

## **Developing iBooks: A Case Study Teaching Gram-stain Analysis**

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**Abstract:** University of California at Irvine's medical school is one of many programs that have transitioned to iPad based instruction. Release of iBooks Author, a development tool for electronic books, in January 2012 enabled the creation of "iBooks" that transitioned the iPad from an instructional content viewer to an advanced learning experience including interactivity and multimedia. This tool was the first time that instructors could develop customized instructional content for the iPad without prior programming experience. However, there currently lack any guidelines for iBook development, and there have been few evidenced-based research projects utilizing the tool. Therefore, the purpose of this instructional design project was to design, develop, and evaluate a prototype iBook intended to inform development decisions for instructional designers. The iBook design focused on integration of *The First Principles of Instruction* (Merrill, 2013), *Principles of Multimedia Learning* (Mayer, 2001), and *iOS Human Interface Guidelines* (Apple, 2012). Improved test scores, increased skill confidence, and positive participant responses indicate that selected theories and guidelines were applicable to iBooks development. The author suggests that these implications could be broadly applied to eBook development, and discusses additional design concerns for future research.

### **Introduction**

On August 3rd, 2010 the University of California at Irvine (UCI) took a bold leap into the educational technology future by committing to distribute iPads to every incoming medical student. Now in their third year of iPad distribution they have overcome initial technology integration issues such as iPad training, digitization of curricular content, and searching for effective educational applications. UCI is now prepared for the next step, custom iPad training material designed specifically to target the needs of their students and take advantage of the tablets functionality. iBooks, a multimedia and interactively enhanced electronic book, was chosen as the delivery for this instruction, and Gram-stain interpretation, a microbiology topic covered by UCI medical students, was chosen as the instructional content to populate the iBook. However, due to the lack of literature on iBook development, a prototype was needed that used relevant literature from various disciplines for design, measured educational efficacy, and could inform generalizable iBook development guidelines. Therefore, the purpose of this instructional design project

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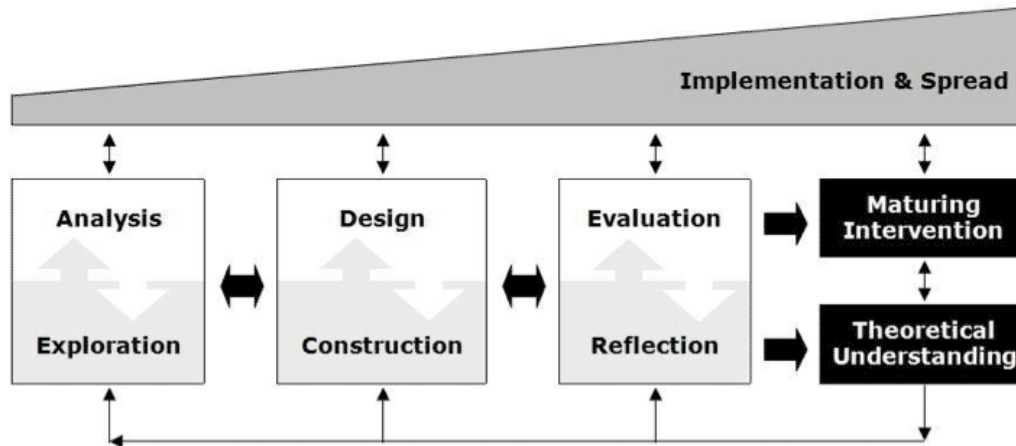
In order for UCI to realize the maximum value of their technological investment it would be necessary to take advantage of the iPad's unique capabilities such as touch navigation, integrated multimedia, and embedded assessments. The release of iBooks Author in January 2012, an application for developing advanced electronic books, was the first time that instructors could develop customized instructional material to integrate with the iPad instead of only using the device for viewing content. Without requiring programming expertise, this new development tool brought with it a simple drag and drop interface for adding functionality such as movies, quizzes, 3D objects, and imagery to targeted instruction through eBooks. However, barely one year since the release of iBooks Author it is clear that, while promising, the research is still lacking and further evidence-based studies are needed to assess the development and implementation of iBooks content (Payne, Goodson, Tahim, Wharrad & Fan 2012).

Gram-stain interpretation, a microbiology topic covered by most medical students, was a perfect instructional test bed for this type of technology. Gram-stains are an experiment commonly performed on bacterial cultures to assist with identification of pathogens ailing a patient. The process involves a multistage dying process to impart color into the bacteria followed by a visual assessment performed under a microscope. The visual nature of Gram-stain interpretation is easily decoupled from the psychomotor heavy staining process, and would benefit from the multimedia capabilities of iBooks.

