Learning Red Cell Morphology and Quantitation using a Scenario-Based Learning Environment (SaBLE)

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Abstract

Instructional design has long been a topic of interest in education. Many learning theories have been developed over the years to aid educators in creating and delivering educational content effectively. In hematology, understanding red cell morphology and quantitation is crucial for performing manual differentials. The use of a Scenario-Based Learning Environment (SaBLE), an adaptive e-learning platform, may improve students' critical thinking and understanding of the basics of red cell indices, morphology, and quantitation. A total of 4 SaBLE modules were created in two sets. The first set of two modules were created as pre- and post-module knowledge checks to establish the efficacy of the second set of modules. The second set of modules focused on red cell morphology and quantitation. Both content modules incorporate cognitive load theory, scaffolding, and desirable difficulty in their design. The modules also use immediate and delayed feedback as those have been shown to be the most effective with learners at a lower level. As the modules were not beta-tested by students, some adjustments may need to be made to the modules after receiving feedback from students. Data exported from SaBLE, such as time spent on the modules and correct or incorrect answers, will also need to be reviewed to determine the overall efficacy of the modules.

Introduction

Red cell morphology is foundational knowledge in hematology as manual differentials are routine work. Students sometimes struggle to learn morphology and quantitation, which may hinder their confidence and lower their work quality. Instructional design is an important aspect of student learning and seeks to find the most effective method to help students learn.

Instructional design is continuously developing and can incorporate many theories and principles. Cognitive load theory (CLT) has become a prevalent basis for instructional design over the years. Cognitive load theory is a theoretical framework of instructional design based on human cognitive architecture (Sweller, 2019). One of the main principles of CLT is that working memory, or extraneous load, is limited in capacity and duration when processing new information to be stored in long-term memory (Chen et al., 2017; Sweller, 2019). Reducing extraneous load is important in instructional design based on CLT for effective learning which is why a minimal guidance approach does not work as it places a large load on working memory (Kirschner et al. 2006). Instructional designs that ignore the limitations of working memory are not effective.

Educational games have also been shown to be effective in instructional design as introductory material. Games can help with student motivation and introduce new concepts in an integrated manner (Braghirolli et al., 2016). In game-based learning, scaffolding is a useful tool. Scaffolds serve to assist students with attaining base knowledge that would not be attainable on their own (Chen & Law, 2015; Barzilai & Blau, 2013). Implementation of this in instructional design can help alleviate extraneous load in the learning process. However, not all scaffolds are adaptive and may not be very effective.

Another key aspect of instructional design is feedback timing. Feedback helps students learn by giving them information about their responses. The type of feedback provided is important in the learning process. A study conducted by Lemley et al. in 2007 showed that immediate feedback was more effective than delayed feedback. However, due to the limitations of the study, they concluded that more research was needed on how students use feedback. In a study by Clariana et al. in 1991, immediate and delayed feedback was found to be more useful for lower-level questions that were identical while answer-until-correct feedback was found more useful for higher-level questions that required more recall and review. In general, feedback is an effective tool. A major limitation concerning feedback is the possibility that a student memorizes the answer given in feedback without truly processing the information.

When thinking about how to deliver content and the type of feedback to give, the difficulty of the content must also be taken into consideration. A key feature in instructional design is finding an appropriate difficulty level. The term desirable difficulty refers to a strategy that suggests that challenge demands more cognitive effort from learners which improves learning (Eliasz & Nelson, 2022). Desirable difficulty also plays a role CLT and scaffolding. In CLT, content that is too challenging can overload a learner's cognitive capacity, while content that is not challenging enough does not motivate a learner to actively consume the content. Scaffolding provides a means to build up to a desired level of difficulty that will be effective. Feedback timing also depends on the desired difficulty level of the intended learners.

Scenario-Based Learning Environment (SaBLE) is an adaptive e-learning platform that was designed using the principles of CLT, game theory, feedback timing, and goal-based learning (Wiesner et al., 2017). Using SaBLE, we aim to help students better understand important concepts relating to red cell morphology and quantitation.

