A Computerized Database Approach to Enhance Critical Thinking

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ABSTRACT. Because additional approaches to critical thinking and problem-solving within pharmacy education are needed, this pilot clerkship study involved the development and implementation of a computerized clinical database designed to teach critical-thinking skills through structure of information entry. This database, the Arkansas Clinical Encounter System (ACES), was devised to parallel the structure or the prototyping that many clinicians use to gather information, to reach a decision based on available information, and to document outcomes. Although this study did not show a statistical difference in students' critical-thinking scores using pre- and post-Watson-Glaser

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Critical Thinking Appraisal testing, important weaknesses that were not part of the original study design were uncovered. These documentation and computer-expertise weaknesses must be addressed by all schools and colleges of pharmacy in order to prepare for reimbursement for cognitive services. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: getinfo@haworthpressinc.com]*

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INTRODUCTION

The American Association of Colleges of Pharmacy (AACP) states that entry-level degree programs should foster the development of problem-solving in order to prepare students appropriately to practice in today's health-care arena (1). Problem-solving, through critical thinking, should be a major programmatic educational outcome. The American Council on Pharmaceutical Education's (ACPE) recently revised Accreditation Standards and Guidelines specifically address critical thinking (2). The guidelines recommend that programs incorporate educational technologies that promote students' abilities to interpret and organize knowledge and develop the foundations for critical-thinking skills. Therefore, current programs should provide two pertinent components for the development of skilled problem-solvers: (a) curricular experiences that promote the development of fundamental strategies for critical thinking, and (b) an environment, incorporating current technology, which promotes problem-solving.

A number of pharmacy educators have attempted to develop methods to enhance critical thinking. These methods have included the use of "no-technology," the use of "low-technology," and the use of "high-technology." "No-technology" approaches have incorporated the problem-based learning method, a method frequently employed in medical education, to enhance cognitive skills required for critical thinking (3,4). Other "no-tech" approaches have included in-class discussion techniques to facilitate students' critical thinking (5) and the use of a student-compiled "peripheral brain," or self-accumulated handbook reference, for use during didactic coursework (6). A "low-tech" approach has used written techniques, visual models, and in-class assignments as means of enhancing students' critical-thinking skills (7). "High-tech" methods have incorporated computer-based case studies to develop students' critical-thinking skills in basic science courses such as medicinal chemistry and physical pharmacy (8,9). Of all these reports, only one–the peripheral brain study–attempted to objectively measure the effect the intervention had on students' critical-thinking skills. The authors concluded that allowing students to use a peripheral brain in classes such as a pharmacotherapy course improved the students' higher-order thinking skills, but was insufficient in itself to develop critical-thinking skills (6). Studies objectively measuring the impact of other high-tech methods for enhancing critical thinking are lacking.

Critical Thinking

Critical thinking has been defined as a rational response to questions that cannot be answered definitively and for which all relevant information may not be available (10). In pharmacy, much of the professional's intrinsic worth is dependent on the ability to make knowledgeable, informed decisions. Bordage and Zacks (11) describe the organization of knowledge as a distinctive factor in expert problem-solving. Their work is based on a well-established psychological model of memory that replaces the *categorization model* of memory structure with the *prototype model*. They state the prototype model best describes clinical reasoning. In this model, knowledge of a category is structured around a prototype which captures the essentials of that category. They argue that knowledge structures of experts are no different from those of students; the expert's knowledge structures are simply larger and more easily accessible. They further state that the prototype model approximates the clinical decision-making which occurs in medical practice. For this reason, it may also be a better model to describe the clinical decision-making associated with pharmaceutical care.

Clinical decision-making skills are distinguished by the development of: (a) a useful knowledge base, (b) some rules for accessing and applying the knowledge, and (c) prototypes for classifying instances. The challenge to current pharmacy educators is how to assist the inexperienced decision-maker with the creation of an efficient problem representation prototype upon which they can base their approach to decision-making. Technology may aid in this goal.