### **Design Methodology**

Educational design research (EDR) was chosen as the research framework for this project. EDR is a flexible framework comprised of a cyclical, reflective and iterative development methodology while at the same time collecting internally valid data to advance theory (Reeves, 2006). This concept was compatible with the need for iBook development to progress towards a mature intervention while also informing the theoretical understanding of design and development. Following this framework, each cycle would contribute towards constructing, evaluating, modifying, and generalizing mobile eBook development guidelines.

Each cycle advances in three phases, represented in Figure 1, labeled "Analysis & Exploration", "Design & Construction" and "Evaluation & Reflection". Analysis and exploration will focus on identifying a topic area as well as literature that can be used to inform the educational design and tool development processes. Design and construction focuses on the implementation of research collected in the previous phase mixed with craft knowledge. Evaluation and reflection focuses on assessment of the intervention and analysis of the results. Each phase informs the others with the end of cycles producing a maturing intervention and increased theoretical understanding of both educational and development theories. Iterative cycles move the intervention closer to actual use and distribution as represented by "Implementation & Spread".



**Figure 1.** Breakdown of individual phases within an EDR cycle: Adapted from *Conducting Educational Design Research* (p. 77), by S. McKenney and T. C. Reeves, 2012, New York: Routledge.

### Analysis & Exploration

eBook development, an interdisciplinary endeavor, includes a wide cross-section of theoretical applications. This prototype focused on implementing research from educational theory, multimedia design theory, and human-computer interface (HCI) guidelines. Table 1 lists the theory or guideline type, its name, and selection rationale. The table is not intended to be all encompassing nor a recommendation for other researchers. Instead, it is a starting point for assessing the validity of each selection as it related to eBook development before integrating additional theories or guidelines.

**Table 1.** Microbiology iBook applied theories and guidelines

Aspect	Theory / Guideline	Rationale
Educational theory	First principles of instruction	Broadly applicable framework that brings together instructional design principles agreed upon by a wide selection of pre-existing theories (Merrill, 2013).
Multimedia design theory	Multimedia learning principles	Set of principles intended to maximize learning as it is impacted by cognitive load through the design of multimedia instructional elements (Mayer, 2001).
HCI guidelines	iOS Human Interface Guidelines	Guidelines published by Apple regarding user interface interaction through direct manipulation (touch navigation) and design consistency (Apple, 2012).

## Design & Development

First principles of instruction, multimedia design, and iOS HCI guidelines are represented throughout the eBook as a single melded design. The following examples provide single instances of theory or guideline application within the larger context of the intervention.

### *First principles of instruction*

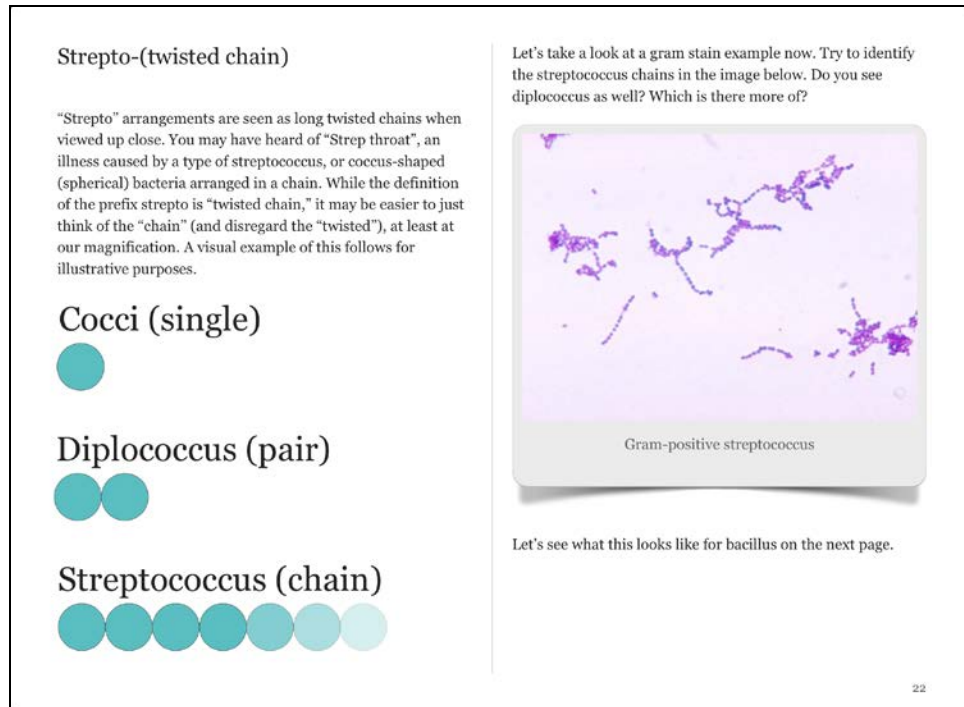
The activation principle, one of the first principles of instruction, states that “Learning is promoted when learners recall existing knowledge and skills as a foundation for new skills” (Merrill, 2013). To achieve this principle, microbiology instruction within the eBook was scaffold into three self-supporting yet cumulative modules. The learner was instructed on how to analyze a Gram-stain for the following three criteria: Gram-stain result, morphology, and arrangement. Each of these assessments was then added to an analysis that culminates in a description of the bacteria as seen in Figure 2. As the learner progressed through instruction they were taught to first identify a Gram-stain result, then a Gram-stain result and morphology, and finally an analysis containing all three criteria. This recall and build upon previous skills was one implementation of the first principles of instruction, specifically the activation principle.