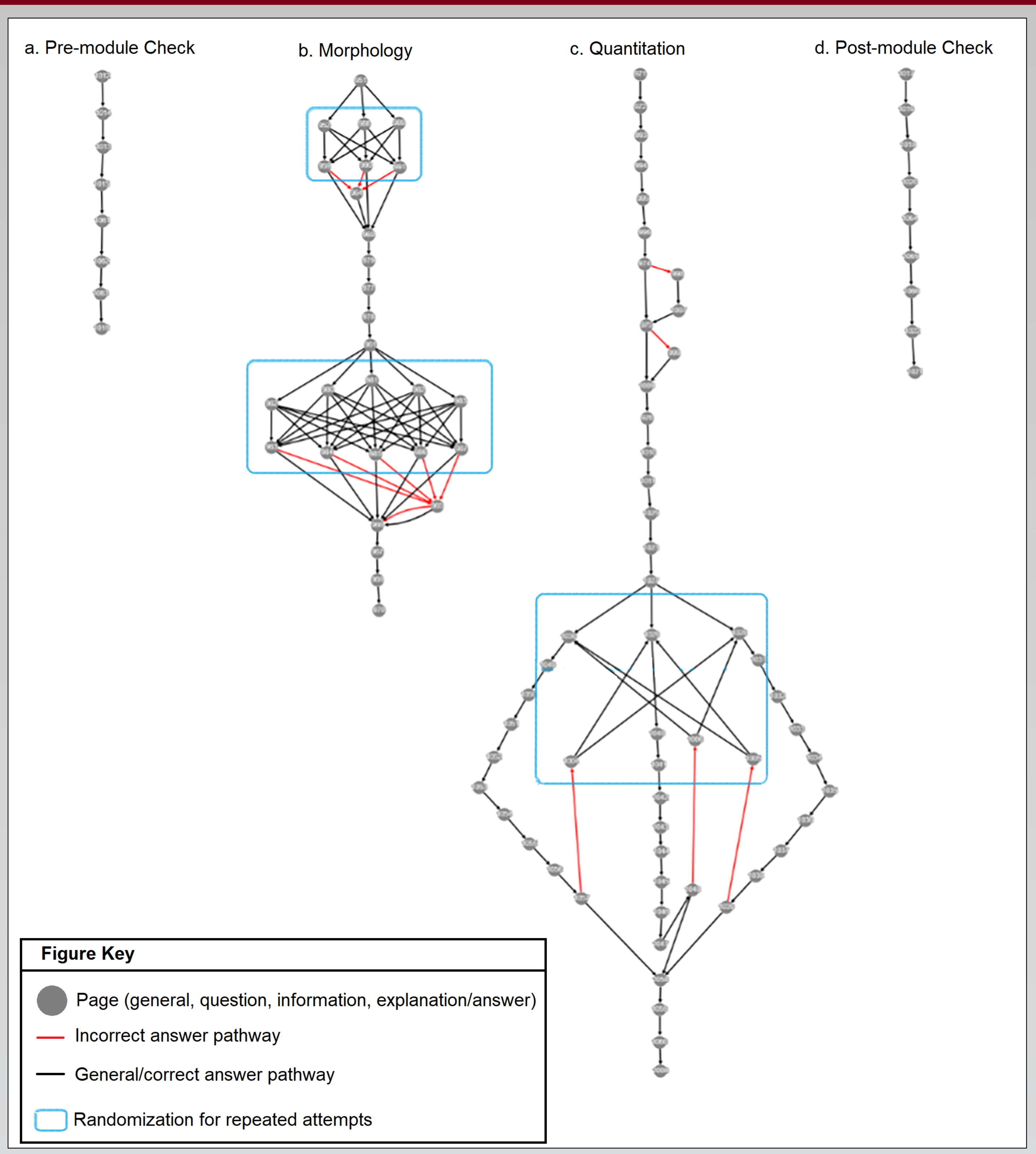

Figure 1. Module node graphs

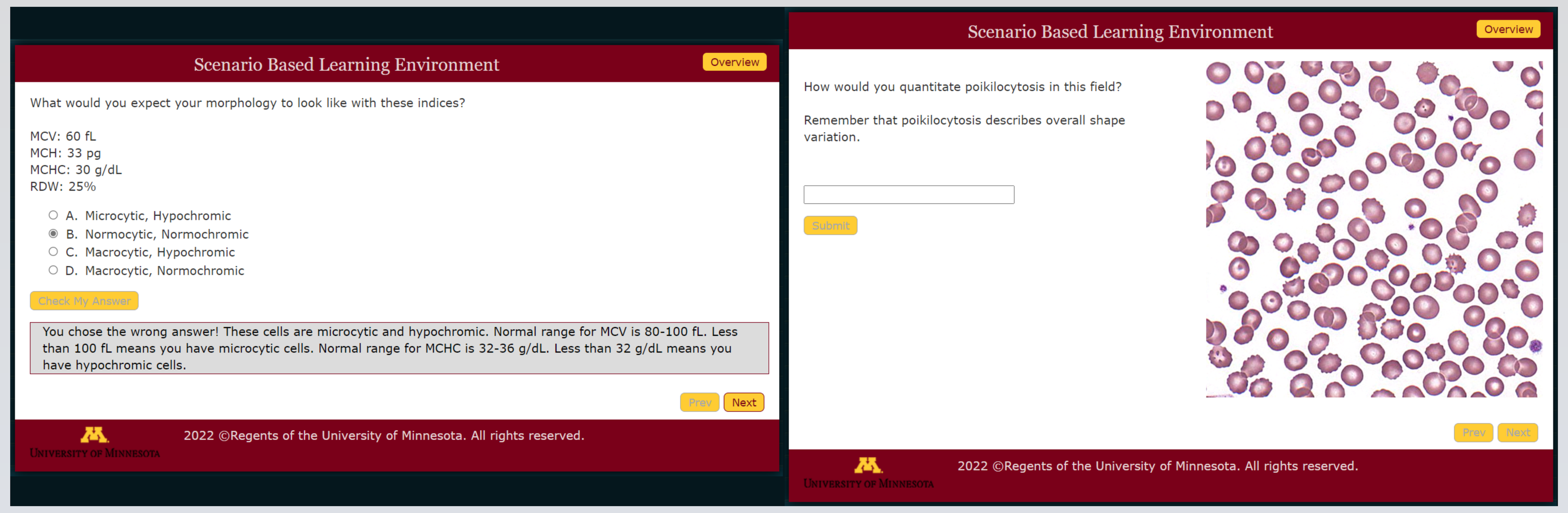

Figure 2. Screenshots of questions from the morphology and quantitation modules. Multiple choice question from morphology module with immediate feedback (left) and fill-in-the-blank question from quantitation module (right).

Table 1. Pre- and Post-Module Red Cell Morphology Questions

Pre-module	Post-module
Which area of a blood smear should you look at to view morphology? What should that area look like?	Which area of a blood smear should you look at to view morphology? What should that area look like?
When looking at a blood smear, how do you determine if a red cell is macrocytic?	When looking at a blood smear, how do you determine if a red cell is microcytic?
How do you determine if a red cell morphology quantitates as 2+?	How do you determine if a red cell morphology quantitates as 1+?

Table 2. Pre- and Post-Module Self-Assessment Questions

How confident are you with identifying red cell morphology?
How confident are you with using red cell indices to help determine morphology?
How confident are you with quantitating red cell morphology?

Methods

Four modules were created for this project. The first and last modules are pre- and post-module knowledge checks that were created to assess the efficacy of the second and third modules. These modules contain a few open-ended questions relating to the topics covered in the second and third modules (Table 1) as well as self-assessment questions to gauge the students' perceived level of knowledge on the topic (Table 2). Responses obtained from the questions in Table 1 will be coded for qualitative evaluation. The questions from Table 2 will be Likert scales so that statistical analysis can be generated. The second module covers red cell indices, viewing fields, and morphologies. This module has a linear progression, uses immediate feedback, and is a scaffold for the second module. The third module covers quantitation and uses immediate and delayed feedback. The structure of the second module is linear but includes some scenario-based questions with multiple paths for students to take depending on their answers.

Discussion