Technology

In 1975, the Millis Commission Report (12) defined pharmacy as a knowledge-based profession, but more than two decades later, the knowledge base of pharmacy practitioners is often limited to what can be memorized or retrieved from dated references. The growing augmentation of knowledge through computer-based technologies such as on-line databases, references on CD-ROM, electronic mail (e-mail), computer conferencing, and the Internet offers the possibility of advancing the quality of practitioner decisions in even the most remote locations. Unfortunately, pharmacy education has lagged behind in the use of this technology and has failed to provide students with tools and guidance to organize information in a way that enhances problem-solving and clinical decision-making. The challenge for the future is in mastering information: one must select and present information in ways that promote cognition and support decision-making. A position paper by AACP acknowledged this role for education (13), calling for schools to aid in developing practice models which efficiently and comprehensively deliver pharmaceutical care, using available information for problem-solving.

Gouveia (14) identified a major barrier to successful introduction of pharmaceutical care when he noted that the collection and dissemination of information to patients and practitioners will largely determine how successful pharmacists are in implementing pharmaceutical care. Therefore, use of current technology that improves pharmacists' access to information will improve their ability to provide professional, cognitive services. It is the provision and documentation of these cognitive services which may drive future incomes for all practicing pharmacists.

Combining Critical Thinking and Technology

Educating students in the logic of clinical decision-making is problematic because students must be introduced to formal schemes used for drawing inferences that are meaningfully linked to clinical materials, but are analytically separable from them while remaining generalizable to others of similar structure (15). A technological environment with hyperlinks to multiple electronic drug information resources and computerized pharmacy care plans could assist students in this educational process by providing an organizational structure for clinical materials (*i.e.*, information). This technological environment, integrated with documentation software during clinical experiences, could assist students in organizing patient data and augment the clinical decision-making process. In addition, the documentation software could provide a means of capturing cognitive services rendered.

The purpose of this pilot study was two-fold. The first purpose was to provide clerkship students with a computer-based pharmaceutical care record and clinical documentation system supported by online electronic resources, all designed to encourage development of patient-care prototypes. As defined by Bordage and Zacks, *prototyping* is the process of prompting the user to develop a thorough informational database, to construct several plausible representations of the situation, and to provide documentation of the outcome of their actions (11). In this pilot study, students were expected to develop a standardized approach to clinical cases and, therefore, to clinical decision-making. Secondly, we wanted to evaluate the effects of the ACES computerized database program on critical-thinking abilities.

METHODS

Computerized Database

The computerized Arkansas Clinical Encounter System (ACES) was designed to improve critical thinking skills through a "prototype model" approach. Created for use on an 80386-computer running on Windows® 3.1, the database software was Paradox for Windows®, and the communications software was Procomm for Windows®. The system was designed to guide students in data acquisition and decision-making through the required steps mandated by ACES. The program systematically required students to consider and acquire all pertinent drug, laboratory, and patient information, thereby establishing an information base from which to draw inferences. The software served as a tool for meeting the day-to-day student needs for accumulation of patient information in the development of care plans and subsequent clinical documentation.

ACES provided the added capability of accessing remote databases for information retrieval, e-mail exchanges, and aggregation of data at a central location. The database contained not only information about the patient and drugs taken, but also all meaningful clinical and laboratory data as well as documentation of interventions outcomes.

The Pharmacist's Work-up of Drug Therapy (PWDT) (16), which includes patient description data, medical problems lists, medical and medication histories, systems review, laboratory values, patient-specific drug-related problems lists, desired outcome statements, therapeutic alternatives, pharmacists' recommendations, and therapeutic drug monitoring was modified to meet the requirements of the clerkships and to serve as a template for data collection and the decision-making strategy for the program. Students were able to use the information-retrieval tools provided by the networked system when accessing the library databases (*e.g.*, Micromedex®, Medline®, and IPA®). This facilitated their development of therapeutic care plans and appropriate interventions.

In addition, students were permitted a limited number of faxed reprints from library sources, if those were not locally available. Also, e-mail access to all College faculty, including the Poison/Drug Information Center, was available. Interventions were recorded and the outcome of these interventions documented. All information in the ACES database could be queried for compilation or analysis by any combination of data fields; for example, each preceptor could determine student interventions according to a disease domain and print all related fields.

