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Development of a Prototype Computer-Based Instruction Module: Foundational Neuroscience for Physical Therapy Students

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ABSTRACT
This paper details one faculty members approach to developing a prototype module for a computer based instruction (CBI) course in foundational neuroscience for physical therapy students. The process was based on the generic instructional systems design model, ADDIE. ADDIE is an acronym for Analysis, Design, Development, Implementation, and Evaluation. Each step has an outcome that feeds the subsequent step or results in modification of the prior step in order to reach the desired outcome. The analysis section summarizes the state of the global academic environment in health professions education and the environment at the University of Nebraska Medical Center (UNMC) where the project took place. Events that led to development of the CBI course module are described and results of a national and local survey analysis to determine the level of interest in a CBI course for foundational neuroscience are reported. The design section outlines formation of the design team for the CBI module and describes the pedagogy of the module. Development explains the rational for determining the mode of CBI delivery, reports the amount of faculty time required for module development, and lists the equipment needed and skills required. Implementation reviews the process employed for peer validation of content and for student editorial feedback. Evaluation consists of a summary pre and post-test of results and qualitative feedback provided by test students.

INTRODUCTION

Neuroscience is integral to the curriculum for physical therapy students.[1] It is part of the foundational information required for learning examination and intervention procedures with patients. Traditionally, neuroscience courses for physical therapy students have been taught via traditional lecture and laboratory methods. However, a current trend in education is to integrate technology into the classroom in a variety of ways.[2]

This trend is echoed in the critical success factors for enhancing and expanding the educational environment as a component of the Strategic Plan at this author's university. One of the specific goals mentioned is to apply technology to improve education.[3] In addition, faculty are encouraged to develop educational scholarship as a cornerstone for improving learning experiences[3]. A plethora of research over the past several years has been published comparing the effectiveness of computer based instruction (CBI) to traditional methods4,5. In spite of this, there is no conclusive evidence supporting the exclusive use of either instructional approach. This is particularly true in the specific area of teaching neuroscience to physical therapy students where no research comparing the effectiveness of instructional methodology has been published. General benefits of CBI have been reported. These include: the ability to provide immediate feedback,[6-8] self-paced (asynchronous) learning[6-10] and incorporation of graphics to illustrate visual concepts.[6,11-13] The ability to incorporate moving graphics to demonstrate concepts is believed to be one of the more valuable components of CBI because it may enhance student learning.[6,11-14] Graphics enhanced CBI may be especially beneficial for teaching subjects such as neuroscience because of the visual, dynamic nature of numerous concepts.

Based on this information, it appears that development of the CBI format for students is a critical component of any study attempting to compare the effectiveness of CBI relative to traditional lecture. Therefore instructional design would be a key factor in a study of this nature. There are a multitude of instructional systems design models, but the majority are based on the generic "ADDIE" model.[15] ADDIE is an acronym for Analysis, Design, Development, Implementation and Evaluation. Each step has an outcome that feeds the subsequent step. When developing a CBI course, one recommendation for best results is to use a modified ADDIE model, which incorporates a more holistic, iterative approach to CBI module development.[15] Insertion of a rapid prototype CBI module development phase as an extension of the overall course design phase is encouraged in this approach.

The rapid prototype is a quickly assembled module that can be tested through peer and student evaluation early in the instructional design process. Based on feedback, the module design can be revised until there is confidence in the prototype. Once the prototype is completed, subsequent modules can be formulated more efficiently since the developers are assured of the intent and capabilities of the program. In addition, since major technical issues have been resolved, completion of the remaining modules becomes a fairly simplistic process.

Thus, the intent of this paper is to describe an example of development of a rapid prototype CBI module in foundational neuroscience for physical therapy students with the eventual goal of comparing the effectiveness of CBI to traditional teaching. The remainder of this article will provide a detailed account of the process which was based on a modified ADDIE systems design model.

