

An Exploratory Study of Computer-Based Instruction Utilizing iFARM Modules in a College Introductory Agronomy Course



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Abstract

The purpose of this study was to describe an educational agronomy curriculum developed for an introductory crop production course at a land-grant university. The iFARM (Interactive Fundamental Agricultural Resource Modules) modules were created to display a similar teaching platform for an introductory agronomy course, which is offered in both the Fall and Spring semesters. The Spring course is often limited to inside labs due to inclement weather. The iFARM modules were a set of 13 agronomy-related modules developed to provide educators an alternative form of instruction to enhance students' experiences. Five semesters of 226 individuals consisting of primarily freshman or sophomore males from the College of Agriculture completed a questionnaire at the end of the course. Of the 226 students, 79% reported the modules were useful for their learning; while 21% thought that the modules did not contribute to their learning in the course. When comparing students' perceptions of the learning experiences using post-test scores for the Fall and Spring semesters average post-test scores, there was a noticeable difference which could be attributed to the modifications in instruction from the Fall semester to the Spring semester ($d = 0.83$, large effect size). The study concluded that students experienced an overall positive learning experience while using the iFARM modules and the modules were somewhat effective in teaching the participants new material.

Introduction

Educators are under increasing pressure to reexamine their teaching positions as well as to improve the development of effective teaching

strategies (Miller and Powell, 1998; Miller, 1997; Diebel et al., 1998). Students need to be provided with choices in instructional methods to maintain motivation and attention and to address the different learning styles (Miller, 1997; Seiler et al., 1997). College undergraduates realize the importance of computer literacy and they are growing up in an information-based society that requires knowledge of computer technologies to succeed both personally and professionally (Sanders and Morrison-Shetlar, 2001). Online-learning using games, simulations and case studies have tremendous potential to initiate and link opportunities for students and educators to real-world situations. These experiences enable students to achieve higher-order thinking processes. Decision-making and problem-solving skills are essential elements of learning within the agricultural science disciplines. By the creation of multi-media replicas that demonstrate real-world experiences students and educators benefit directly by combining lecture with practice.

Technology in the university classroom has made great strides in the area of presentation of materials for both educators and students. Those educators that have explored this resource have experienced a rapid transition from typical lecture type formats, to interactive student centered Internet courses (Oliver et al., 1998). This transition requires instructors to develop new skills for curriculum development and delivery and to keep up-to-date on the quickening pace of technology adoption and change in the computer areas (Diebel et al. 1998; Miller and Powell, (1998). James et al., (2000), in a project involving

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applications of technology to teaching science, mathematics, and technology, stated that strategies for improving instruction should include “active learning environments.” Milheim (1995) stated that “interactivity is one of the most important factors in the design and development of effective computer-based instruction materials” (p. 225). Born and Miller (1999) and Whittington (2004) stressed that students learn what they practice. By operating computers to solve problems and learn content, students obtain valuable experience they need to perform optimally in the agricultural work-place.

In an active learning setting, technology has the power to support students and teachers in obtaining, organizing, manipulating, and displaying information (Means and Olson, 1994). The Internet and a variety of emerging communication, visualization and simulation technologies now offer students active learning experiences ranging from experimentation to real-world problem-solving. Students say they are motivated by solving real-world problems, they often express a preference for doing rather than listening (Lombardi, 2007). The use of realistic activities within online learning environments has been shown to have many benefits for learners in online units and courses; many courses have been based on complex and sustained scenarios and cases, where students become immersed in problem-solving within realistic situations resembling the contexts where the knowledge they are learning can be realistically applied (Herrington et al., 2003).

There has been much criticism about science, technology, engineering and mathematics (STEM) education not focusing enough on hands-on application, especially in authentic real-world contexts (Pierrakos et al., 2010). Past research has indicated that most students show little evidence of using critical thinking abilities when solving problems (Cano and Martinez, 1991). Furthermore, researchers have identified cognitive deficiencies that characterize poor problem solvers, with a passive approach to learning as an underlying causal factor (Chance, 1981; Rudd et al., 2000). Rushton and Jenson (2005) and Fuerstein (1980) believed that intellectual capacities were not entirely determined by heredity and that cognitive performance could be positively influenced. Real-world application is where relevant problems are introduced at the beginning of instruction and used to provide the context and incentive for the learning that ensues.

