Improving Online Interactive Modules: An Iterative Design Model

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Abstract— **With the promotion of online and interactive learning, instructors may be tempted to include arbitrarily the latest technologies into their modules without considering the ramifications on students and their learning processes. Instead, we propose that online and interactive modules should be carefully designed using multiple levels of review to ensure clarity of instruction, ease of use of interactive components, and engagement of the students with the material and any related activities. This paper documents the process to design and improve an online module using an iterative process involving instructional designers, student pilot tests, and a focus group. Feedback from these constituents enabled instructors to optimize instructional design to maximize learning opportunities and achievement in online environments.**

Keywords—iterative design process; student focus group; interactive online modules; cognitive learning; human geography

I. INTRODUCTION

Relatively recent changes in the focus of curriculum preparation from instructor-centered to learner-centered has put more attention on the deliberate design of courses and the development of content and assignments. In online courses, new technologies increasingly are being introduced to provide students with content and provide opportunities for students to interact with that content. However, designing new learning environments is challenging, and the center of attention tends to be on the delivery of new content through the technology rather than assessment of the impact of these new learning technologies on student learning [1]. Additionally, assessment of courses is often inadequate, poorly timed, and limited in the effect it has on course or module modification and improvement. While considered important, feedback on module design before it is delivered to students within the structure of a formal class is uncommon [2].

Using a cognitive theory framework, an online interactive learning module was developed for an introductory human geography course and as part of the development of a completely online textbook. The cognitive theory framework supports a multimedia design of educational materials [3][4][5] through which students can engage in meaningful learning when they actively process material through "selecting relevant words and pictures, organizing them into coherent pictorial and verbal models, and integrating them with each other and appropriate prior knowledge" [5]. This module is one of several developed that includes imagery, custom videos, readings, discussions, animations, interactive exercises, and assessments. In the module the integration of theory and applications takes place through activities in which theories and ideas are applied for use in practical situations to answer real-world geographic questions, bringing the course material "alive" for students.

The purpose of this paper is to document and analyze the iterative design process for the development and improvement of this online interactive human geography module. This iterative design process involved the input and feedback from Instructional designers (IDs), student pilot testers, and a student focus group. In the design process and improvement of the module, we obtained feedback in the three areas of (1) engagement, (2) clarity and ease of use of module elements, and (3) the ability of the module elements to assist in meeting learning outcomes.

This paper begins with the literature associated with a learner-centered approach utilizing a multimedia design, and the use of assessment and feedback to design and then improve modules that have a learner-centered focus. Specific examples of courses that have used an iterative design process or involved feedback from instructional designers and students in the course design process are included. Then, the design of the interactive module, based on a process of student-centered learning, created for the introductory human geography course is detailed. Next, we outline the use of an iterative design process using IDs, student pilot testers, and a student focus group that provided the basis for module redesign. We present the results and lessons learned from this iterative process. Finally, we conclude with the broader implications of this research on optimizing instructional design to maximize learning opportunities.

II. LITERATURE

Traditional curriculum preparation has conventionally focused on the instructor rather than the learner. That is, the instructor prepared the material for delivery and expected students to absorb the material through lectures, readings

and written exams. In recent years a paradigm shift has moved the emphasis from teaching to learning and to a student-centered curriculum with a greater emphasis on meeting learning outcomes and the ability for students to demonstrate skills and competencies within courses and modules. In the world of online courses this means that contemporary online learning development is moving away from courses with "pages of electronic text, to more deliberately planned learning designs, learning tasks, and processes structured in deliberate ways" [6].

Correspondingly, there is more of a focus on how learners learn and the design of effective learning environments based on best practices. The learner-centered model calls for active student participation and the use of multidimensional products to develop deeper understanding by students [7]. As technology has developed and become a more integral part of the distance learning environment, it has impacted the delivery of content, learning tasks, and assignments [8]. The ways by which information is presented and also the way in which students interact with that material are important. Furthermore, the medium employed can motivate and engage students as active and collaborative learners rather than just providing information to them. Multimedia instruction rather than "flat resources," such as static text documents, have been identified as an important element of high-level interactive engagement and student satisfaction [9][10].