METHOD

The analysis, development, implementation, and evaluation aspects of the ADDIE model each contained research elements. The analysis portion included two surveys: 1) a survey of all accredited physical therapy programs in the United States was implemented in order to gather information concerning the present state of basic neuroscience instruction for physical therapy students and to determine the extent to which computer based instruction is being used in neuroscience curricula, and 2) attitudinal surveys of two classes of physical therapy students at the author's institution who had previously taken the traditional neuroscience course. The intent of the student surveys was to determine: 1) whether anecdotal student comments expressing dissatisfaction with the present neuroscience course format were representative of the entire class, 2) if students might be interested in a CBI neuroscience course as an alternative to the present (traditionally taught) course, and 3) if students had previous experience with CBI courses during their undergraduate education.

The development portion included a summary of project costs in terms of hours and monetary costs for software. The implementation portion included a summary of feedback from prototype reviewers and states average time spent by the student reviewers working through the module. Lastly, the evaluation portion included both quantitative and qualitative assessment of the prototype module by a cadre of fourteen physical therapy program students who were currently taking the traditional neuroscience course. The quantitative assessment involved comparison of the pre and post-test scores achieved by each test student. The tests each consisted of six multiple choice questions (four foils/question), with two points awarded for a correct answer. The qualitative evaluation consisted of a survey of students after they had completed the module.

Data Analysis

A dependent T-test was used to analyze the results of the pre and post-test scores for the fourteen students who evaluated the prototype module. The survey results and other findings related to components of the modified ADDIE design model are summarized in the results section.

RESULTS

Survey results for the analysis portion of the design model are summarized in tables 1 and 2. Table 1 summarizes the notable findings of a survey of all accredited physical therapy programs in the United States concerning the present state of basic neuroscience instruction for physical therapy students and to determine the extent to which computer based instruction is being used in neuroscience curricula. This survey was sent to program directors during the fall of 2000 and spring of 2001. The cover letter requested that the director pass the survey on to the faculty member responsible for teaching neuroscience. Out of 181 survey's sent, 130 were returned for a total return rate of 72%. Follow-up questions were included in the survey for individuals who answered in the affirmative to questions #2 and #3 in Table 1.

Table 1. Summary of Basic Neuroscience for Physical Therapy Students Curriculum Survey of Physical Therapy Programs in the USA.

	% of affirmative responses	% of negative responses
1) Are any CBI aids utilized for neuroscience teaching?	59%	41%
2) Has CBI use effectiveness for any course in your program curriculum been analyzed?	10%	90%
3) Do you have an opinion concerning the effectiveness of CBI for teaching neuroscience?	55%	38%*
4) Would you be interested in a CBI program for teaching basic neuroscience topics?	81%	19%

* 7% of those surveyed did not respond to this question

Table 2. **Summary of Survey of UNMC Student Attitudes Concerning the Neuroscience Portion of the First Semester Curriculum**

Question	Mean Response (based on a 5 point Likert Scale, 1=Strongly Agree, 5=Strongly Disagree)
1) The neuroanatomy portion of the CBA 571 course presented an appropriate amount of information in the time span allotted.	4.06
2) I adequately comprehended the material presented in the neuroanatomy portion of CBA 571.	4.08
3) The resources available for supplemental instruction in the neuroanatomy portion of CBA 571 (A-V room, library, instructor availability) were sufficient.	3.45
4) Do you think a self-paced computer assisted instructional program (CAI) would be a desirable alternative for teaching the neuroanatomy portion of last semester's CBA 571 course?	2.48
5) Do you think you would have used CAI supplements if they were available when you were studying for neuroanatomy?	1.81
6) Have you used a computer based instructional program as a supplement to learning material for a course previously?	1.33*
7) Have you previously taken a college course or courses in which a CAI program was used as the primary means of delivering the information?	1.67*

