrinsic feedback, but this is a new hypothesis that should be investigated on its own.

10. Conclusions

This study examined feedback as a primary instructional strategy because it has been described as a powerful component in learning. This study provided a setting for studying a complex set of interrelated factors in the relatively new sphere of online learning. The inter-combination of these particular factors appears to be important from other research, but it has never been explicitly addressed, and never in an experimental setting. Findings of this study have shown that feedback and learner control have a significant interaction effect for declarative knowledge acquisition. For satisfaction, however, feedback is only salient for declarative knowledge learning, and not for procedural knowledge learning. Other factors, such as interest and comfort level produce effects in most situations. It is still unclear what factors affect knowledge acquisition for procedural knowledge. The challenge remains for future research to determine the relative importance of the elements uncovered in this preliminary study.

Online learning is becoming a major industry, and many of us, students and teachers alike, either are being impacted by it or will feel its presence in the future. It is therefore imperative that we come to a good understanding of the important elements that make it work successfully.

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