The design of the online interactive module for this study is predicated on Mayer's research on cognitive theory-based assumptions regarding the way that people learn from words, pictures, and active processing of material (what Mayer considers the two elements of the "Dual Channel Assumption and the Active processing assumption) in computer-based multimedia presentations results in deeper understanding in learners [5]. This concept of knowledge transmission is based on a constructivist point of view where knowledge is constructed by the learner through activity [8]. This construction has led to the development of "new learning environments" or what Martens et al. [8] call "constructivist e-learning environments" in which activities are created to challenge students and provide them with realistic contexts so that students become intrinsically motivated to explore and control their own learning process.

Despite the shift in the teaching/learning paradigm and the rise of assurance of learning outcome assessments, there is a lack of available texts and other material to guide instructors involved in module design/redesign, and a lack of attention given to and results in terms of course improvement derived from the type of student feedback currently elicited [11][12]. Course-based student assessment, now commonly found at most accredited higher education institutions, is created to encourage instructors to examine their roles as course creators and to articulate their goals and objectives. The process of collecting student feedback through formal assessment of individual teachers and courses is widespread [12]. While there are other purposes for formal assessments, a significant function of this feedback is to provide instructors with information about their teaching, with the intention that they will use this feedback to improve their courses and enhance the effectiveness of their teaching. Most commonly, these student evaluation surveys take the form of automatically scanned standard questionnaires with questions like, 'The instructor is knowledgeable about the course material' and 'The instructor inspires interest in the course and course content', using a five-point scale ranging from 'strongly agree' to 'strongly disagree'. Customarily, course-based student assessment is done at the end of a semester, leaving no time for modification to be made to a module or course for that cohort of students or even the incoming cohort of students. Furthermore, research has shown that the test-retest reliability of students' evaluations is high, indicating that the performance of the teachers is not improving with experience, perhaps as a result of teachers and institutions not taking the student feedback sufficiently seriously [12]. While student evaluations and ratings of an instructor and course might be reliable, they do not in themselves lead to any improvement in the quality of teaching and the effectiveness of course content and course design [13]. Formative assessment is a well-recognized element of basic Web site design and publication, yet it has received limited attention in the literature on online module development [14].

In line with the cognitive theory for learning, course or module evaluation based on criteria that is co-operatively developed and focused on obtaining information about the quality and effectiveness of the module should be most constructive in course redesign. Additionally, some scholars believe evaluation should not be just a retrospective process, but it should be an integral part of module development, informing instructors before, during, and after the process, e.g., [2].

Designing and improving new learning environments is challenging. Much of the available research shows an emphasis on delivery of these new learning environments rather than on analysis, evaluation and process of development, e.g., [15]. Module authors need to consider design elements including perceived applicability, content organization and interaction, ease of use, and the potential for learner engagement [14].

Designers of new online learning environments rarely gain knowledge of how students will perceive the module and associated tasks before they are delivered to the students. Greenberg [16] asserts that quality assessments should be taking place during the design of the course and include the course creators. Some rare examples of this can be seen in Kingston et al. [17] and Lederman [18]. Kingston et al. [17] utilized mobile technologies and virtual fieldtrips to teach physical geography. Students who had taken the old module and completed the new module were given questionnaires and then participated in a focus group to investigate the effectiveness of the new technologies.

Improvements were made to the material based on student feedback. Lederman [18] also suggests that focus groups can be very useful for pre-testing educational materials as they "provide an opportunity for extensive commentary, unrestrained by the limits of a survey questionnaire or the student-teacher relationship which may affect course evaluations at the end of a class" ([18], page 126). Skye et al. [14] concluded that multiple methods of data collection could be used to provide information to module developers to improve modules and to address module ease of use, navigation and content. Based on the precedent set by these examples, in designing our module we used an iterative process that required design advice and inspection by IDs, student pilot tests, a student focus group, and refining of the module prior to incorporating the module into classes.

III. MODULE DESIGN

The interactive multi-media module design uses the concepts of space, place, and human-environment interaction to study the process of hydraulic fracturing (otherwise known as fracking) from a geographic perspective. The module requires approximately 30 to 45 minutes for completion. Hover texts and graphics provide the module with text explanations. Using a web-based format, the module lists the learning objectives and begins with a short reading of one to two paragraphs in length that provides an overview of the applied topic. Next, a three minute narrated animation illustrates the concept of fracking. This is followed by a short video, which discusses the geographic implications of the topic. Finally, a series of interactive exercises allows the student to explore the topic using geographic tools (e.g., visual examination, verbal descriptions, digital mapping, cognitive perceptions, and mathematical modeling). For several of the module elements described above, an interactive textbox appears to the right where the student is encouraged to take notes.