Computer-based instruction allows self-paced learning and evaluation, offering

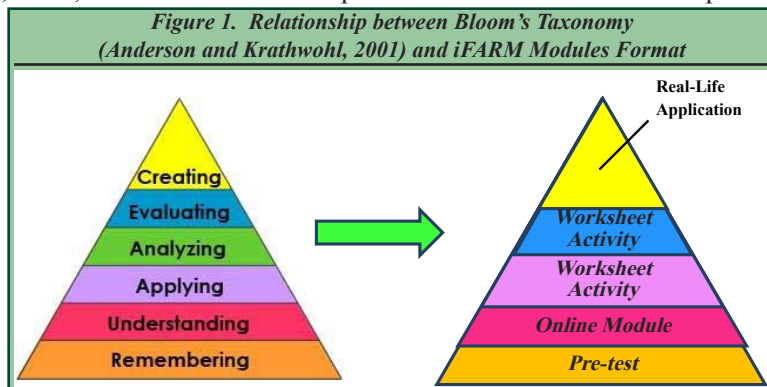
students some immediate feedback on their abilities to comprehend the information. Computer technology is very different from any other teaching tool we have ever known (O’Kane and Armstrong, 1997). An interactive approach to instruction which employs hands-on activities should help students gain success in the classroom. The modules: Interactive Fundamental Agricultural Resource Modules or “iFARM” were created to find a solution to help students learn scientific principles while thinking critically (Unruh Snyder et al., 2009). The iFARM modules provided students with an engaging way of learning using examples of how to apply content in real-world context which helped them pursue education and careers in plant sciences. The iFARM modules are a set of 13 agronomy related modules.

Conceptual and Theoretical Framework

The conceptual framework for this study was based on the six levels of Bloom’s Taxonomy model. The purpose of the model was to encourage students to “climb” higher in their level of thinking; meaning that once one level is mastered the student progresses to the next while never forgetting what they have already mastered. In the 1990’s, the model was restructured in order to update the taxonomy to make it more relevant for the 21st century student and teacher (Anderson and Krathwohl, 2001). The new model terms are (from lowest level to highest): remembering, understanding, applying, analyzing, evaluating and creating (Figure 1).

For the purposes of iFARM the pre-test administered was at the remembering level where students were asked to recall relevant knowledge from their long-term memory. The on-line iFARM module was at the understanding level where students constructed meaning from written terms and graphics. The next two levels, applying and analyzing, were addressed when students were asked to complete an activity worksheet where they used what they had learned to complete problems based on real-life scenarios. The evaluating level was accomplished when the students completed

Figure 1. Relationship between Bloom’s Taxonomy (Anderson and Krathwohl, 2001) and iFARM Modules Format



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their post-tests. The last level of Bloom's Taxonomy, creating had not been entirely mastered by the students of the course. This level was partly addressed by the post-test where the students were asked to put fundamentals together to form a functional whole but the other aspect of this level was a real-life application where the students used what they have learned to answer and work through real-life scenarios centered on the topics taught in the modules. The students were continuing to master this aspect of the level in their everyday lives.

The theoretical framework for this study was based upon the concept of active learning where the core elements of active learning are student activity and engagement in the learning process. Active learning required students to do meaningful learning activities and think about what they were doing (Knobloch et al., 2007; Bonwell and Eison, 1991). In short, active learning refers to activities that are introduced into the classroom. Active learning is often compared to the traditional lecture where students passively receive information from the instructor (Prince, 2004). The growing influence of constructivism as a philosophical approach to learning, as well as research studies and papers investigating alternative models of teaching and learning, have prompted many teachers in universities to implement more authentic teaching and learning environments (Herrington and Herrington, 2006). The challenge teachers have faced is to align university teaching and learning with the way learning is achieved in real-life settings, to base instructional methods on more realistic approaches (Anderson et al., 1996; Collins et al., 1989; McLellan, 1996; Cobb and Bowers, 1999). According to a study by Armstrong (1983), students who receive a formal education learn better when they are actively engaged in the learning process as opposed to those who do not partake in the learning process.

