

## Usability and Efficacy of Neurologic Digital Case Studies to Promote Clinical Decision-Making Skills Among Physical Therapist Students

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Clinical decision-making (CDM) is essential to professional competency but remains a difficult concept to teach and learn. The purpose of this study was to assess usability and efficacy of digital case studies for development of CDM skills within the neurologic physical therapy curriculum.

**METHOD:** A two-part pilot study was designed to: 1) examine the usability and perceived efficacy of digital case studies; and 2) examine the efficacy of case studies upon student CDM skill development. Twenty-one students participated in the initial pilot study and were given a 5-question survey and open-response questions that were analyzed quantitatively and qualitatively. The second phase of the study consisted of two groups ( $n=48$ ): one completed digital case studies, and another completed paper cases. Both groups completed pre- and post-tests, and data were analyzed using independent sample *t*-test for comparing mean difference. **ASSESSMENT:** Students reported digital case studies as user-friendly, but there was no statistically significant difference found in CDM between groups. **CONCLUSION:** While the use of digital case studies generated student satisfaction, they do not appear to eclipse low-tech options in terms of efficacy. Various pedagogies can yield similar results, and thus faculty resources should be considered when developing educational methodologies. *J Allied Health* 2019; 48(1):31-37.

**CRITICAL THINKING** is a complex process that requires assimilation and interpretation of facts and evidence, engagement in problem-solving and self-assessment, purposeful self-regulatory judgment, and ethical and intuitive explanation. Cognitive skills, including analysis, judgment, inference, reasoning, reflection, and synthesis are integral components of critical thinking.<sup>1</sup> In the healthcare setting, critical

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thinking becomes an essential component of clinical decision-making (CDM), is an element of professional practice that draws upon advanced cognitive skills, and is essential to professional competency.<sup>1</sup> Critical thinking is considered one of the seven key factors in a model of professional behavior for physical therapist students, but is a difficult concept to learn, teach, and evaluate.<sup>1-5</sup> In the entry-level physical therapist curriculum, it is a concept that is further complicated by the need to develop and utilize pedagogies that support the development of a holistic approach toward patient evaluation and treatment, and asks students to apply intuitive knowledge that addresses patients' needs on biological, social, and psychosocial levels.<sup>6,7</sup> In an effort advance high-level cognitive skills and flexibility of thinking, less traditional teaching methodologies including digital technologies and case studies using virtual patients may be of value in the neurologic physical therapy curriculum. Digital technologies can be characterized as multimedia software programs that enhance face-to-face instruction that have the ability to improve theoretical comprehension of content, enhance comprehension or previous studied topics, and create an articulation between theory and practice.<sup>8,9</sup>

Despite the challenges that accompany the development of critical thinking and CDM skills, educators are required by the Commission on Accreditation of Physical Therapy Education (CAPTE) to develop and assess students' clinical reasoning skills.<sup>5</sup> CAPTE mandates have arisen in response to legislation that has advocated for greater autonomy in physical therapy practice and has advanced direct access, or access without a physician referral, to physical therapy services.<sup>9,10</sup> CAPTE has also revised its mandates to align with the American Physical Therapy Association's (APTA) *Vision 2020*, which states that by the year 2020, physical therapy services will be provided by doctors of physical therapy.<sup>11</sup> These initiatives have resulted in an expansion in the scope of physical therapy practice that includes an increase in responsibility and accountability for safe and effective patient care decisions.<sup>4,12</sup> Thus, high-level critical thinking and decision-making skills among entry-level physical therapists are critical to providing safe and effective care.

In addition to CAPTE and APTA requirements, there are other compelling reasons that educators should focus on CDM skill attainment during the didactic period of student physical therapists' training. Black et al.<sup>12</sup> showed that while clinical reasoning skills do improve during the first year of professional physical therapy practice, the largest areas of improvement during this time are found in confidence and communication. Atkinson and Nixon-Cave<sup>13</sup> demonstrated that expertise may not necessarily be attributed to years of experience, but rather to strong CDM abilities. A study by Huhn et al.<sup>4</sup> showed that physical therapy students demonstrate a more rapid rate of clinical reasoning skills attainment while they are in an academic setting compared to when they are participating in clinical education rotations. These findings are in contrast to a widely held belief that exposure to authentic patient care situations is superior to classroom pedagogies, and it underscores the need to promote CDM skills as part of entry-level physical therapy students' academic preparation for clinical practice.