Different components in the module require different intensities of interactivity. For example the animation and videos require students to click to start or more forward. The multimedia uses animation, voiceover, and video to engage students in a different way than simply reading the content. Other activities have a higher intensity of interactivity. The clickable maps require students to be actively engaged in thinking about, manipulating, and actively participating in the learning through completing the exercise. An example of this is when students have to use a calculator embedded in the module to find the population change in Williston, North Dakota and Rifle, Colorado. Likewise, they have to click on the markers that show fracking violations in Pennsylvania and make active decisions about what information to use to contribute to the discussion on the blog tied to this activity.

The results of the interactive exercises are shared with the instructor and, in some cases, other students. The interactive exercises were developed using publically available software such as micromob, Scribblar, Google Earth and ArcGIS ™ (Figs. 1 and 2).

Figure 1. Interactive exercise using Google Earth

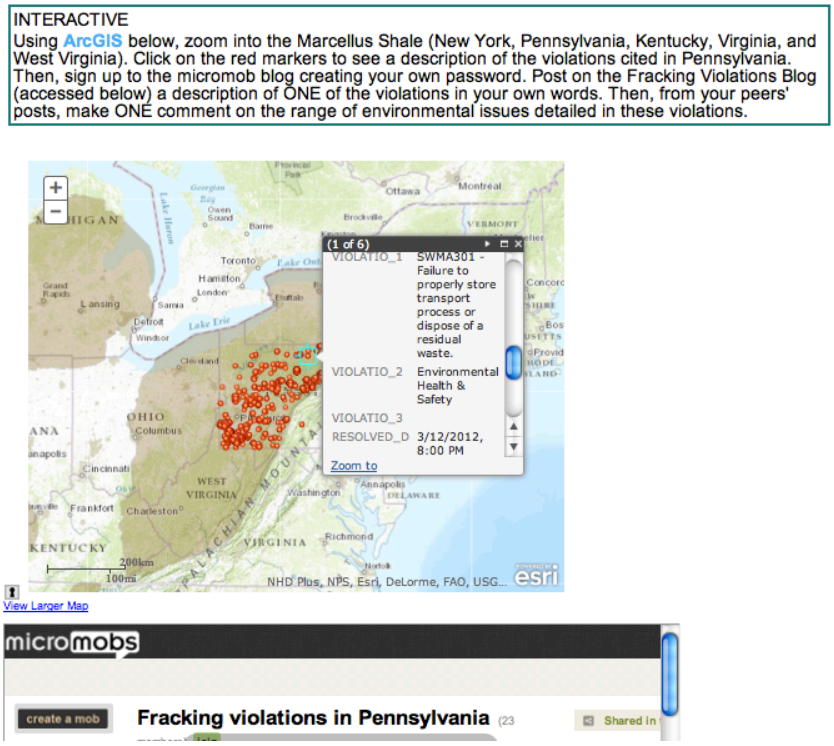

Figure 2. Interactive exercise using ARCGIS

IV. METHODOLOGY FOR ITERATIVE DESIGN DEVELOPMENT AND IMPROVEMENT OF AN ONLINE MODULE

In an iterative design process to develop and improve an online interactive human geography module, we engaged instructional designers, student pilot testers, and a student focus group. We focused on three areas for module assessment and improvement: (1) engagement, (2) clarity and ease of use of module elements, and (3) the ability of the module elements to assist in meeting learning outcomes. We also asked our IDs, student pilot testers, and focus group students to suggest general improvements to the module.

The online interactive module was created and evaluated in four stages (Fig. 3). At the beginning of the module's design, the instructors met with IDs from the University to gain knowledge about software (with a focus on free software) and design. After the module was designed the instructors met once again with the IDs to test for functionality of the module. Next, the module was pilot tested with three student volunteers. These students provided feedback on the module design and functionality. Finally, a group of 17 students participated in a large-scale pilot. As a group and simultaneously, each student completed the module in advance of the focus group interview.