Purpose and Research Questions

The purpose of this study was to describe students' perceptions of the learning experience using an educational agronomy curriculum developed for an introductory crop production course. Modules were developed that included lessons derived from material relevant to the goals of the course, instructional materials, worksheets, visual aids and activities that cover the subject material relating to agronomy. Research questions examined included:

1. (R1)What were students' perceived learning experiences using the iFARM modules?
2. (R2)Was there a difference in test scores between Fall and Spring semesters?

The pedagogical objectives of the iFARM modules were to focus on achieving a scientific principle and a critical thinking objective. The scientific principle encompassing demonstrations of scientific methods being utilized in order for students to identify problems, formulate hypothesis tests, conduct and analyze data and derive conclusions. The critical thinking objective was for students to be exposed to complex problems based on evidence-based information throughout each module. The learning objectives of the modules varied according to the subject content represented in the 13 modules. However, the overall objectives were designed to help students: develop an understanding of crop production, become aware of agronomic resources and to improve their ability to identify (ID) crop and weed plants.

Methodology/Procedures

Crop Production (AGRY 105) focuses on the fundamental principles of crop production. The class and lab combine ways to apply technological advances in agronomy to active crop-production situations including: basic soils, agricultural meteorology and crop physiology and breeding. The course was offered every semester and meets two days a week for a 50-minute lecture and a lab once-a-week. The study was conducted in the Fall and Spring semesters of 2008 to 2011.

Interactive Fundamental Agriculture Resource Modules (iFARM) were utilized during the course of the semester as a tool to help retain information learned in both class and lab. Students participated in a pretest, worksheet and a post-test to complete each iFARM assignment. They were allowed to use the computers within the Crops Resource Center (CRC) room, located on the main campus, or any computer where they had access to the campus's main server.

Background of Study

The development of iFARM consisted of the following project team developers: subject-matter experts, content writers, an instructional designer and multimedia developers. The modules were built using the Flash software to create animations. Visual designers utilized Adobe Illustrator to draw the iFARM characters and every complex visual element within the modules. Backgrounds, 3-state buttons and dynamic text were included directly in Adobe Flash. These animations allowed the students to experience activities through moving objects to simulate their ability to do the activities thus experiencing experiential learning. The researchers started with a general storyboard utilizing basic PowerPoint as the tool to

tell the story of the animation, mimicking as close of replication of the plants or situations as possible for the flash designers to understand the correct biological diagrams and processes. The PowerPoint included each step of what the students were expected to complete. After the first phase of storyboarding was completed with PowerPoint, it went into the Flash software. Once the Flash modules were finished, they were tested and deployed embedded in an HTML page that was displayed within the learning management system.

The iFARM modules were first implemented in an introductory freshman-level agronomy course starting in the Fall of 2008 using the Blackboard website. After completion of the first six modules in the Summer of 2008 (Phase I), the last seven modules were introduced in the Spring 2009 (Phase II), for a total of 13 modules created over 2008-2009 (Table 1). The modules were delivered to AGRY 105 in the following semesters: Spring 2009, Fall 2009, Spring 2010, Fall 2010, and Spring 2011. Thus, in total 226 students participated over the three years.

Table 1. List of Modules Developed During Phase I and Phase II

Phase I	Phase II
U.S Cropping Regions	Plant Breeding
Soil	Reproduction
Climate	Seed Quality
Germination-Early Growth	Integrated Pest Management
Roots (Biological Nitrogen Fixation)	Residue Management
Stems and Leaves	Seed Calibration
	Precision Farming

*Modules were used in the AGRY 105 course (Crop Production).
 **Study conducted at Purdue University.
 ***Participants were from the semesters of Fall 2008 to Spring 2011.

Although the learning objectives were the same for both the Fall and Spring semesters, there were differences in the instruction of the course due to uncontrollable issues of the Midwest weather between the semesters. The Spring semesters had limited outdoor lab-based activities, while the Fall semesters had more opportunities to go outdoors to conduct additional lab instruction. As a result, the Fall instructor was able to do more hands-on outdoor activities where the participants were able to learn and practice the techniques being taught while also using the modules as a second teaching method. However, the Spring semester relied more on the modules with few hands-on outdoor activities. The weather barriers oftentimes lead to defining alternative ways of presenting the same content. While the objectives of this specific course were the same for both the Fall and Spring semesters, there were differences in the instruction of the course. Although students in the Fall semesters were offered the chance to go outdoors to participate in hands-on activities, the content of the labs was the same, the difference being that the

Fall semester students were able to use what they had learned in real-life scenarios.