**Figure 2.** Activation Principle as applied to Gram-stain analysis

### *Multimedia learning principles*

Mayer’s multimedia learning principles are focused on the management of cognitive load as it relates to the implementation of multimedia within instruction. Two of these principles, spatial and temporal contiguity, suggest that learning is enhanced when images are placed near and at the same time as related text (Mayer, 2001). Examples of the spatial contiguity principles and the temporal contiguity principles can be seen in Figure 3. For example, if instructional content was too long to allow placement of an example image near the text then content was broken down into smaller chunks in order to maintain compliance with the spatial and temporal contiguity principles.



**Figure 3.** Screen shot of Microbiology iBook

### *iOS Design Guidelines*

There is currently no dominant set of design guidelines for iBooks specifically or even eBooks in general. However, since iBooks is developed by Apple and displayed on the iOS operating system, the best option was to use the iOS design guidelines. Apple defines consistency, one of the HCI design principles, as “an app that takes advantage of the standards and paradigms people are comfortable with” (Apple, 2012). Apple includes their iOS standards as an example of acceptable paradigms. To follow this principle of consistency, the iBook was developed using a template provided by the iBooks Author application. Additionally, interface elements through the eBook, such as those seen in Figure 3, maintained design parameters such as look, interaction, size, color and relative placement to text throughout the instruction.

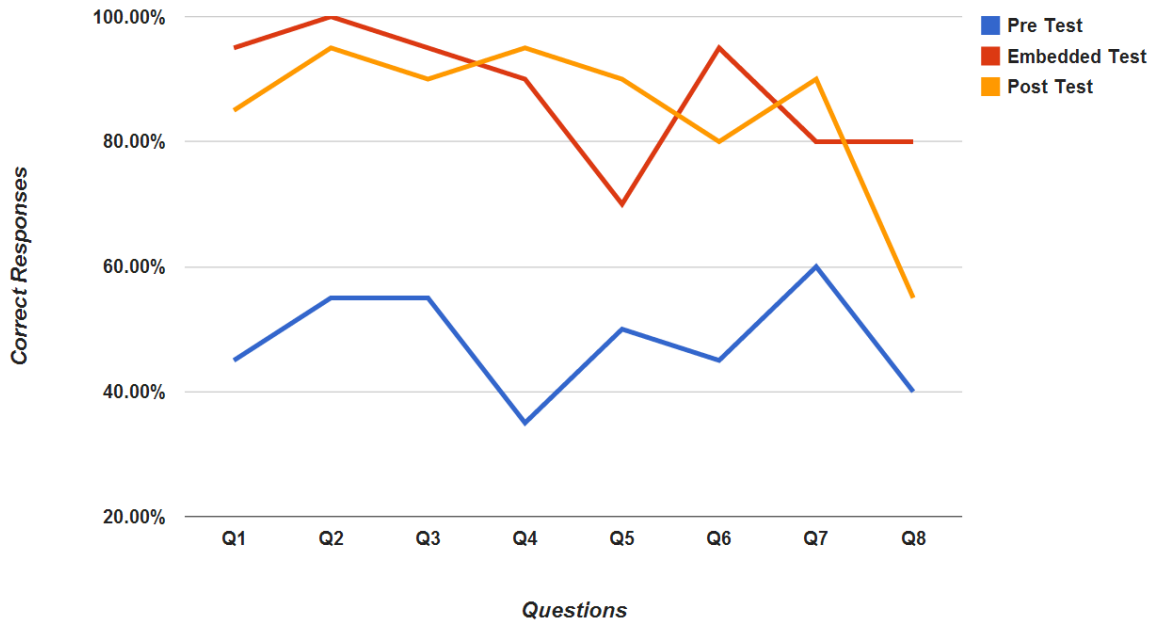
### **Evaluation & Reflection**

Five assessments were integrated into the instruction including a pretest, posttest, and three quizzes embedded after each module. Instructional assessment items included two questions on Gram-stain results, two on morphology, three on bacterial arrangement, and a final question testing a cumulative skill assessment.