STUDY DESIGN

Student Selection

After the students' third academic year, but before beginning senior clerkships, traditional entry-level Pharm.D. students were assigned in two groups using a table of random numbers. The entire third-year class was involved. The accuracy of randomization was confirmed by comparing the mean scores from their cumulative third-year therapeutics course using an independent student's t-test; no difference was found between the group means. The groups numbered, for study and control, 27 and 31, respectively. Study group students were oriented to ACES by the project staff. This orientation lasted an hour and occurred two weeks prior to the students' enrollment in the fourth professional year. During this orientation, the staff reviewed how one may document clinical activities (*e.g.*, patient monitoring) using the ACES system, with specific examples, and how other on-line databases (*e.g.*, Micromedex®) could be incorporated into patient monitoring. A question-and-answer period followed. Students were informed during the orientation that a staff member would be available to work with them at their request when it became necessary for them to work with ACES in their clerkships. The control group was given hard copy documentation forms (identical to the ACES system) and instructed to use them to document all patient-care activities while on clerkships. No instruction concerning the use of on-line databases as a means of supporting patient monitoring was provided.

Prior to beginning either their adult medicine or ambulatory care clerkship, all students in both groups were administered the Watson-Glaser Critical Thinking Appraisal (WGCTA) (17). A review of the literature revealed one other pharmacy-related study using WGCTA to assess critical-thinking abilities (18). The authors of the WGCTA established the significance of WGCTA testing with the Scholastic Aptitude Test (SAT) and the American College Test (ACT) in nonprofessional students, noting that the test only evaluates a component of intelligence (17). WGCTA has a long history, is frequently reviewed, and is used with regularity to measure critical-thinking abilities (19).

The impact of the ACES on critical-thinking skills of the study group was measured through the WGCTA. The WGCTA consists of 80 items arranged in five 16-item subtests, which examine the following traits: *Inference, Recognition of Assumptions, Deduction, Interpretation, and Evaluation of Arguments*.

Project Evaluation

Postclerkship WGCTA scores from both groups were compared using the Mann-Whitney U test. It was hypothesized that the ACES would improve basic skills in critical thinking and that this improvement would be reflected in higher postclerkship scores for the study group participating in ACES. Student documentation skills were assessed to determine if sufficient recommendation was taking place to allow reimbursement for cognitive services. Summative evaluation of students' documentation skills included their ability to: (a) document pertinent patient information, (b) document interventions recommended to the patient-care team, (c) document the expected outcome of the intervention and how the achievement of this outcome would be measured, and (d) rate documented recommendations as appropriate or inappropriate. This evaluation of students' documentation skills was performed by a faculty panel consisting of clerkship preceptors. Impact of the clinical documentation system on patient outcomes was also assessed through review of the appropriateness of proposed interventions by this same panel. Project evaluation consisted of a summative assessment of student and preceptor attitudes toward the ACES documentation system using five-point Likert-type questionnaires.

RESULTS

Critical Thinking Scores

The scores from the WGCTA pre- and postclerkship testing are shown in Table 1. No statistically significant differences in postclerkship WGCTA scores were found between the two groups, except that the inference subtest score was statistically higher in the control group when compared to the study group.

Evaluation of Student Documentation Skills by Faculty

A faculty panel composed of clerkship preceptors reviewed student documentation skills. This was the first time student documentation abilities were evaluated across adult medicine clerkships within the

TABLE 1. Watson-Glaser Critical Thinking Appraisal Scores for Both Groups Before and After Exposure to the ACES System Designed to Enhance Critical Thinking During Clinical Clerkships.

