Scenario-based e-learning and Feedback Effects on Learning Outcomes and Motivation

Sacha Johnson, Ph.D.
sevesach@isu.edu
Idaho State University
921 S. 8th Ave., Stop 8064
Pocatello, ID 83209

David Coffland, Ed.D.
coffdavi@isu.edu
Idaho State University
921 S. 8th Ave., Stop 8081
Pocatello, ID 83209

Introduction

The purpose of this study was to examine whether the use of real-world context and two types of feedback with e-learning affected learning outcomes and motivation over time for learners in medical laboratory science (MLS) and medical laboratory technology (MLT) programs. This study examined incorporating the scenario of landing a dream job in a medical lab, performing virtual lab tests (manual sperm cell counts) and reporting the results. The study also incorporated feedback related to the reported results. Because MLS and MLT professionals will conduct laboratory tests and report those results to physicians, it was thought that delivering contextualized, online instruction with 'virtual' consequences, manual cell count instruction could be less abstract and more meaningful to learners, which might help improve both motivation and learning outcomes.

Literature Review

As far back as 1989, Brown, Collins, and Duguid acknowledged that, "Authentic activity... is important for learners, because it is the only way they gain access to the standpoint that enables practitioners to act meaningfully and purposefully" (p. 36). The authors suggested that in traditional education settings, students may be able to pass exams, but not be able to use the conceptual knowledge in practice. To address the disconnect between knowing and doing, they recommended the use of cognitive apprenticeships, or situated learning, to contextualize learning using the social and physical context of the instruction. In 1995, Choi and Hannafin suggested that situated learning anchors knowledge and skills in realistic contexts.

Scenario-based learning, and later scenario-based e-learning, grew out of this idea that situated learning provides context for how information will be used in the real-world (Errington, 2011). According to Errington (2010), scenario-based learning refers to educational approaches that use scenarios to bring about desired learning outcomes.

Clark and Mayer (2011) asserted that scenario-based learning goes by many names, such as whole-task, case-based, problem-based, and immersive instruction. Researchers have examined the use of scenarios as preparation for flipped learning in which lecture-based material is delivered online and then applied in person (Lehmann, Bosse, Simon, Nikendei, & Huwendiek, 2013).

Errington (2010) asserted that scenarios have the potential to provide rich practical experience that extends past conventional lectures and tutorials and Clark (2016) suggested that "Scenario-based learning can lead to better transfer to tasks different from those used in the training and to greater long-term retention" (p. 55) and that it should be considered "in situations in which on-the-job experience is rare, dangerous, or impractical" (Clark, 2013, p. 13), but she cautioned that more research is needed before we can extend these conclusions to all situations.

Feedback is tied closely to all types of instruction and Keller (2010) suggested that feedback should be provided to help improve student confidence and show learners how to take corrective action. Similar to scenario-based learning, feedback types go by different names. In general, corrective feedback indicates only the correctness of a learner's response; whereas, more elaborative or explanatory feedback not only provides the correctness of a learner's response but also includes additional information about why an answer was incorrect and how to rectify the mistake.

Based on the results of their analysis of 12 meta-analyses in 2011, Hattie and Gan asserted that feedback is a powerful influence on learning outcomes. Feedback has also been found to play an important role in computer-based instruction. In 1995, Azevedo and Bernard extracted effect sizes from 14 studies examining feedback and suggested that feedback has to be regarded as one of the most critical components of computer-based instruction.

Keller (2010), Hattie and Gan (2011) and others have also suggested that feedback can impact learner confidence and motivation. However, despite there being a multitude of research on feedback, the findings are varied and inconsistent (Shute, 2008). Lechermeier and Fassnacht (2018) suggested that "Although an extensive body of research has stressed its importance, a conclusive overall picture on feedback characteristics effects is missing" (p. 145).

Similar to feedback, although a tremendous amount of research has been conducted on motivation, there is little guidance for those who want to be more effective at motivating learners (Keller, 2010). Therefore, Keller developed his ARCS model of motivational design for learning, which includes attention, relevance, confidence, and satisfaction components.