The focus group students provided feedback on their engagement with the module, the clarity and ease of use of the different module elements, and how they thought the module elements assisted them in achieving the learning outcomes stated at the outset of the module (Fig. 4). Both members of the research team were present – one to serve as moderator and the other as a note taker who recorded speakers, comments and significant non-verbal behavior [19].

To address a potential a repercussion of focus groups, we had two mechanisms to minimize groupthink [20]. First, students each filled out a short questionnaire at the completion of the module. The questionnaire allowed us to obtain individual feedback that may not have come out in the group discussion but that might have been vital to improving the e-learning modules. Second, we asked the focus group members to jot down notes during the group interview. In the event students did not get a chance to share their comments, these notes were collected at the end.

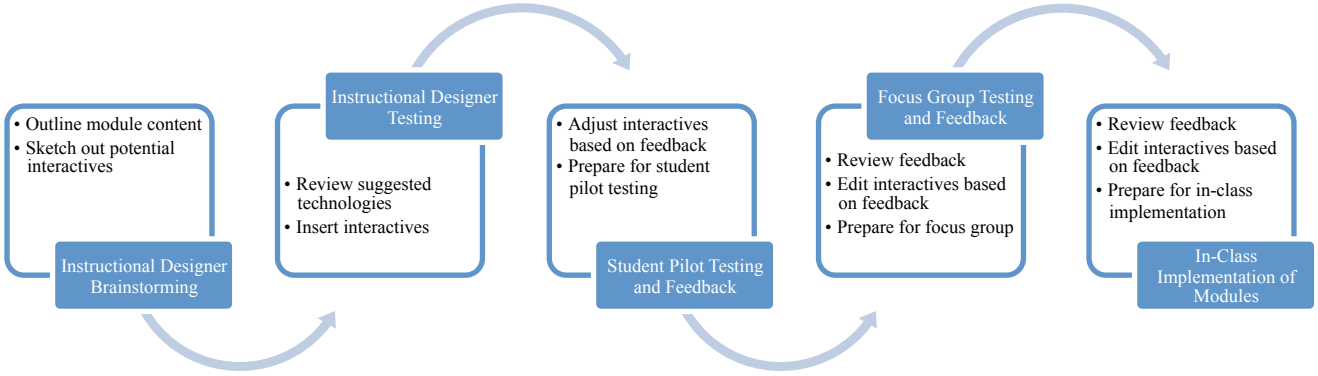

Figure 3. The Four Stages of Module Creation and Evaluation

Introductions

Facilitator introduces members of the research team and each of the group members introduce themselves. The facilitator provides the background and ground rules (confidential and anonymous reporting, honest opinions, etc.). The facilitator will inform the group that we would like to collect notes made by the participants during the session to ensure we collected as much feedback as possible, if the participants are willing.

Issues and Discussion Questions (Semi-structured)

Overall Impressions

- *Please share with us overall how you felt about the modules?*
- *What did you like about the modules? What didn't you like about the modules?*

Engagement

- *What about the material (videos, photos, readings) did you find the most engaging?*
- *How did the interactive exercises affect your interest in the content?*
- *Did any of the material or exercises make you want to learn more about the topic? If so, which and how?*

Clarity and Ease of Use of Elements

- *What concepts or parts of the module were the most clear? The least clear?*
- *What aspect of the interactive exercises did you find the clearest/easiest? What aspects were unclear/more difficult?*

Learning

- *Overall, how useful did you find the exercises?*
- *How did the interactive exercises assist you in understanding course content? In applying course content?*
- *How did the interactive exercises challenge you?*

Improvements

- *What improvements could we make to improve the elements of the modules?*

Summary of what we have heard

- *Have we missed anything?*

Collect notes (to review later).

Figure 4. Focus Group Questions

We reviewed the results of the surveys and interviews, coded the data and created categories to allow trends to emerge and to be able to develop summary statements that capture the essence of the responses [18][21]. The results of the coding offer two outcomes. First, the student responses helped us identify which of the interactive exercises had greater perceived value to students and which of the module elements need to be discarded or modified due to their inability to engage students and help them meet the stated learning outcomes for the module. Second, areas of confusion and lack of clarity were identified. The modules were then revised to address weaknesses.

V. Feedback and Discussion

Given the quality and content of the feedback from the three audiences, we concur with Greenberg [16] that assessment provided during the design of the course that include course creators can result in a quality outcome. Specifically, the feedback obtained for all design elements (content, clarity, ease of use, and engagement) were vital to ensuring the desired learning outcome could be achieved using these interactive exercises [14].