Two survey instruments were also added to the iBook. The pre-instruction survey measured the learners experience with Apple products generally, iBooks specifically, and a Likert-scale question measuring confidence in Gram-stain analysis. Upon completion of instruction the post-instruction survey retested the learner's confidence level with Gram-stain analysis then asked two open-ended questions soliciting comments and any problems experienced using the iBook. The results of these assessment and survey items

were used to evaluate the use of the first principles of instruction, multimedia learning principles, and iOS design guidelines in the development of the iBook.

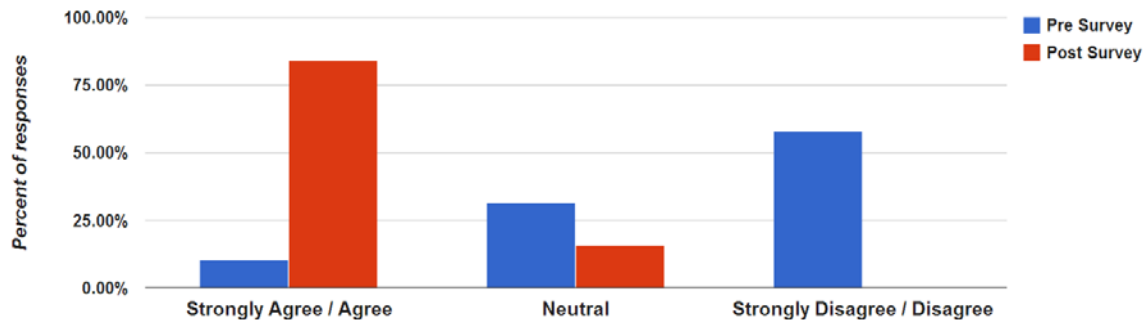
According to the assessment data, represented in Figure 4, all 20 students improved on their ability to analyze Gram-stains throughout the instruction. The average pretest score was 45%, embedded 88%, and posttest 85%.



**Figure 4.** Gram-stain pre, embedded, and posttest assessment results.

The lowest scoring question on the post test was the culminating skills test. This question asked the learner to identify all three assessment items from a single gram stain. The majority of students were able to identify the gram result and bacterial shape, but confusion seems to arise from the bacterial arrangement.

Participant responses on confidence performing a specific Gram-stain analysis show large gains as seen in Figure 5. Of the 19 participants who responded to both pre and post questions, when asked if they could identify Gram-positive staphylococcus, 11% answered strongly agree or agree in the pre survey and 84% in the post survey.



**Figure 5.** Confidence identifying Gram-positive staphylococcus

Sixteen respondents reported no difficulty while using the iBook. Of the four respondents who commented on problems, two expressed issues analyzing images due to quality and color clarity. The remaining two participants had problems with navigation saying, “Some of the chapter pages only included the title. At first it was unclear as to what I should do, then decided to flip the page. I think I'm still adjusting to using iBooks.”

### *Reflection*

First Principles of Instruction proved to be an impactful theory for the Microbiology iBook. The assessment outcomes and positive responses from participants showed that it was educationally effective, enjoyable to follow, and raised participant skill confidence levels. The breakdown of instructional content fit well within the structural per page content limitations of the iBooks format. While promising, more evidence-based research should be done to assess the use of these principles for eBook development broadly. Additional theories should also be used for augmenting the instructional design principles to take advantage of other eBook capabilities such as social networking.

The multimedia learning principles also proved to be an effective theory, and easy to implement within iBooks Author. However, comments from participants regarding clarity of images suggest that an additional multimedia principle should be considered. The author suggests the following principle for testing:

- Resolution principle: Learning is enhanced when multimedia content is greater than or equal to the screen resolution of the device it is being viewed on.

The iOS design guidelines also proved effective for the iBook. Despite only half of participants having experience with the iBooks format, only two comments included problems with the interface regarding navigation. This suggests that while generally effective, either the instruction needed to provide additional navigation support or that the default templates may require minor modification. While specific iBook design guidelines may be more effective, the iOS documentation proved a suitable substitute, and should be followed for iBook development to maximize the learning experience. In general, the author recommends using the platform specific design guidelines when possible.

### **Conclusion**

The first Microbiology iBook prototype proved quantitatively and qualitatively successful using the pre-existing educational theories and developmental guidelines. However, there is an identified need to expand current theory to include concerns specific to iBook development and eBooks in general.

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doi:10.3109/17453054.2012.747173