Technology integration has been shown to improve critical thinking and CDM skills among healthcare practitioners and students and has specific appeal for millennial learners, who develop critical thinking through active participation and experimentation and view technology as necessary to this process.<sup>14,15</sup> Rapid shifts from one internet site to another result in learning that is non-linear and irregular, occurs through trial and error versus step by step scaffolding of information, and is characterized by multitasking and a limited tolerance for delay.<sup>14-16</sup> The interactive nature of technology allows for automatic and immediate feedback, which can provide the positive reinforcement that is desirable and considered important to many millennials.<sup>15</sup>

The integration of technology into educational practice has been fueled by computer-assisted learning (CAL), or the supplementation of traditional lecture and lab learning experiences with computer-based activities. Several recent studies have investigated student perceptions of CAL in physical therapy curriculums. When comparing CAL modules to stand-alone video clips among 37 physical therapy students in an adult neurological rehabilitation course, the group randomly assigned to CAL perceived an improvement in clinical reasoning skills and also reported that the reflective component built into the module allowed for a more meaningful learning experience.<sup>17</sup> Likewise, Seif, Brown, and Annan-Coults<sup>18</sup> concluded that use of an interactive, technology-based clinical reasoning lesson was perceived to foster development of clinical reasoning skills among physical therapy students in the examination, evaluation, and treatment of patients with orthopedic conditions. These perceptions are reflective of contemporary learning styles among millennials and parallel those of occupational therapy students, who

reported having the highest level of control over use of CD-ROM patient case studies because this modality allows students to view them at a time that is convenient for them and permits them to replay portions.<sup>19</sup>

In response to APTA and CAPTE initiatives and evolving student learning styles, CAL has expanded over the past 10 years, and methods including interactive CD-ROM programs, e-learning websites, and digital case studies are becoming commonplace in physical therapist education programs. Research supports this trend. Veneri,<sup>9</sup> in a systematic review, highlighted many of the potential benefits of using CAL, but also underscored the need to conduct more research on this topic. The author reported that few studies have been published on the use of CAL, and most are centered on teaching anatomy or musculoskeletal physical therapy skills.<sup>9</sup> Lysaght and Bent<sup>19</sup> found that a variety of case presentation modalities, including paper case studies, videotape, live patient interviews, and online CD-ROM cases, were effective at teaching clinical reasoning skills for occupational therapy students. However, the researchers concluded that student grades on a clinical reasoning assignment were similar regardless of pedagogy used.<sup>19</sup> Hara et al.<sup>8</sup> conducted a literature review of 21 studies designed to assess the effect of digital case studies upon nursing education and concluded that clinical case studies inserted into digital technologies enhanced cognitive, procedural, and attitudinal learning, with the greatest effect upon cognitive learning.<sup>8</sup> Similarly, integration of virtual case studies into clinical courses of a nurse practitioner program resulted in learning gains in the areas of assessment, differential diagnosis, and intervention, as measured by a standardized grading rubric.<sup>1</sup>

Many other pedagogical benefits of using CAL have been reported in the literature. The virtual patient environment permitted by the creation of digital case studies serves as a safe venue in which decision-making mistakes can be made and are, in fact, encouraged, as there is no chance of adverse effects occurring with patients.<sup>9,20</sup> The ability to learn from making errors has significant value, as it has been shown in previous research to lead to the development of clinical reasoning skills and improve outcomes and decision-making in future situations.<sup>20</sup> Digital case studies also provide exposure to patient care situations that students may not otherwise experience during their didactic training.<sup>12</sup> Immediate feedback, including expert rationale and supporting evidence, can be embedded into divergent sections of a case and provided to students immediately. This has been shown to support development of clinical reasoning skills.<sup>20</sup>