Analysis of Data

Approval was obtained from the university’s Institutional Review Board and no identifying information was used in data analysis. Data analyzed for each student included the completed set of both a pre-test and a post-test of knowledge comprehension, as well as the iFARM evaluation questionnaire. SPSS 19 was used to analyze data. If individual students were missing, the student was removed from the study. Correct responses to content items, as well as a few demographical questions, such as: age group, gender, college major and school year classifications were analyzed. For Table 3, the responses were a Likert-type scale ranging from strongly agree to strongly disagree. Data were coded to combine agreed responses together and disagreed responses together. After coding was complete, data were imported into SPSS where percentages were calculated by conducting frequency distributions for both the Fall semesters and the Spring semesters. The total average percent agreed number was calculated by adding all three Fall semester percentages and dividing by three and then repeating the process for the three Spring semesters. Frequency distributions were conducted for the pre-tests and post-tests for both the Fall semesters and the Spring semesters. In addition to frequency distributions, paired t-tests were conducted to calculate significant differences in overall scores in both the Fall and Spring semesters. Practical differences were determined using effect sizes (Cohen’s d).

Moreover, qualitative responses were analyzed using an open-coding method, which included identification of unique themes. Conceptual labels were given to each data piece that personified the primary component of that piece. No identifying information was used in either the quantitative or qualitative data analysis.

Participants

The student population consisted of mostly under 20 (44%) and 20-25 (53%) year olds that were primarily freshman or sophomore males from the College of Agriculture from Fall 2008 to Spring 2011 (Table 2). Overall, 68% of the student population was male. Of these students most of them were enrolled in the course as a non-requirement for their majors.

Data Sources

The pre-tests and post-tests were developed by the instructor with questions based upon concept principles of the course. The data were collected using

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Table 2. Frequency Distribution of the Demographic Variables of the Population for Fall and Spring Semester in Introductory Agronomy Class (AGRY 105)

Variable	f	Variable	f	Variable	f
Age		Classification		College	
under 20	99	Freshman	72	Agriculture	161
20-25	120	Sophomore	53	Liberal Arts	2
26-30	7	Junior	17	Science	2
		Senior	28	Undergraduate Studies	4
		Not Specified	2	Not Specified	4
Gender		Major			
Male	153	Required	20		
Female	71	Not Required	152		

*Study conducted at Purdue University.

**Participants were from the semesters of Fall 2008 to Spring 2011.

summative evaluation to look at the efficacy within each module and the final assessment evaluated the overall use of iFARM. A few qualitative responses were also used to help address common themes in participants' responses. On the post-test, students were asked to comment on their learning experiences using the module; however, not all students responded to this question and if a student did respond to the question on one or two modules they were not consistent in answering the question on all modules. The use of these methods was to provide a comprehensive collection of data that delivered saturation of responses on iFARM.

Summative Evaluation

The knowledge pre-tests were administered to the participants prior to each module while the knowledge post-tests were administered at the completion of the module and related activities using the Blackboard

Table 3. Evaluation of iFARM Questions and Percent Agreed for Fall and Spring Semesters in Introductory Agronomy Course (AGRY 105)

Question	Fall (n=147)	Spring (n=79)
	Total Average Percent Agreed	Total Average Percent Agreed
The visual display of iFARM was easy to follow.	87.1	95.4
The delivery format of iFARM (interactive online module in Blackboard) was well chosen.	79.7	87.2
Important terms, concepts, and information were provided effectively.	77.1	84.7
The learning materials (worksheet, web-links, references, etc.) coordinated to form one cohesive program.	74.0	79.4
The use of iFARM stimulated my learning.	60.7	61.1
iFARM was useful for my learning.	64.5	71.5
Overall Mean (SD)	73.9 (9.8)	79.9 (12.2)

*iFARM (Interactive Fundamental Agricultural Resource Modules): a set of 13 agronomy related modules

**Study conducted at Purdue University.

***Participants were from the semesters of Fall 2008 to Spring 2011.

website. Both the pre-test and post-test were developed by the lead subject-matter expert to help participants learn what they were supposed to learn after using the instructional module. The final assessment of the overall use of iFARM was developed by the combined efforts of the lead module developer and an instructional design expert and administered as a hand-out at the end of the semester. The six Likert-type scale questions were written and organized in a way to provide information on the product's effectiveness (its ability to do what it was designed to do). The pre-tests, post-tests, and the final assessment were not pilot tested for reliability and validity prior to implementing them.