Attention refers to capturing and sustaining learner attention, relevance refers to the perceived usefulness and importance of the instruction to the learner, confidence refers to how confident the learners are they can be successful, and satisfaction has to do with learner expectations and how they feel about their performance. According to Keller (2010), these elements can affect how much effort learners put into accomplishing a goal.

Methods

Two research questions were examined for this study. The first research question involved whether scenario level (present or not present) and feedback type (intrinsic or elaborative) had significant main effects over time on college students' ability to manually count sperm cells or whether there was an interaction between these two independent variables on learning outcomes as measured by the researcher-developed knowledge instrument.

The second research question was whether scenario level and feedback type had an effect on learners' motivation over time or whether there was an interaction between the two independent variables on motivation as measured by Keller's (2010) Instructional Materials Motivation Survey (IMMS). The IMMS is a 36-item self-report measure of students' attention, relevance, confidence, and satisfaction. Its validity and reliability have been described by Keller. The knowledge instrument was designed to measure whether students could recall the procedure of counting sperm cells and doing the necessary computations to report an accurate total cell count. Content validity was established using the Delphi method with experts from the content area.

As such, this study made use of a repeated measures design with two between groups factors, scenarios (present or absent) and feedback (elaborative or intrinsic). Both instruments were administered at three time points with the survey being administered first in case learners' content performance might have affected their motivation.

Treatments

All of the instructional treatments were designed as web-based modules using the existing text-based standard operating procedure and the expertise of an MLS Body Fluids and Urinalysis course as well as other MLS professionals. Each treatment consisted of a worked example followed by two practice activities for learners to complete and those practice activities included either intrinsic or elaborative feedback. All four treatments contained the same information, but it was presented differently based on the scenario and feedback levels.

The scenario-based treatments started with, "Congratulations! You've just landed your first dream job in a medical laboratory. One of the first tests that have come in is a semen analysis…" Then the lesson led learners into the patient scenario and what they would be doing as part of their new job. The remaining lesson pages were also tied to performing job duties as guided by their new supervisor, Dave.

The two treatments without scenarios began, "This lesson is designed to show you how to manually count sperm cells using a standard hemocytometer. A hemocytometer is a specialized microscope slide." The remaining lesson pages contained the same information as the scenario treatment, but presented the information directly without tying it to patients or working in a medical lab.

The intrinsic feedback provided learners with consequences for their responses. So not just informing participants whether they were correct or incorrect, but also the impact of their reported counts. For example, the intrinsic feedback stated, "Although it was within the reference range, your count was significantly different from Dave's calculation of eight hundred fifty-seven million 500 thousand. Such an erroneous calculation could have negative clinical consequences."

Elaborative feedback on the other hand informed learners whether they were correct or incorrect and provided them guidance to rectify incorrect answers. For example, the elaborative feedback for the same question stated, "Incorrect, the correct answer is eight hundred fifty-seven million 500 thousand. It looks like you may have calculated incorrectly."

Elaborative feedback was presented without any context of the medical lab. Both feedback types included a summary of the correct steps as well as the values that should have been obtained.

Because the main interest in this study was the efficacy of a scenario-based instructional approach with intrinsic feedback, the no scenario with elaborative feedback treatment served as the control group for this study.

Data Collection

The target population for this study was MLS and MLT students. This was done to be able to provide real-world, job-related scenarios and relevant feedback. Although faculty in such programs at other institutions across the United States expressed interest in being involved in this study, no students from those programs participated; therefore, the majority of participants were from the researchers' institution and also included participants from other programs at the institution.

Due to the limited number of participants, the study materials were delivered four times in an effort to increase power for inferential statistics. During each iteration, data were collected over seven weeks. Participants were randomly assigned to one of the four treatment groups that were differentiated by the two independent variables. During the first week, informed consent was obtained and participants submitted a demographic survey, which was collected anonymously strictly for describing the sample. After that, participants completed the pre-IMMS followed by the researcher-developed knowledge pretest. During the fourth week, the instructional interventions were delivered via the learning management system followed by the immediate-post IMMS and then the immediate knowledge posttest. Lastly, participants completed the delayed-post IMMS and delayed knowledge posttest during week seven. After all participants had completed the study materials, the data were exported from the learning management system to Excel, where they were anonymized, and coded for analysis using IBM SPSS.