The iterative process allowed us to obtain feedback from different audiences and revise the module accordingly before we finalized it for in-class implementation. In the first three phases of feedback, we used the responses to modify the interactive exercises for clarity and ease of use. In the focus group stage, we not only focused on clarity and ease of use but also on engagement and ability to meet learning outcomes. In addition to these three areas, the focus group also provided feedback through general likes/dislikes, technical comments, and recommendations for the module. The students even recommended additional content they would like to see included.

The IDs' feedback from the pre-tests was mostly technical in nature and was intended to improve the student experience. For example:

- You might want to include an example of the word popper and explicitly tell students when they see blue text in following pages to hover over the word for additional information.
- You may want to add a comment above the animation, telling students to let each slide load before they try to watch it so there are no buffering issues.
- You may want to direct students to click "finish" after they take their notes so this is saved and ready to be submitted to you.
- I had issues getting the Google Earth plug in to download on my computer and ended up having to manually install it and restart the browser. You may want to take a second on the introduction page to tell students to download the plug in. This way they can have it installed and ready as they move through the lesson.
- You might want to expand the pixel dimensions of the calculator tool so students don't have to scroll in this box.
- I was able to comment on the blog, but once I submitted my comment I got kicked out of Softchalk to the actual blog page. I am trying to find alternative tools to help you accomplish the same thing. One option might be a tool called MicroMob (free, but students would have to register for an account).

The three student volunteers, who completed the pre-test, offered similar feedback but this time as representative users. Some comments from the pre-testers were:

- I tested the Module, but couldn't open Scribblar on my computer, but I think it was only a problem with my computer not the module itself.
- I was very impressed with the map interface, it worked well in conjunction with the activity.
- It was extremely helpful in learning about fracking and fracking sites when I was able to visualize what was talked about in the video from the lesson.
- On the cognitive map I was a little unsure what to do with the second drawing tool? So...I didn't really mess with it.
- I really like the blog section I thought it was cool but I wasn't entirely sure what to do. I think it's meant to be interactive with other students commenting on each others post, right?
- The map with the shale plays was a little difficult to read
- The layout might work better if you kind of separated the directions from the text? Or changed the lettering so it's easier to distinguish from the info?
- I really liked that you guys came at this from several different angles. I REALLY think that reinforces the information. Especially with the drawing.
- I also liked that you weren't exactly for or against fracking you gave different perspectives which allowed me (the student) to make up their own mind on where they stood. Unfortunately, I was already against fracking to begin with but had I never heard of if I'd be able to empathize with multiple sides.
- I like that I had to take notes during the YouTube video and that it gave me the option to print.
- I think it's important to have a basic understanding of the processes you're learning about so the intro video was very helpful and kind of set the foundation for the info that followed.

The focus group students provided a different set of insights, including their overall impression of the module, including likes and dislikes, their perceptions on clarity and ease of use, engagement with the material and their general perceptions of how the interactive components helped them to meet the learning objectives.

In general, the students comments related to likes and dislikes were distinctly separate. The students liked the interactivity and the way the interactive components made them “think about the material” and “made it clearer.” The dislikes mostly centered on technical issues such as wanting to break up the text and having to sign up for so many things (from free software).

Per the survey, the students indicated they would like to have more interactive exercises in their courses with 88% of students in agreement. The responses from both the survey and the interviews provided additional insight as to why the students would be interested:

- Because learning with visual and hand on exercise is much better than just reading a textbook.
- It helped get info across in a way a lecture might not- the added interactivity reinforced it by requiring me to put forth the lesson I had just learned.
- More and more learning is occurring online, but there is only so much one can take from online classes. Interactive courses like this may increase the level of participation.
- …Interactive material like this is great, especially for learning complex material in a brief snapshot, which this achieves remarkably.
- It takes learning to another level…drawing a map uses a different part of your brain and it forces you to kind of think critically about the subject matter.

From the survey, students overwhelmingly believed that the interactive exercises helped them to learn more (Fig. 5). They also indicated that the interactive activities helped them to describe the process of fracking (Fig. 6) and the activities helped them to use the geographic tools to explore fracking from a geographic perspective (Fig. 7). They were less certain, but still positive that the interactive exercises helped them to apply the geographic perspectives to fracking (Fig. 8).