Despite its advantages, the use of CAL gives rise to several challenges. Students have reported difficulty with technology use, internet connectivity issues, the need for a computer with sufficient memory to store and

use cases, and time constraints that accompany engagement in online patient case studies.<sup>19</sup> Further, CAL activities must be designed in such a way that they offer novel and substantive learning experiences, as student engagement and motivation can only be fostered if pedagogical practices are perceived as worthwhile.<sup>21</sup>

While studies on student perceptions, preferences, and learning contribute meaningfully to the literature, there is a dearth of evidence relating to the effect of CAL practices upon critical thinking in the neurologic physical therapy curriculum. It is therefore important to examine the ways in which digital technologies can advance content learning in this area of physical therapists' education. The purpose of this two-part pilot study was to assess the effect of digital case study technology upon critical thinking skills in physical therapist students, by a) investigating the usability and perceived efficacy of web-based neurologic digital case studies in a neurologic physical therapy curriculum, and b) assessing the effect of digital case studies upon student learning. With respect to student learning, the authors hypothesized that statistically significant learning gains, evidenced through pre and post-test exam scores, would be achieved with the incorporation of digital technologies into the curriculum.

## Model Description and Evaluation

### Case Study Software

Four interactive, digital case studies pertaining to the physical therapy management of adult, neuromuscular conditions were designed for physical therapist students participating in a neurological rehabilitation course at a research-based university in the Northeast United States. Articulate Quizmaker® (Articulate Global Inc., New York) was utilized to create the patient case studies. This software was chosen for several reasons. It is relatively inexpensive, and once purchased there are no annual licensing or user fees. The software is simple to use, can be adapted for many educational purposes, and permits the instructor to embed visual enhancements such as video clips, diagnostic imaging pictures, charts, and graphs.

Cases may be constructed in a variety of ways, from a simple step-wise structure through a set of questions to a more complex, branching design. After being presented with initial case information, data, and/or images, the user is required to synthesize concepts and make clinical decisions regarding patient care. If answered correctly, the user is provided with positive reinforcement regarding the decision and then directed to the next part of the case. If the user answers the question incorrectly, several options exist for student remediation through extensive branching options. For example, the student may be simply informed that they are incorrect and brought back to the same question for

another attempt, or they may be directed to a brief tutorial which explains why their answer was not correct and then redirected back to the same question or branched to a new set of questions specifically tailored to their original response. This pattern continues until the user achieves mastery of the case. The student can receive feedback in the form of a score or qualitative feedback at the completion of the case.

The Articulate Quizmaker® case studies offer several advantages which benefit instructors as well as students. The case studies can be embedded or uploaded on a course website to be used as independent study tools, can serve as an assessment method, or incorporated into PowerPoint slides for in-class use to promote application and synthesis of knowledge and support clinical reasoning development via guided discussion led by an experienced clinician. Furthermore, student response software can be used in conjunction with the case studies, affording the instructor the opportunity to evaluate student comprehension of concepts in real time, promote discussion, and give immediate feedback. Articulate Quizmaker® case studies can also be easily edited to reflect current best practices and scientific evidence as it emerges. A reference slide containing key articles and texts may also be inserted within the case study as a student resource.

### Study Design—Part 1

This was a two-part pilot study. The initial pilot study ( $n=21$ ) was conducted to examine the usability and perceived efficacy of four, on-line digital case studies created with Articulate Quizmaker® software. The following year, a randomized control study ( $n=48$ ) was conducted to examine the effect of digital case studies compared to paper study guide questions on knowledge acquisition among students in a neurological rehabilitation course.

The case studies were written by the investigators, and the literature was searched using Medline, OVID, and CINAHL to gather evidence for clinical decisions pertaining to the cases. The case studies were piloted by the authors and edits were made to ensure appropriate branching and links throughout the cases. Once the cases were beta-tested and edited, they were uploaded to the Blackboard learning website for the course. This cohort was chosen because students were near the completion of the neurologic physical therapy curriculum and thus had the required foundational knowledge needed to complete the case studies.