Data Analysis

Descriptive statistics were used to provide a complete description of the sample using participants' reported demographic information. For research question one, a 2x2 repeated measures analysis of variance, ANOVA, was used to determine whether any main effects for scenarios or feedback existed or whether there was an interaction between those two independent variables on learning outcomes over time. A second 2x2 repeated measures ANOVA was used for research question two to determine whether any main effects for scenarios or feedback existed or whether there was an interaction between these two independent variables on motivation over time. Additionally, Chi-square tests of independence were used to determine whether there was a relationship between participants' treatment groups and their ability to manually count sperm cells.

Results

The intended sample was MLS and MLT students so the real-world, job-related scenarios and intrinsic feedback would be relevant to their chosen profession. Therefore, attempts were made to solicit participants from outside institutions; however, although faculty at 10 outside institutions expressed interest, no learners from those institutions participated, which had a major impact on the number of participants obtained as well as trying to ensure relevance of the scenarios and intrinsic feedback to these majors.

Since a limited number of participants from MLS and MLT programs were obtained, university students from other programs within and outside of ISU were invited to participate. These additional calls for participants resulted in the study being conducted a total of four times (N = 84).

The first iteration of the study included 48 undergraduate and graduate students taking a Urinalysis and Body Fluids class as part of their Medical Laboratory Science program at a medium-sized university in the West during the fall 2019 semester ($N = 48$). The subsequent iterations included the students from other programs from within the same university as well as outside the institution ($N = 36$). Each iteration saw fewer numbers and by spring of 2020, many schools and other services shut down due to COVID-19.

The descriptive statistics showed that 60% of the participants were non-traditional students, as defined by being 25 or older, 63% were female, and 60% were enrolled in a MLS program. Data were included for a total of 84 participants in the sample descriptives because there was no way to de-anonymize the demographic survey data.

The majority of learners (92%) had previously taken an online course and had taken an online exam or assessment (94%). Nearly 70% of the participants had used the same learning management system that was used to deliver all of the study materials and 81% had not had previous instruction on the topic covered in the instructional treatments, manual cell counts.

For research question one, participants' content acquisition and cell count accuracy, the data were analyzed with and without three outliers identified in SPSS and both analyses yielded similar results. No statistically significant effects were observed for scenario level (present or not) or feedback type (elaborative or intrinsic), nor was an interaction observed for these two independent variables; however, there was one statistically significant result, which was for time.

Pairwise comparisons using a Bonferroni adjustment saw a statistically significant increase from the pretest to the immediate post test, which would be expected as a result of the instruction; however, a statistically significant increase was also observed from the immediate posttest to the delayed posttest, which was somewhat unexpected because of the two-week delay between those two posttests.

A Chi square analysis was used to examine participants' mastery for performing manual cell counts accurately. Correct answers were defined as within plus or minus one standard deviation of the mean of experts' counts. Mastery was defined by answering at least two out of three cell count questions correctly; whereas, not having met mastery was defined by answering one or fewer cell count questions correctly. The results of the Chi square analysis showed no statistically significant differences for the immediate or delayed posttests and the treatment conditions did not appear to have an effect on participants' accuracy of manually counting sperm cells.

In contrast to the results on the content knowledge scores, participants' skill mastery dropped between the immediate posttest and the delayed posttest, which would be expected after the two-week delay. Although not statistically significant, higher mastery levels were observed when intrinsic feedback was paired with scenarios and when elaborative feedback was paired with no scenarios on both the immediate and delayed posttests.