Results/Findings

iFARM Evaluation

R1: What were students' perceived learning experiences using the iFARM modules?

The first research question was to examine the students' perceived learning experiences of the iFARM modules. The students from all six semesters were asked the same six questions based on a Likert-type scale in regards to their overall experience with the iFARM modules. The six participating semesters were divided into their Fall and Spring semesters and depicts the percent of students that agreed with the six iFARM evaluation questions (Table 3). It is important to compare the percentages between Fall and Spring because the comparison is essential to know if there is a difference between how the Fall and Spring semesters viewed the modules due to the

fact that the Spring semesters were relying more on the information coming from the modules than the Fall semesters (Table 3). Based upon the overall mean of the Spring semesters 79.9% agreed with the six items asked in the evaluation while 73.9% agreed in the Fall semesters. The students in the Spring semesters had more positive perceptions of their learning experiences with the modules ($d=0.54$, medium effect size). According to the total average percent of students who agreed with the six questions: 95.4% thought that the visual display of iFARM was easy to follow in the Spring semesters while 87.1% agreed in the Fall semesters. During the Spring semesters 87.2% of students thought that the delivery format for iFARM was well chosen while 79.7% of the Fall semester agreed; 84.7% of Spring semester students thought that important terms, concepts and information were provided effectively; while 74.0% of Fall semester students thought that the learning materials coordinated

Table 4. Themes Regarding Students' Perceived Usefulness of iFARM Modules in Introductory Agronomy Course (AGRY 105)

Theme	Frequency (N = 226)	Example Quotations
Yes	34% (n = 77)	"I found it very useful and enjoyed it." "Yes, learned a lot." "Yes, I was an effective learning tool." "Yes I found it very useful and thought it was a great way to catch on to the information." "It was very fun and virtually interactive."
Yes, helped me learn new material.	45% (n = 101)	"Yes, it allowed me to see how the information we are learning in class can actually be put to practical use." "I learned much from iFARM activities and also I understood some modern methods which I haven't seen before." "Yes, it helped in understanding weather better." "Yes it taught me a lot I didn't already know."
No	18% (n = 41)	"Not really, it was a waste of time." "Not really because I know most of it already." "No, it had too many technical difficulties." "No, it is too difficult to use."
It was too simplistic for our age.	3% (n = 7)	"Some of the tasks were almost childish. Make them a challenge. Don't leave some of the questions for unlimited answers." "iFARM still seemed like a middle school activity."

*iFARM (Interactive Fundamental Agricultural Resource Modules): a set of 13 agronomy related modules

**Study conducted at Purdue University.

***Participants were from the semesters of Fall 2008 to Spring 2011.

to form one cohesive program; and 61.1% of Spring semester students thought that iFARM stimulated their learning. While 64.5% of Fall semester students thought that iFARM was useful to their learning.

All 226 students were given an opportunity to comment on their experience with individual iFARM modules in a qualitative format on the post-test. Themes discovered while analyzing student responses on whether or not the modules were useful. Table 4 illustrates the themes as well as example quotations of perceived module usefulness from the students. Of the 226 students 79% responded that they found the modules useful to their learning; while 21% thought that the modules did not contribute to their learning in the course with 3% of those students indicated that the modules were childish or too simplistic.

Knowledge Pre-test and Post-test Evaluation

R2: Was there a difference in test scores between Fall and Spring semesters?

The second research question was to examine the difference in test scores between the Fall and Spring semesters. Table 5 depicts the overall averages for the knowledge pre-tests and the post-tests divided into Fall and Spring semesters. Students who completed the modules during the Fall semester performed 73% as a grand average on the knowledge post-tests.

Students who completed modules during the Spring semester performed 68% as a grand average on the knowledge post-tests. Both, the Fall and Spring semester cohorts of students, had significantly higher post-test scores in comparison to pre-test scores, which leads us to believe that the modules were effective in teaching the participants some new material. In comparison between the two semesters, the Spring semesters' increase was less than the Fall semesters' increase.