Convenience sampling was used to recruit student participants. Student participation in this study was voluntary. No incentives or negative repercussions were issued to influence participation, and anonymity of all participants was maintained. The Institutional Review Board at Northeastern University reviewed the study and deemed it exempt as participation was voluntary, it

**TABLE 1.** Survey Questions, with Rate of Responses and Average Score for Answers, and Open Response Questions

Survey Questions	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Average Score
1. Was the program user friendly?	90.48% (n=19)	4.76% (n=1)	4.76% (n=1)	0	0	4.86/5.0
2. Was feedback easy to understand and helpful to clarify material?	66.67% (n=14)	28.57% (n=6)	4.76% (n=1)	0	0	4.62/5.0
3. Would you like the opportunity to complete additional cases in the future?	71.43% (n=15)	28.57% (n=6)	0	0	0	4.71/5.0
4. Do you feel that the case studies helped you organize your thinking about the subject matter?	57.14% (n=12)	38.10% (n=8)	4.76% (n=1)	0	0	4.52/5.0
5. Do you believe that you would make better clinical decisions with actual patients if presented with situations similar to these case studies in the future?	52.38% (n=11)	38.10% (n=8)	9.52% (n=2)	0	0	4.43/5.0
<b>Open Response Questions</b>						
1. What was your favorite part about using this program?						
2. What was your least favorite aspect of using the digital case studies?						
3. Do you have any additional comments?						

would not impact student grades, and involved a teaching pedagogy.

Once students completed the case studies, they were provided with a link to a brief, 5-question survey on SurveyMonkey. The survey contained questions on the usability or ease of using this technology, student favorability, and perceived efficacy of the modality (Table 1). The survey questions were developed by the authors, as a search of the literature did not yield any validated, standardized tools for examining student perceptions of using digital case studies. The questions were drafted to get student feedback on the ease of using this specific software, the benefits of embedded feedback on learning, and their satisfaction with digital patient case studies. Students were also asked about the perceived effect of digital case studies on their clinical reasoning and decision-making abilities. A 5-point Likert scale was used for the survey, in which answer choices ranged from “strongly agree” rated as 5 points to “strongly disagree” rated as 1 point. A copy of the survey questions, rate of responses, and average score for answers are detailed in Table 1.

### Study Design—Part 2

The second part of this study was conducted the following year with a new cohort of physical therapist students taking the same neurological rehabilitation course. The purpose of this piece of the study was to examine the efficacy of the digital case studies on student decision-making. We sought to determine if digital case studies were more effective than traditional paper case studies on physical therapist students’ development of CDM skills.

Pre- and post-test exams were administered. Exam questions were identical and taken from previous final exams for the Neurological Rehabilitation II course.

Questions pertained to clinical decisions for the physical therapy management of persons with neurologic health conditions. All students had completed lectures and labs of Neurological Rehabilitation I and II courses prior to participating in the study. Participation in the study was voluntary, and students were explicitly informed verbally and in writing that participation would not affect their course grades and they could stop participating in the study at any point without penalty. The IRB at Northeastern University also determined this portion of the study was exempt.

Participants (n=48) were randomly assigned to one of two groups: the Articulate Quizmaker® cases (n=24) or paper case studies and study questions (n=24). Pre- and post-test scores were analyzed to determine if there was a statistically significant difference between the two groups. Once data were collected, the digital and paper case studies were made available to the entire class.

### Outcomes

Twenty-one students participated in the initial pilot study. Descriptive statistics were used to analyze the data. The students reported that the case studies were user friendly with an average rating of 4.9 out of 5; 19 of 21 participants (90.5%) answered “strongly agree” and 1 participant (4.8%) answered “agree.” Only 1 out of 21 subjects was “neutral” as to whether the case studies were user friendly, and no respondents answered “disagree” or “strongly disagree.” Twenty out of 21 participants (95.2%) answered “strongly agree” or “agree” to the question “Was feedback easy to understand and helpful to clarify material?,” and 1 out of 21 (4.8%) answered “neutral.” All of the participants strongly agreed or agreed they would like the opportunity to complete additional case studies in the future (4.71/5 average rating).

When asked if the “case studies helped you organize your thinking about the subject matter,” 57.1% of the students said they strongly agreed, 38.1% agreed and 4.8% were neutral. All but 2 students (9.5%) strongly agreed or agreed that they would make better clinical decisions with actual patients in similar situations as a result of completing the case studies (4.43/5 average rating). Results may be biased by self-selection to participate in the case studies and survey. It is possible that students with a preferential bias toward neurological physical therapy participated, which could skew favorability ratings.