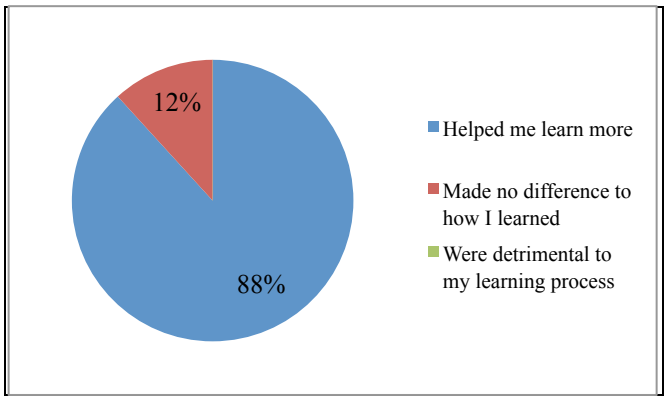

Figure 5. Overall, the interactive exercises _____.

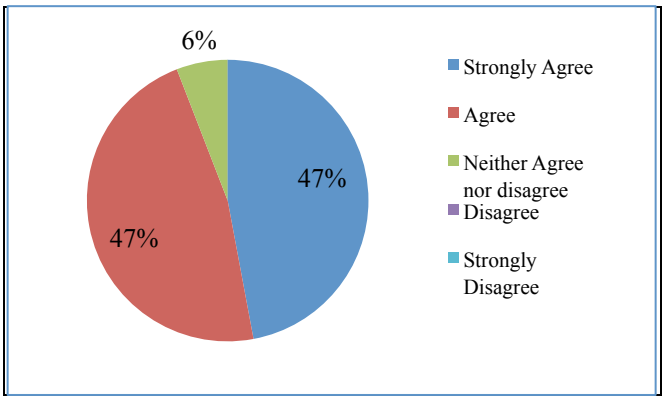

Figure 6. The interactive exercises helped me to describe the process of fracking.

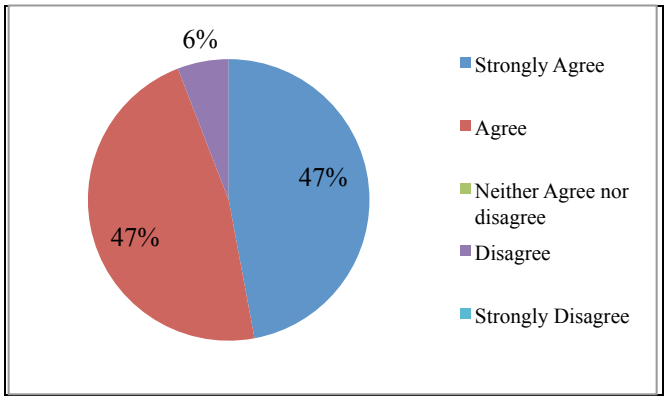

Figure 7. The interactive exercises helped me to use the geographic tools (visual verbal, cognitive, mathematical, digital) in exploring fracking from a geographic perspective).

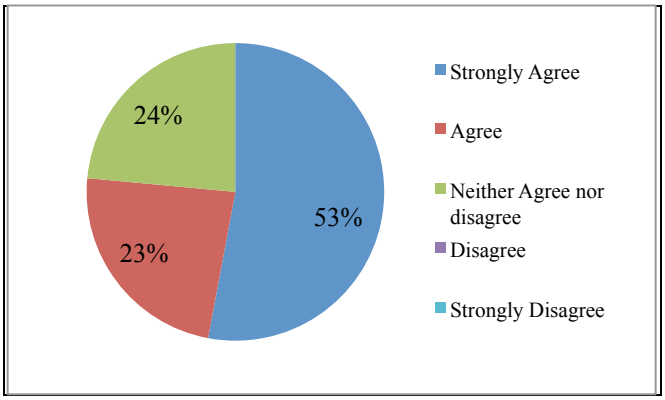

Figure 8. The interactive exercises helped me to apply the geographic perspectives (space, place, human-environment interaction) to fracking.

The feedback from the focus group interview was similar. When asked "if the material had just been presented as text, would you have learned as much?", the response was a resounding 'no!'. Opinions on the level of interactivity and how it helped students meet learning objectives was mixed. A few students responded that the lower intensity interactive really (video and animation) were instrumental in helping them learn the material.