	Control Group		**Treatment Group**	
Watson-Glaser Critical Thinking Appraisal Subtests	*Pre-test**	*Post-test**	*Pre-test**	*Post-test**
Inference	10.0	9.5**	9.5	8.6**
Recognition of assumptions	12.5	12.1	12.4	11.6
Deduction	11.5	11.3	11.9	10.8
Interpretation	11.9	11.7	12.1	11.9
Evaluation of arguments	9.4	10.2	10.4	11.1
Composite score	55.3	54.8	55.5	54.0

*Data are mean scores for each subtest and a mean composite score.
** $P < 0.05$

College. The goal of the evaluation process was to determine if students were documenting the correct information in sufficient detail to permit reimbursement for cognitive services based on the opinion of the faculty review panel. A total of 240 interventions were reviewed by the panel. When systematic evaluation of the students' ability to document was studied by the faculty panel, students did not meet expectations. The results (Table 2) revealed that students' ability to document interventions for reimbursement purposes was inadequate. Complete demographics were recorded only 83% of the time. Problem statement identification and review of systems were deemed incorrect 8% and 10% of the time, respectively. The appropriateness of outcomes was correct 82% of the time, but the panel was unable to determine the outcomes in 7% of records because of incomplete information. As a result of this study, the faculty panel identified two major areas to be addressed by the curriculum in the future: (a) the ability of students to identify and document the correct monitoring parameters associated with drug therapy, and (b) the selection of appropriate therapeutic alternatives. Students recorded their recommendations as being followed 61% of the time. The students' ability to influence other healthcare providers was higher than expected.

Classification of Interventions

Table 3 lists the classification of student recommendations. These recommendations ranged from changing drug therapy to suggestions

TABLE 2. Summary of a Faculty Panel Evaluation of Student Documentation Skills.

Items Evaluated	Yes	No	Not Applicable	Unable to Ascertain
Is patient demographic data thorough and complete?	199	41	0	0
Is the problem statement appropriate?	204	20	12	4
Is the review of systems appropriate?	214	24	0	2
Is the expected outcome appropriate?	196	27	1	16
Is the therapeutic alternative appropriate?	97	70	67	6
Are monitoring parameters appropriate?	124	82	28	6
Is the proposed intervention appropriate?	192	11	8	29

TABLE 3. Classification and Outcome of Documented Student Interventions as Evaluated by a Faculty Panel.

Classification of Interventions/Recommendations			
Recommended a drug change	56	Recommended an increase in dose	6
Recommended a drug	40	Non-laboratory monitoring parameters	3
Education given-M.D. or nurse	31	Recommended drawing drug levels	3
Recommended discontinue a drug	26	Change dosage form	2
Recommended a decrease in dose	18	Order a pharmacokinetic consult	2
Change in dosing schedule/hold dose	15	Change route of administration	1
Order a laboratory test	11	Cancel laboratory test ordered	0
Recommended a dose	6	No response	20

Outcome of Interventions			
Acceptance		*Impact*	
Recommendation followed	147	Perceived positive impact on care	120
Recommendation not applicable	50	Perceived positive impact on both care and cost	81
Recommendation not followed	17	Perceived positive impact on cost	11
Recommendation partially followed	9	No response	28
No response	17		

for obtaining laboratory tests to ensure safe and effective pharmacotherapy. The students indicated, according to their perceptions, a positive impact on cost, on care, and on both cost and care for 5%, 50%, and 34% of the interventions, respectively.

Preceptor Attitudes

Faculty members (preceptors) involved with the students in the project were anonymously surveyed on 13 topics related to the ACES project using a five-point Likert-type scale. The questionnaire was arranged in ordinal fashion with a score of "1" representing a poor response, "2" some response but less than adequate, "3" an adequate response, "4" more than adequate, and "5" representing a very positive response. Overall, preceptors found the ACES approach problematic. Specific problems identified were how well the software ran on available hardware (mean score of 2.0) and how adequately students were being trained to use ACES (mean score of 2.2). These low opinions regarding the operation of the software and hardware may have adversely influenced other aspects of the study and should be noted by other investigators. Further, a question relating to students' computer expertise when arriving in clerkships resulted in the faculty strongly stating that students needed more "computer savvy" prior to clerkships (mean score of 4.3). Faculty members' impressions of students' ability to document clinical activities prior to the project was a mean of 1.7 and increased to a mean of 2.5 (still less than adequate) as a result of the project. The students were felt to lack an understanding of the importance of documentation of clinical activities (mean rating of 2.4). The overall impression of the faculty to the ACES concept was favorable, but the execution was considered flawed due to equipment and software issues as well as students' inability to operate computers effectively.