* Questions #6 and #7 requested a **yes** or **no** response, 1=yes, 2=no

The follow-up question for #2 in Table 1 asked the respondent to briefly summarize their findings (if they felt comfortable sharing the information) or cite the reference where the results were published if available. Only five comments were made and no citations were provided in this section. The lack of literature references was consistent with the findings of a literature search conducted during the preliminary stage of this project. The specific comments were as follows:

> "Students are given assignments involving CD-ROM's each week. They are not discussed in class, yet they are tested over the material. The students who are engaged to demonstrate self-motivation do well when tested."
>
> "It took a lot of time, money and effort to develop (CBI). Our study showed it was equal to amount of learning achieved by traditional methods."
>
> "The course survey revealed Web Atlas provided good example of MRI images."
>
> "Class surveys were taken over past 3 years to assess use of multiple sources- models, anatomical specimens & computer programs. Students liked the guided and self-directed study component. Grades over past 3 years are about the same. Satisfaction level is higher and allows broader base of resources."
>
> "Currently analyzing a first year course (no neuro content). Students seem better prepared for lab (hands-on) sessions."

The follow-up question for #3 in Table 1 requested comments if they did indeed have an opinion. Sixty-one out the 71 respondents to the affirmative offered comments. All comments except one were in favor of using CBI. The vast majority expressed that CBI was most valuable as an adjunct to traditional lecture and laboratory teaching methods. No one suggested that CBI should be used as the sole method of teaching neuroscience. The lone negative comment was,

> "Haven't really seen any CBI products worth using. It is necessary to see the brain in 3-D. Students waste too much time navigating the software."

Table 2 provides results of attitudinal surveys of two classes of physical therapy students. These were conducted during the Spring semesters of 2001 and 2002 after each first year class had completed their first semester course work, which included the introductory neuroscience class. One hundred percent of the physical therapy program students completed their surveys. Student responses to questions 1-5 in the survey confirmed that the students were dissatisfied with the course in its present format and that they were amenable to the possibility of learning the material via computer based instruction. Over half the students had used computer based instruction as a supplement to learning in previous courses; however, less than half had taken a course in which CBI was the primary means of instruction.

Table 3 lists direct costs for development of the prototype module. Additional considerations are reported in the discussion section of this manuscript. Feedback from different prototype test subjects which characterized the implementation portion of the design model are also addressed in the discussion section of this manuscript.

Table 3. Prototype Development Summary

Software (total cost)	$2057
Faculty Hours	70
IT Consultant Hours	62
Computer Graphic Art Tech Hours	15
Total Hours for Project Development	147

Lastly, a descriptive summary of the Pre and Post-test scores is provided in Table 4 and results from a Dependent T-test analysis of the data are provided in Table 5. The qualitative evaluation consisted of a survey of students after they had completed the module. A summary of responses is shown in table 6. The test students were also asked to express their opinions in writing concerning whether or not the entire course should be offered in an online format and to explain their rationale for their opinion.

Table 4.CBI Prototype Module: Descriptive Summary of Pre and Post-test Scores

	Mean	Std. Dev.	Std. Error
Pre-test	**7.1429**	**1.5119**	**.4041**
Post-test	**11.5714**	**.8516**	**.2276**

N=14

Table 5. CBI Prototype Module: Dependent-T-test Analysis of Pre versus Post-test Scores

Mean	Std. Dev.	Std. Error	t	Sig. (2-tailed)
-4.4286	**1.7852**	**.4771**	**-9.282**	**.000**

N=14

Table 6. **Summary of Test Student Responses Concerning the Prototype Module**

Question	Response	
1) How would you assess your ability to use a computer to complete course work of this nature?	Excellent	36%
	Very Good	43%
	Good	14%
	Fair	7%
	Not Very Good	0%
	Poor	0%
2) Did you find this module easy to use?	Yes	100%
	No	0%
3) How would you like it if the entire introductory neuroscience course for P.T. students was in this format?	Strongly Approve	0%
	Approve	29%
	Neutral	43%
	Disapprove	29%
	Strongly Disapprove	0%
4) Do you think this method would be an effective way to learn the introductory neuroscience material for P.T. students?	Extremely Effective	0%
	Effective	0%
	Neutral	529%
	Not Effective	21%
	Extremely Ineffective	0%

Twelve of the fourteen students responded. Several consistent themes were noted. Themes of comments in favor of the CBI format included:

1. The CBI format would work well because it is convenient and easy to use.\
2. The animations and pictures really with the understanding of concepts.
3. Taking the quizzes helped to test understanding of the material.