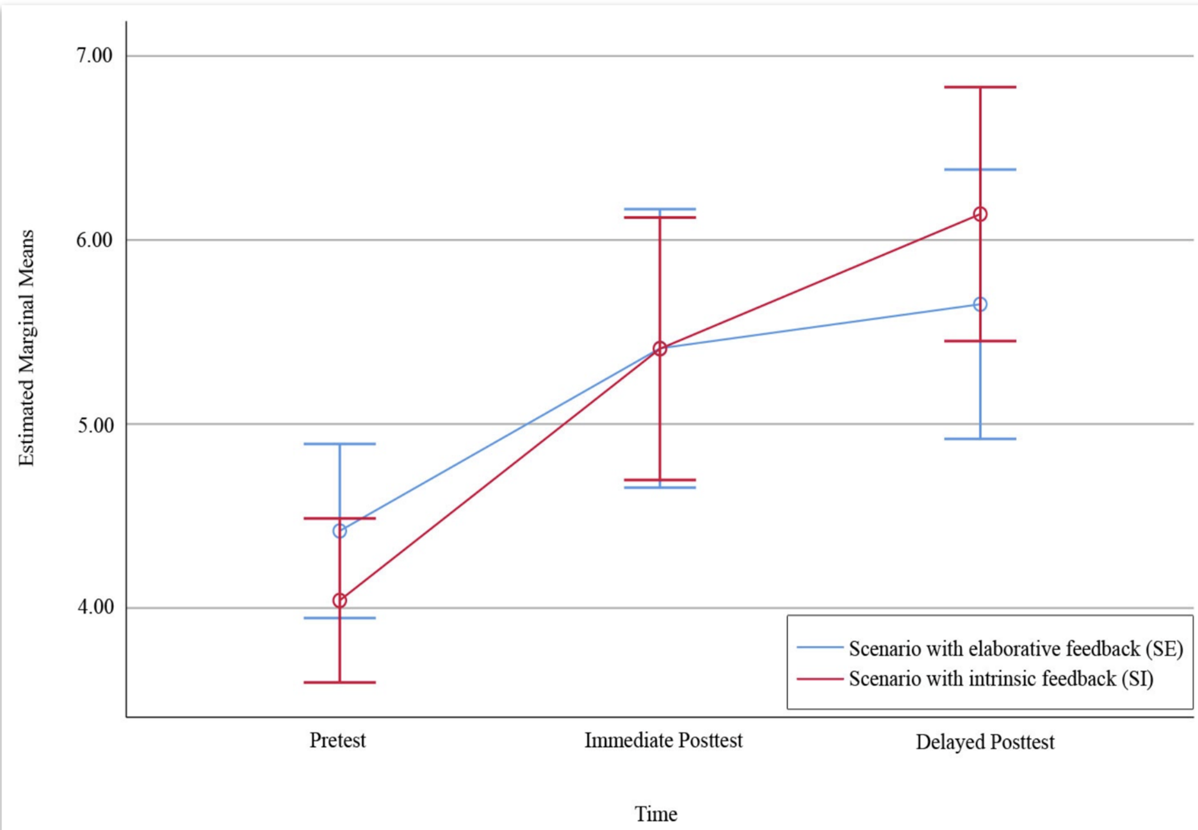
For research question two, examining the effect of scenarios and feedback type on participants' motivation over time, the results of the 2x2 repeated measures ANOVA indicated there was not a statistically significant difference in IMMS scores over time based on scenario level or feedback type. Additionally, no statistically significant interaction between the two variables was observed.

Similar to the knowledge scores, the only statistically significant main effect observed was for time. Pairwise comparisons showed a statistically significant decrease in motivation from the pre-IMMS to the immediate post-IMMS. Although not statistically significant, a slight increase from the immediate post-IMMS to the delayed post-IMMS was observed for all treatment groups except those who received elaborative feedback with scenarios.