Student Attitudes

Students were anonymously surveyed at the completion of their clerkships using a five-point Likert-type scale questionnaire similar to that used for preceptors. Seven questions related to the use of ACES, plus an opportunity to express opinions related to strengths and weaknesses of the ACES system. Results indicated poor student acceptance of the ACES system. A mean of 2.2 was reported by the students for survey questions relating to the amount of time needed to enter information and the ability of ACES to improve their ability to document their patient encounters. ACES was scored at 2.9 on simplicity of use. Students rated ACES's ability to improve problem-solving at 2.4. Strengths identified in the comment section of the questionnaire indicated that the software: (a) made organization of patient data easier (seven), (b) prompted students what to consider during patient monitoring (two), (c) aided in thinking about drug therapy (two), (d) aided in sorting out patients' medical problems (one), aided in visualizing laboratory data (two), (e) led to concise documentation (one), (f) provided guidance in what their role as a clinical pharmacist should be (one), and (g) aided in providing thorough coverage of all the monitoring parameters (one). The overwhelming weakness in the comments section was that the program was time-consuming (eleven). Other weaknesses identified by the students included the following: (a) students were being thrown out of the system (two), (b) software was too complicated (two), (c) software was too confusing (one), (d) information entered would disappear when moving between data-entry screens (one), (e) difficulty in understanding what to do with the care plan (one), and (f) difficulty in fitting patients into available categories (one).

DISCUSSION

Our study failed to show any difference in post-clerkship WGCTA scores between the two groups, except that the inference subtest scores were statistically higher in the control group when compared to the study group. The cause of this difference could not be explained by the investigators. It should be noted that both the authors of the WGCTA examination (17) and the reviewers (19) of this instrument state that only the composite score should be used as a reliable measure of critical thinking; therefore, we were not overly concerned with this singular result.

When assessing the lack of improvement in critical-thinking scores, a number of possible explanations exist. It is possible that when the postclerkship WGCTA testing took place, students were not as focused because they knew it had no bearing on their grade. It also is possible that our study did improve clinical reasoning but that the WGCTA was not sufficiently sensitive to measure a change in critical thinking. Perhaps it is not possible at this time to see a change in critical-thinking skills secondary to one intervention, a speculation based on our results and those of others (6). A limitation of WGCTA is that it was designed after World War II and may possibly have lost some of its relevance for current students. The California Critical Thinking Instrument is an alternative instrument with which to measure critical thinking and may have been a more sensitive instrument to use in this study. Unfortunately, the authors did not learn of its existence until after data was collected and analyzed. Another possibility is that a sample of approximately 30 students was insufficient to see a change in scores. We used all available students–the entire class–for this pilot study.

Enhancing patient monitoring and facilitating the development of problem-solving skills is one goal of pharmaceutical education. Other schools and colleges of pharmacy may benefit from our experience when exploring similar means of enhancing problem-solving skills in terms of developing critical thinkers. The original focus of the study involved the development and implementation of a computerized clinical database designed to reinforce critical-thinking skills through structure of information entry. Although the results of our study did not determine what we initially set out to test, the study revealed several concerns vital to pharmacy education. Perhaps more importantly, the study revealed a lack of students' ability to effectively document their activities.

The first concern was the lack of computer knowledge and experience by students. Brief training (one hour) prior to study implementation did not provide students with sufficient expertise to use on-line information services, data management, and documentation software as a means of enhancing patient monitoring. If students are to be expected to function in the evolving informational practice environment, these basic computer skills must be achieved at some point prior to experiential clerkships. ACPE recognizes the importance of computer skills in practice by referring to them in the required practice competencies (2). Although the investigators assumed students possessed a level of competency and comfort with computers, this was not the fact.