Themes of comments opposed to the CBI format included:

1. Lecture from an experienced instructor adds value to the information.
2. Lecture allows students to ask questions and receive immediate feedback.
3. Difficulty in viewing animations was encountered by some of the students.
4. CBI may narrow the students view of the information taught.

Themes of comments that were neutral to the CBI format included;

1. Having both formats available for students to use would be ideal.

DISCUSSION

Analysis

The first phase of any instructional systems design approach is the analysis phase. In this case an effort was made to attempt to determine the extent to which computer based instruction is being used by Physical Therapy Education Programs in their neuroscience curricula. Based on the findings of this survey, it appeared that a majority of physical therapy faculty teaching neuroscience were attempting to utilize some form of CBI as an adjunct to student learning. In addition, the vast majority (81% in the survey) of faculty indicated that they were interested in a CBI module that covers basic neuroscience topics. No faculty reported documented findings comparing the effectiveness of traditional neuroscience teaching approaches (lecture/lab) to CBI.

Next, student interest in a CBI based alternative approach to the traditional neuroscience course at the author's institution was investigated. The results provided evidence of student interest in changing the neuroscience course instructional format. However, the student interest in change appeared to be based more on their dissatisfaction with the present course format rather than on any specific interests in, or previous experiences with CBI. Therefore, it was concluded that a CBI teaching format could be a viable course format alternative, but not necessarily the only option.

Design

Based on the analysis findings and the strategic plan directives for education at the author's institution, the determination was made to pursue development of a CBI course in Foundational Neuroscience for physical therapy students. The next step in the modified ADDIE instructional systems design model was to determine how to develop a rapid prototype module. Fortunately, experts in the field of instructional design and development were available for consultation at the author's institution through the Information Technology Department. Two individuals agreed to consult on the project and a series of meetings were set-up to facilitate the process. The goals of these meetings were to: 1) ascertain the pedagogical approaches that the course instructor would prefer to utilize for the course, 2), determine the ideal mode of delivery for the CBI module (and eventually the entire course) and 3) set a plan of action for development of the prototype module. In addition to the consultation, several resources were found to be useful during this stage of the process. They included textbook references,[16,17] literature references,[18-21] and website references.[22-24]

The initial meetings with the IT personnel focused on options available for teaching information via computer. While the instructor felt text based information should serve as the foundation for student learning, incorporation of moving graphics would play a key role in enhancing student learning. The ability to integrate immediate feedback and self-paced learning into the course were deemed important, too. Finally, video images of actual patient examples were determined to be a vital addition to course content. The modes of information delivery capable of including all of the above teaching tools were considered to be either web-based or CD-ROM based. After experimenting with both options, it was agreed that a web-based format, using course platform software (Blackboard™ v5.6) would be the best option. Rationale for this choice included: full university support of this online course system, ability to incorporate all identified features with fewer limitations in file size/memory capabilities, ability to incorporate web hyperlinks for additional learning opportunities, and ability of the program to keep track of individual module pre and post-test scores as well as student time spent on each module.

Subsequent meetings concentrated on course format. It was determined that the course would first present students with a

series of textual instructions outlining the functionality of the course. These instructions would serve as scaffolding for the student; outlining the steps to proceed through the course and instructor expectations. The student would begin each instructional module with an online pre-test (multiple choice format). Upon completion, the student would progress through the content with buttons located at the bottom of the screen. Co-located animations, still illustrations, and videos would appear with the text to increase course continuity, illustrate content, and associate difficult concepts with a practical application. Students would be asked to complete an online post-test (multiple choice format) at the conclusion of each module. The online testing would be interactive, with references to the course textbook and individual CBI module pages provided for all incorrect answers to test questions.