Additional comments regarding the ability of the interactive exercises to assist students to meet learning outcomes included:

- Use of maps and aerial photography helped to contextualize this information. I can see where fracking occurs and what impacts on environment and population it has.
- First it [the module and its interactive activities] explained what space and place meant, then gave an example of each. Then the human-environment interaction.

The students rated the clarity of the interactive exercises in categories of Clear, Somewhat Clear and Unclear (Fig. 9) with the visual and verbal components offering the most clarity. For the mathematical and cognitive components, less than 50% of respondents were confident in how to utilize the interactive activities. In reviewing the comments associated with these activities, we realized that technical issues and perception caused a problem for the students. For instance, there was no mechanism to store the answers for the population growth calculation so when students had to answer questions, they had forgotten the specific numbers. Additionally, the calculator did not appear in one of the Internet browsers on campus, which limited the students' ability to fully utilize the module. While Scribblar™, the drawing software, allowed students to be working simultaneously on their cognitive maps, it did not allow for real-time edits. Students also requested the ability to return to view and discuss each other's maps. This feedback helped us to hone in on the elements in the module that had the least clear instruction and/or software to use.

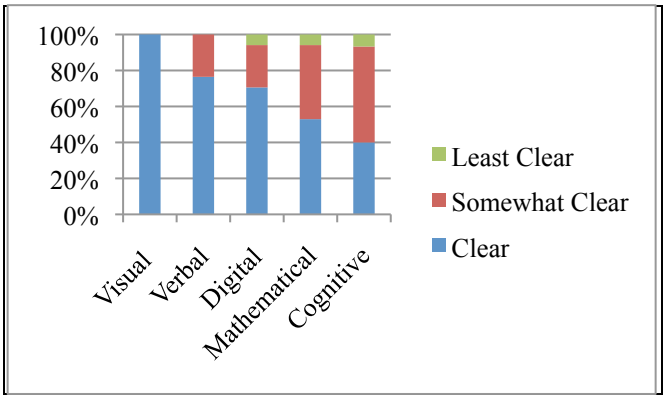

Figure 9. Student rating in terms of Clarity

The students also rated the interactive activities in terms of ease of use (Fig. 10). The mathematical and cognitive maps exercises rated more difficult than the others.

> The scribbler page was time consuming and a bit frustrating, but not bad. For the math exercise, it would have been much easier had the chart and the calculator been on the same section of the page so that the user doesn't have to scroll up and down while remembering the numbers.

The response to the math difficulty appeared to be technical while the cognitive interactive exercise may have been a combination of both technical frustration and conceptual reach as it is often a difficult concept to grasp. Furthermore, students had the most trouble with the free software program used in this section. We recognize this is the case and have modified that section of the module to improve clarity in both instruction and ease of use by changing the software used to capture the cognitive maps drawn by the students. We also provided a textbox for students to type in the results of their calculations for easy reference when they are answering the follow-up questions.

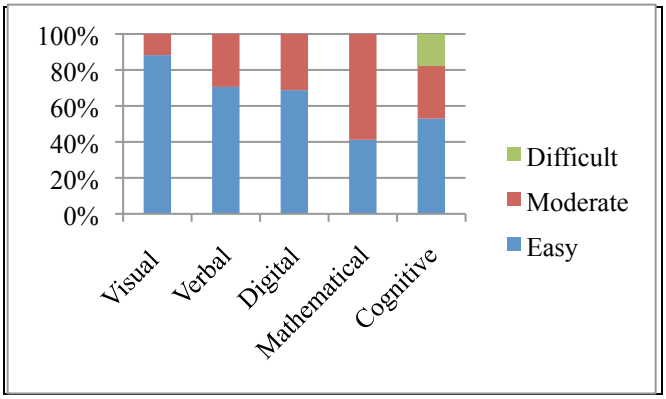

Figure 10. Students' rating of interactive activities in terms of Ease of Use.

The students' reactions to the multi-media interactive components and how it inspired creativity, was consistent with the notion that students have a higher satisfaction and engagement rate using these technologies [9, 10]. The students repeatedly referenced the animation, the news video and the cognitive map exercise. The animation and video seemed to be most helpful in describing the process and providing additional background, while the cognitive map drawing exercise was seen as helpful because it inspired creativity. The students also found value in the quizzes and calculator based exercise.