Interpretations

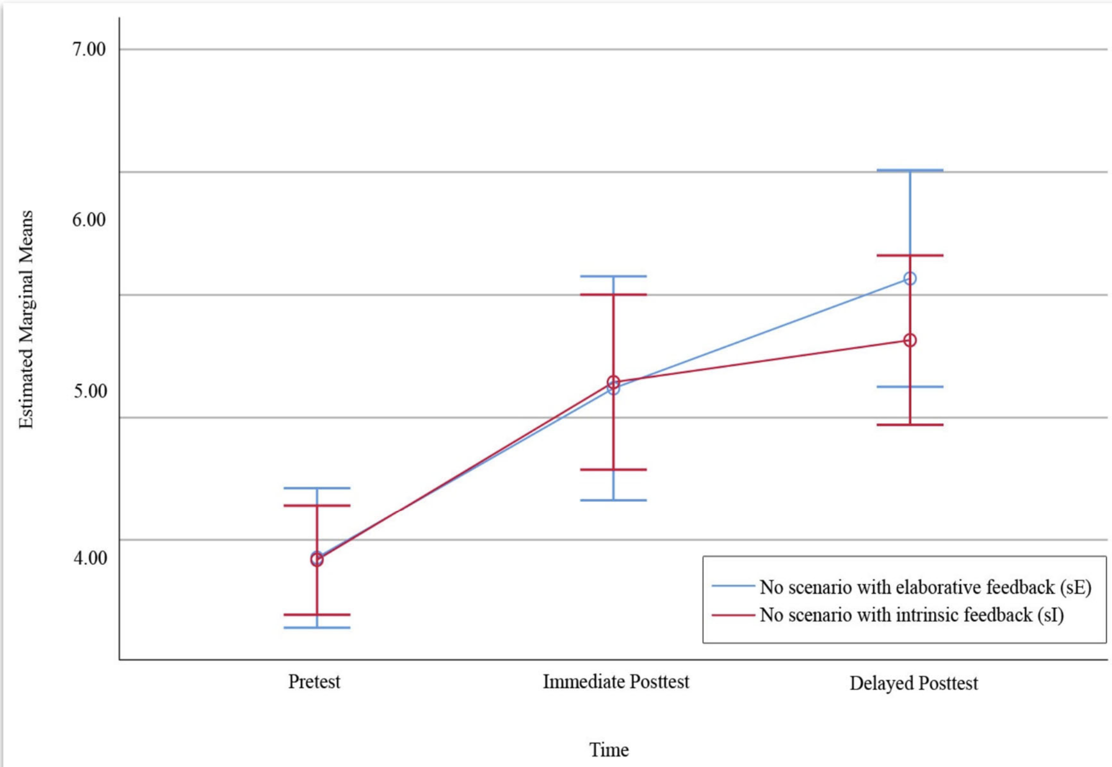
Although no statistically significant differences were observed for research question one, the line graphs in Figure 1 show an apparent interaction effect. For the scenario groups, participants who had scenarios with intrinsic feedback had a lower starting score, but caught up to the participants who had elaborative feedback on the immediate posttest, and then surpassed them on the delayed posttest.

Figure 1



As shown in Figure 2, participants who received intrinsic and elaborative feedback with scenarios had similar means on the pretest and immediate posttest, but those who had elaborative feedback appeared to score higher on the delayed posttest than participants who had intrinsic feedback with the scenarios.