Participants were also provided with open response questions regarding favorite and least favorite aspects of the digital case studies at the end of the survey and were asked if they had any further comments about the experience. Overall, studies reported that Articulate Quizmaker® provided a forum that was more realistic and interactive than other formats. Another subject commented: “I think overall these are great tools to use as an adjunct to traditional studying. I think some of the cases are much too basic and could be made more difficult to really test the students’ knowledge. But overall I think quizzes like this are going to be very beneficial to students learning process.” Additionally, participants stated that information such as exam findings, vital signs, and other relevant details of the case study should be available for viewing at additional points or on alternative slides because they did not remember previous info as they moved through the slides. Further responses included the desire to view feedback in response to incorrectly answered questions to aid in overall learning, even if the participant got the question correct.

Pre-and post-test scores for the test and control group for the second efficacy phase of this study are shown in Table 2. Data were analyzed using the independent sample *t*-test for comparing the mean differences. The average pre-test score for the control group who received the paper case studies was 82.71% with a median grade of 85% and range of 75–90%. Post-test average and median scores for the control group were unchanged, but the range increased to 65–95%. The test group who participated in the on-line digital case studies had average pre-test score of 79.79%, with a median score of 80% and range of 65–90%. Post-test average and median scores increased modestly to 81.67% and 82.50%, respectively, and the range increased as well to 60–100%. While there was a slight increase in the pre-and post-test scores among the students in the test group, it was not significant ( $p=0.88$ ,  $SED=2.13$ ) or considered to be educationally relevant.

## Discussion

The purpose of this two-part pilot study was to assess the effect of digital case study technology upon critical thinking skills in physical therapist students by: a) investigating the usability and perceived efficacy of web-based neurologic digital case studies in a neurologic

physical therapy curriculum, and b) assessing the effect of digital case studies upon student learning. Results revealed that students found digital case studies to be user friendly, that they enjoyed engaging in this type of teaching and learning tool, and felt that feedback was easy to understand. Students also reported feeling more confident that they would make better clinical decisions in live practice after participating in digital case studies with virtual patients. Qualitative responses, however, indicated that the digital cases were not very difficult and could have been more challenging.

Survey-based perspectives are congruent with contemporary literature that discusses learning styles among a generation of digital natives and assert that millennial students value the ability to search and manipulate information for the generation of knowledge more than they value the attainment of knowledge.<sup>15</sup> Responses to open-ended questions may indicate that student expectations of technology-based learning platforms are different, and that learners perceive digital cases as inherently able to engender metacognitive thought and allow for more complex problem-solving.

Results of the efficacy study comparing pre- and post-test grades for the second cohort of students who engaged in digital case studies compared to paper case studies did not reach statistical significance; however, there was a modest increase in average and median scores for the test group who had access to the Articulate Quizmaker® case studies during the duration of the study. Thus, the researchers’ hypothesis was not supported. There may be several explanations for this. Instructor knowledge with respect to designing effective digital case studies may have been limited, and therefore, the potential for cases to enhance learning impacted. This is noteworthy, as literature suggests that pedagogical strategy is an important variable in the success of online learning.<sup>22</sup> Additionally, there may have been so much similarity between the digital and traditional case studies that the technology interface had little benefit and nothing unique to offer. This is also significant, as mere use of an online tool does not guarantee higher-order thinking, and for technology to be meaningful, the platform must be structured differently to provide novel learner experiences.<sup>22,23</sup> Finally, it may be that this particular technological intervention is not superior to other methodologies for improving clinical reasoning skills. This conclusion has been supported in the literature. An investigation of the effectiveness of computerized case studies compared to traditional paper case studies was conducted in a nursing curriculum in order to assess outcomes of knowledge, attitude, and retention of content delivered. No statistical significance between the two interventions was found.<sup>24</sup> Similarly, no significant differences were found between traditional and computer assisted instruction in the majority of studies reviewed in a recent systematic review.<sup>9</sup>

Results of this pilot study are of value to physical therapist students as well as faculty. With respect to efficacy of digital case studies, pre and post-test measures of learning suggest that students should understand and acknowledge the individual and personal factors that contribute to performance prior to relying on a particular teaching-learning approach. Similar conclusions have been reached in the literature. Huang et al.<sup>25</sup> posited that cognitive style, or the way in which an individual receives, processes, organizes, and presents information, is the key characteristic that most affects the effectiveness of technology-based learning. Groves<sup>26</sup> stated that “teaching and learning clinical reasoning requires the use of a range of strategies to accommodate variations in student learning styles, as well as the context in which teaching takes place.” Evidence therefore suggests that students be attentive and receptive to different methodologies that can enhance knowledge acquisition and construction.