Learning red cell morphology and quantitation is important for manual differentials in hematology. Students sometimes struggle to learn concepts relating to this topic, so it is important to find the most effective way to help them learn. The design of these modules is intended to support student learning and understanding of the topic rather than teaching new content. A student's perspective is a valuable resource for any educational tool. However, since the modules were not beta-tested by students, any adjustments made to the modules were made from an educator's point of view. For future development on this project, students will be able to beta test the modules and give feedback. If needed, extra adjustments can be made to the modules post-student feedback.

As SaBLE can record a students' progression through each module, quantitative and qualitative data can be collected from the modules and analyzed. Quantitative data on how students progress through the modules and their answers from the pre- and post-module knowledge checks can be compiled and reviewed to determine the overall effectiveness of the modules. We can look at the time it takes for students to complete the modules and see if there is any correlation to how well students do on the open-ended pre- and post-module questions. For the Likert scale evaluation, a paired T-test between the pre- and post- module responses will be done. Responses from the pre- and post-module will be compared to determine if there is any significant difference based on the students' confidence level expressed on a numerical scale. A review of cohort scores on the lab practical manual differential can also be examined to determine any differences between performance with and without the SaBLE modules.

Conclusion

For future directions, after the modules have been tested by students, data exported from SaBLE will be reviewed to assess the efficacy of the modules. The coding in SaBLE is complex but has some limitations in page interaction as the platform is still relatively young and new coding is still being developed. Further development on the coding can help expand the type of interactions students have on a page, such as being able to interact with images. Further research on game-based learning may also be beneficial for the development of the modules since many students find educational platforms to be engaging and useful.

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