Regarding the Google Earth™ interactive, the students discussed how they explored and looked at other areas outside of the ones that they were directed to study to see how fracking was evident on the landscape. For the GIS-based exercise, the students also commented on some other data that could be incorporated to give additional insight in the impact of fracking to the region. These types of comments indicate that the interactive module did create a constructivist e-learning environment where students were motivated to explore the subject matter further on their own [8].

One comment we found particularly insightful was the recognition that the various components and levels of intensity of the interactives reinforced learning by touching on various learning styles.

> I think it hit on those components more so than you could in a normal classroom. My whole life teachers have told us there are various learning styles. Some people are audio, others are visual and some are Kinesthetic learners. This module kind of hit on all three of those so just in case you cannot keep your focus to listen to a seven minute video, you have a map to draw to reinforce the concepts you may have not totally gotten from just listening.

Further evidence of the students' engagement was how they provided us with multiple suggestions on additions to the material and interactive content. The students were engaged in the material to the degree that they began thinking of other ways to present and expand on the content covered in the module.

Finally, in both the focus group survey and the discussion, students provided excellent technical recommendations to improve the modules. Notation of these specific items were made and we have edited the module to integrate these suggestions to the best of our ability.

VI. LIMITATIONS AND RECOMMENDATIONS

We recognize that the development of the module and the focus group testing had limitations. First, we were dependent upon the use of free software in developing the interactive modules. This was cumbersome for the students and the instructors as we had to test out a variety of software packages to find the "right" match. Since the modules in the textbook will have many of the same interactive activities, once we have resolved the software issue and/or have

software developed specifically for this purpose, this limitation should be resolved.

Second, the students were asked to complete the module as part of a combined and timed class session. Because of this, student feedback to each other in the cognitive mapping interactive and the ArcGIS™ blogging exercise was limited and the full scope of the interactivity between students was virtually non-existent. We recommend spacing the focus group participation over a series of days so that the interactivity can be fully explored.

VII. CONCLUSION

The iterative process of gathering formative assessment feedback was essential to the improvement of the module. We suspect that often instructors assume that as long as the material is presented, the students should be able to navigate and succeed given the intent. A severe limitation of online content is that instructors do not gain immediate feedback from students unless there is a problem. And then, it is often too late for the instructors to efficiently address the problem without slowing the pace of the class down and confusing and frustrating the students. The idea of obtaining feedback prior to implementation is not innovative or unique; instead it is the exception rather than the rule, e.g., [14][2].

Through the iterative review process, we gained knowledge through the various audiences that would not have been attained through simple implementation of module in class. The IDs provided multiple levels of feedback. In the initial brainstorming session, they offered ideas on technologies and software that might be useful for the interactive components. Utilizing the IDs as a resource was key as it opened up possibilities we had not considered and their expertise in this arena offered insight into what works for students. They also tested the technologies for us. From an end-user perspective, the pilot student group provided us with feedback for functionality and learning. The focus group enabled us to see how a broader sample of multiple learners experienced the modules [18].

Educational delivery models for college courses have changed. Contemporary educational delivery models include online and distance education; however, there has been a gap in the assessment of these learning technologies of their impact on student learning [22]. In the development of learning modules for students in online courses there is room for an iterative design process whereby advice from IDs and feedback from students can and should be taken into consideration.

Ongoing assessment of a course can allow faculty to systematically incorporate feedback from all involved in the teaching and learning process, adding to, replacing, correcting, and improving an ever-growing body of learning materials and best practices. In each redesign of a module or, on a large scale, course shifts can be made towards making it more active and learner-centered [23].

Educational research of this nature tackles the fundamental question of how to optimize instructional design to maximize learning opportunities and achievement in online and distance learning environments [24]. Thus, by enlisting instructional designers and students in curriculum development, we expect to improve the module content and interactive activities by directing revision based on their feedback. While the overall assessment by the IDs, pilot testers and focus group students indicated that interactive activities in the module were perceived favorably by the students and likely required only tweaking for clarity and ease of use, an ongoing consideration should be whether or not the interactive activities are helpful in delivering content and developing desired skill sets. As such, research on perceived and actual learning outcomes should be conducted.

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