Figure 2

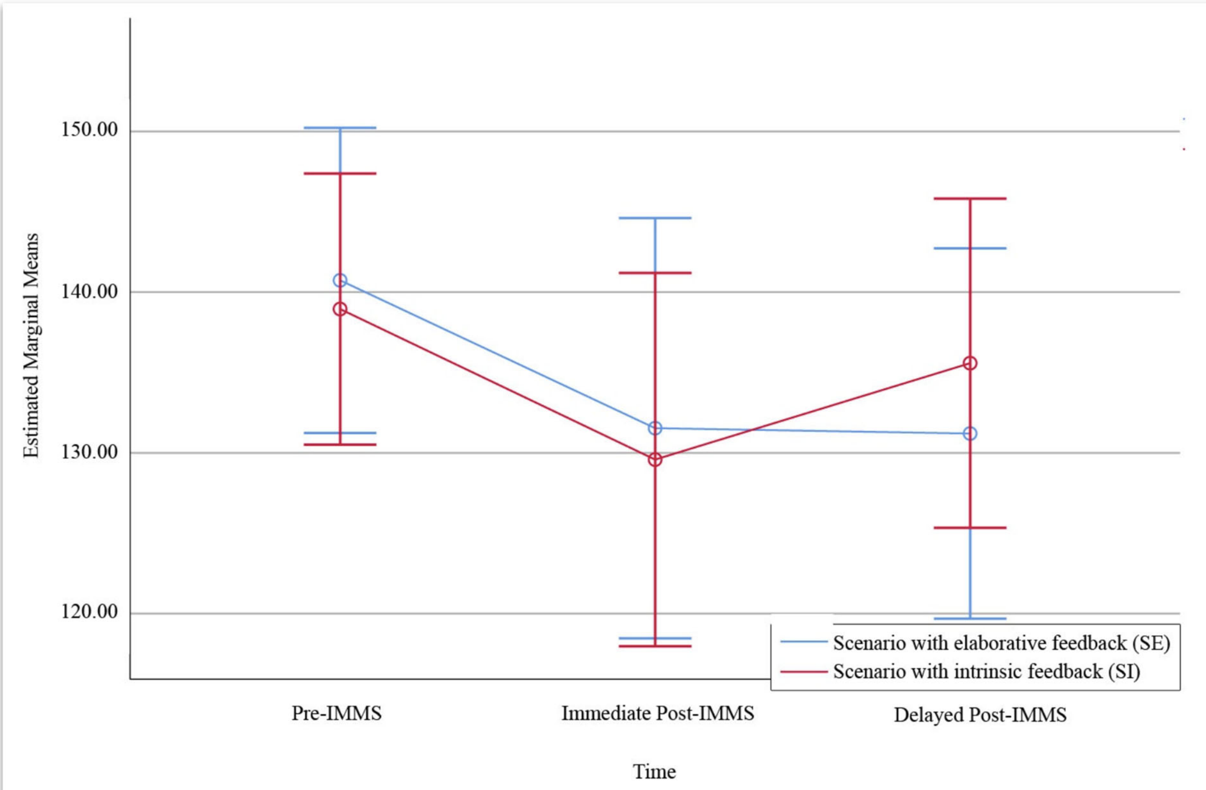


Looking at the results of this study as more of a pilot test due to the low number of participants, it appears the learners in all treatment groups increased their knowledge of manual sperm cell counts regardless of the scenario level or feedback type from pretest to immediate posttest and again from the immediate posttest to the delayed posttest. It is possible this increase was due to the immediate posttest acting as a subsequent learning opportunity. Further, the participants appeared to have learned recall, but not application, which actually decreased from the immediate to the delayed posttest. This could indicate that without sufficient skill' practice, the skill was not necessarily learned (Fisher et al., 2018).

For research question two, participants' IMMS ratings decreased significantly from the pre-IMMS to the immediate post-IMMS, which could have been due to participants being more interested in the study at the start, but having lost interest after waiting two weeks or after having gone through the instructional intervention.

Although not statistically significant, a pattern also emerged for the IMMS results. As shown in Figure 3, while participants in both scenario groups had lower IMMS scores from the pretest to the immediate posttest, participants who had intrinsic feedback rated their motivation slightly higher on the delayed post-IMMS than those who had elaborative feedback paired with scenarios.

Figure 3



Conclusions/Recommendations

Because the lack of statistically significant findings could have been due to the small sample size the first recommendation is for future research using a larger sample. Although the patterns that seemed to emerge were not statistically significant, if future research supports those patterns, a possible recommendation would be to pair intrinsic feedback with scenarios and elaborative feedback without scenarios for optimal knowledge acquisition and improved motivation. Future research is recommended to confirm any possible significance of these patterns with a larger sample and with different disciplines.

Although knowledge scores increased over time, mastery levels did not. Even though that would be expected due to the delayed time after the instruction, it might also indicate that the instructional treatments were not effective for teaching skill acquisition. Therefore, future research examining the effectiveness of scenario-based e-learning for teaching conceptual knowledge versus skill acquisition is recommended.

Further, acquiring skills requires practice so it is possible that the instructional treatments did not include enough practice opportunities. Clark and Mayer (2011) suggested that evidence supports spacing practice over time and future research could help determine whether spaced repetition would be beneficial for teaching manual cell counts.

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