As recommended within medical education literature, students should be afforded multiple opportunities to engage in deliberate practice and receive timely feedback with carefully crafted patient cases by content experts to enhance clinical reasoning abilities and achieve transfer of basic concepts as well as experiential knowledge.<sup>26–28</sup> Educational outcomes have been shown to be relatively similar with multiple methodologies, and thus, faculty resources should be carefully analyzed prior to developing any teaching methodology for promoting clinical reasoning and decision-making skills.<sup>19</sup> Digital case studies appear to be just as effective as other lower and higher tech options available; therefore, faculty should consider using methods they are competent in utilizing and are able to effectively deliver to students. Despite an upfront cost for software, training, and development of digital case studies, there are many potential benefits. Students report favorability of CAL to other methods in the literature, and within this study, student feedback showed they view the technology favorably, report interest in engaging in additional digital case studies, as well as a desire to be challenged to a greater extent with future digital cases. Once faculty develop the cases, they are highly portable and can be used in future courses in a multitude of ways as previously described, thereby providing a significant return on initial investment.

Findings of this pilot study identify several avenues for future research. A quantitative or qualitative investigation of faculty perspectives on the use of digital case studies in neurological physical therapy courses would be beneficial and could help drive curriculum development. Additional study of the impact of various pedagogies on development of CDM skills for neurologic management among physical therapist students utilizing a validated survey tool is also recommended and could strengthen evidence. Research examining student proficiency in CDM utilizing the Clinical Performance

**TABLE 2.** Pre-and Post-Test Scores for the Second Efficacy Phase

Score	Control Group		Test Group	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Average (%)	82.71	82.71	79.79	81.67
Median (%)	85.00	85.00	80.00	82.50
Range (%)	75–90	65–95	65–90	60–100

Instrument and/or Clinical Instructor survey may also reveal findings that could aid faculty in developing methodologies for fostering clinical reasoning skills.

While this study offers a unique contribution to the literature, several limitations need to be addressed. Survey questions, though customized, were not validated. In addition, descriptive statistics only were used to analyze survey results. As a result, accuracy and rigor of the study may have been compromised. Additionally, pre- and post-test questions used to examine group differences were developed by authors and taken from previous final examinations, which has the potential to introduce bias. Though validated measures of physical therapist students’ clinical reasoning skills would be beneficial, literature maintains that these particular skills are difficult to evaluate, and thus, the creation of a standardized tool is challenging.

## Conclusion

Development of critical thinking and clinical decision-making skills among physical therapist students is a vital aspect of their academic preparation. Integration of technology and computer-assisted learning has been shown to contribute to critical thinking. This study contributes to the existing literature on student perceptions of CAL, as well as the efficacy of CAL, by examining and exploring perspectives on digital case studies and examining efficacy of these case studies. Results of this research revealed that while students viewed Articulate Quizmaker® software favorably, no statistically significant gains in learning were achieved with use of this modality.

As other pedagogies may yield similar results, faculty should consider their skill set, time, and resources when developing pedagogies and consider utilizing a variety of modalities to meet learning objectives and promote the development of CDM among physical therapist students. Digital case studies are a promising new teaching tool for promoting critical reasoning among doctor of physical therapy students, yet further research, utilizing standardized assessment methods, is recommended to examine outcomes on a larger scale.

**Significant Contributors:** The following persons are former graduate students in the DPT program at Northeastern University and assisted with the development of case studies and data collection for this study: Olivia Amarin, Caitlin Augello, Kristen Dunn, Brooke Iby, Laurel Mangelinkx, and Larissa Vangel.

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