Conclusion/Implications/Recommendations

College students reported the computer-based modules were beneficial to learning agronomy knowledge in an introductory course. Also, college students scored higher on knowledge tests upon completion of the modules for both, field-based labs and computer-based labs. However, students in the field-based lab section had higher knowledge than their peers in the computer-based lab only section. Results of this study are comparable to the findings of Marrison and Frick (1993), who found that the comparative effectiveness of computer multi-media to traditional lecture instruction as student achievement was essentially equal when taught using the computer multi-media form of instruction as compared to the field-based labs. Students shared they would like to learn using both computer multi-media and traditional lecture situations. Multi-media computer modules provide another venue for agricultural education teachers to supplement or replace a portion of traditional classroom instruction, thus allowing the teacher more time to attend to individual needs of students (Torres and Cano, 1994). The discipline of agricultural education lends itself well to the use of computer multi-media

Table 5. Overall Average of Pre-tests and Post-tests for the Fall and Spring Semesters for an Introductory Agronomy Course (AGRY 105)

	Pre-test Overall Average (SD)	Post-test Overall Average (SD)	Cohen's d
Fall (n=93)	61% (7.74)	73% (7.65)	1.59 Large
Spring (n=80)	60% (12.69)	68% (7.81)	0.76 Medium

*Study conducted at Purdue University.

**Participants were from the semesters of Fall 2008 to Spring 2011.

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because of the variety of courses and topics presented within the curriculum. The results of the study imply that the use of the iFARM modules as an additional form of teaching with lectures is a positive advantage for any agronomy course not just the introductory agronomy course discussed in this article.

This study further confirms previous research illustrating computer modules as novel strategies for the distribution of different concepts to a general audience (Smetana and Bell, 2011). Our findings also help to support the increasing use of computer-based instruction in classrooms. The use of the iFARM modules, which could be modified to allow use in numerous other classrooms and grade levels, could increase motivation and student involvement. There is a constant need for agricultural curricula that targets all grade levels and when used properly modules like iFARM can provide instructional tools necessary to achieve the objectives of college and university courses as well as other grade levels (Smetana and Bell, 2011). Instructional advantages in using modules in a college classroom permit the student to experience life-like situations in a realistic environment, conducive to active involvement. Because today's society is such an information based society the requirement of computer knowledge is both imperative for success in our personal and professional lives.

This study evaluated a small number of students, at a large Midwestern university, in an introductory agronomy course and cannot be applied to any other group of students using the same or an alternative form of web-based instruction. Our study can be used to look at how one class effectively incorporated computer-based instruction to enhance in-class activities to improve student learning and understanding of the course material. The goal of the modules is to increase knowledge on agronomy topics and it is known that long-term knowledge gains have more of an impact than short-term gains in knowledge. A limitation of this study is that it was not a quasi-experimental design that looked specifically at how the modules impacted learning. The difference in knowledge was for the entire course, which could have been contributed due to other factors and not just the difference in how the students experienced the labs. It could be beneficial to do a follow-up knowledge evaluation of the students towards the end of the semester instead of immediately following the end of the module and activity worksheet for retention purposes. Another limitation of the study was the weather during the Spring semesters limiting outdoor lab-based activities. It could have been beneficial to have similar weather both semesters in order to examine whether or not the result would have

been consistent from one semester to the next. Also, conducting reliability and validity tests for the pre-tests, post-tests and final assessment would have been valuable to the study.

For future iFARM analysis pre- and post-test questions should be analyzed for significant knowledge gain and loss per individual module in order to help determine what modules are more helpful for students. Future analysis should also be conducted to analyze what specific improvements should be made to individual modules. Also, it is recommended that more in-depth questions be asked of the students in regards to their opinions about the iFARM modules, context specific, on an individual module basis. Future studies comparing student attitudes among different components of the modules to better generalize student attitudes toward on-line modules are suggested. Finally, it is recommended that additional questions be asked in the questionnaire to better understand students' motivation and what components of the modules' were most beneficial for student learning. Student learning preferences should also be taken into consideration in a future study to help understand what types of learners will benefit more from the use of the iFARM modules.

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