Development

Once the pedagogical approaches of the course and the ideal mode of delivery were determined, a plan of action was outlined for development of the prototype module. It was decided that one typical course lecture (50 minutes) would be converted into CBI format. Development would require a team approach. The faculty member would serve as the content expert and develop the project storyboard, the IT consultants would provide guidance on course design and computer based capabilities, and a computer graphic arts technician would assist with animation, video and illustration production. The faculty member would need to learn the basics of Hyper Text Mark-up Language (HTML), Blackboard™ course platform use, Flash™ animation software, and Adobe™ image and video editing software in order to assist in module development and modification.

Equipment that was needed for prototype development included: computer (Pentium 4™ processor) with high speed web-access, software (Adobe Premiere 6.0 for video editing, $500, Adobe Photoshop 7.0, $267, MX Studio for animations, $730, and a LifeArt CD with neuroscience clipart, $560). Time spent directly on prototype development, not including learning activities for learning software use included: direct faculty involvement (includes meetings with IT consultants) 70 hours, graphic arts technician ~15 hours, IT 12 hours of meetings + ~50 hours in addition to meetings. See Table 3 for a summary of project development costs.

Implementation

After the prototype module was developed and in place on a Blackboard™ course platform, testing procedures were initiated. Content was validated by a peer faculty member who did the first test run of the module. Feedback was documented and editorial changes were made. Next, a novice tester (high school student) was solicited to work through the module in order to determine whether it was user friendly. This test helped identify several areas within the program where instructions were unclear on how to proceed and where concluding instructions were somewhat ambiguous. Lastly, two physical therapy program students who had previously taken the traditional format of the course were asked to try the prototype and document their impressions of the module in terms of ease of use as well as their thoughts concerning the entire course in this format. Comments are summarized here:

- "I liked the repetition of key points in conjunction with focus highlighted on certain aspects of specific components."
- "The pictures were good."
- "The course was easy to navigate."
- "The course flows nicely, it was easy to follow."
- "It was helpful to be able to work at own pace and view the animations or videos as many times as needed, especially the animations."
- "This kind of instruction would have given me a better neuroscience background than I received with the lecture approach."

No additional suggestions for module changes were made by these students. The two student testers spent 20 and 30 minutes respectively working through the prototype module.

Evaluation

The cadre of fourteen test students did indeed improve in their ability to answer questions on the information presented in the CBI module. Thus, it appeared that the prototype module did contribute to student learning. However, the small number of test students and pre/post-test questions weaken the significance of this finding.

With regard to the qualitative analysis of the prototype module, while the group of test students found the module easy to use, they were evenly divided in their impressions of whether the CBI format would be an acceptable teaching format for an entire

course. Therefore, no clear verdict could be made concerning student preference for CBI or traditional lecture format for the course based on these findings. However, the student testing of the prototype module did help this investigator reach several conclusions. First, technological problems with downloading some of the animations needed to be addressed prior to attempting to fully integrate the course into CBI format. Second, the CBI format employed in this case appears to be appropriate for teaching the foundational neuroscience information for physical therapy students.

Lastly, based on the investigator's teaching experience and these results, no matter what method is used for delivering information, student learning preferences will vary.

CONCLUSION

This paper has described one potential method for developing and testing a prototype CBI module for professional students. The process took three years to complete. Full time faculty members interested in converting courses to CBI format would be advised to consider whether the time and effort involved in such an undertaking are truly worth the potential benefits. Due to the inconclusive findings of this pilot investigation, the next step of the project will be to convert the entire course into CBI format and compare it to traditional lecture. The question of whether CBI can free up faculty time (if this truly does occur with CBI) in the long run and still provide students with appropriate, effective learning of essential information remains to be answered.

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