The second concern was that during the project, equipment, and software malfunctions frustrated both students and clerkship preceptors. All computers were networked together over networks (LANs) and modem connections. The lack of ability for students to sign on correctly, coupled with equipment failure, caused delays in data entry and stifled enthusiasm.

The third concern we uncovered was that the software programs we used were too large and complex for computers with a 386 processing speed. Consequently, loading software and entering data were both slow and tedious processes. This third factor will be easy to overcome using technologically faster processors.

If similar problems are being experienced nationwide, the ability of the pharmacy profession to maximize available informational services as means of improving the pharmacist's provision of pharmaceutical care will be greatly hindered. We surmise that if "prototyping" approaches using computerized databases are to positively impact critical thinking, our pharmacy students must become more computer-literate. They must also be adequately trained to use the software; moreover, the software should be user-friendly. Perhaps most importantly, the use of computer documentation software should be introduced earlier in the pharmacy curriculum.

Some recommendations can be made based on our experience. To fully prepare students for the intensive clerkship period associated with entry-level programs and to have an impact on critical thinking, some mechanism which incorporates patient monitoring throughout the first three years of an entry-level program is necessary. A controlled and reproducible laboratory exercise using computer-assisted learning or standardized patient scenarios followed by computerized case development, documentation, and testing is one possibility. Standardized cases, incorporating the ACES approach, would allow students to practice patient monitoring and develop a familiarity with pharmacy references, both hard copy and on-line. Using this format throughout the first three years could be combined with increasing patient case complexity as students advance through the professional program. Components of pharmaceutical care (including therapeutic drug regimen development, therapeutic outcome monitoring, and altering drug therapy regimens) could also be introduced in step-wise fashion, concurrent with other courses which emphasize patient-care skills.

We believe that laptop or hand-held "palmtop" stand-alone programs would have allowed students to acquire information directly at the bedside or the nursing station. This ability may have improved data collection and the accuracy of data-entry. These portable devices would allow students to access the Internet to acquire information, plus allow them to download accumulated information and documentation to centralized data accumulation computers. This technology currently exists, but colleges may find it financially difficult to keep up with the technological advancements in both hardware and software. However, we feel that colleges of pharmacy must evaluate and procure a commercial "documentation of professional activities" system (*e.g.*, Clinitrends®) for use early in the curriculum so that students develop those professional behaviors necessary for future documentation and reimbursement. Many commercial documentation systems are now appearing on the market either as stand-alone systems or tied in with product distribution and dispensing systems. Alternatively, colleges and schools of pharmacy may decide to develop such a system on their own, although this is not recommended based on our experience.

Our results have generated a concerted effort by our faculty to place more emphasis on the importance of documentation. This increased awareness by the faculty for the need to teach documentation formally, as well as decision-making and critical thinking, applies to all levels of the curriculum. Appropriate documentation of pharmacy interventions is imperative if we are to prepare students for reimbursement for cognitive services. In the coming era of the on-line medical record coupled with electronic billing, the importance of effective electronic documentation for reimbursement of cognitive services associated with pharmaceutical care cannot be overemphasized.

CONCLUSION

The use of the ACES software did not demonstrate an improvement in the critical-thinking skills of our senior students. The slow speed of the computers used, breakdowns, the complexity of the software, along with the lack of computer skills by our students, the relaxed atmosphere during post-WGCTA testing, and possibly even the evaluation instrument itself may have had a negative impact on our results. There is considerable opportunity for further study with improved hardware and software and future results may affirm our original hypothesis.

Although the authors feel that the concept and study design were appropriate as a pilot study, the value of the study may be related to issues peripheral to our primary hypotheses. We revealed that students' understanding of the importance of adequate documentation of their clinical activities and their ability to provide it were less than expected. Patient data and student-derived conclusions were at times incomplete and inaccurate. If our results can be extrapolated to other schools of pharmacy and to pharmacy practitioners, then considerable educational effort needs to occur. At the least, other schools and colleges of pharmacy should address these concerns to ensure that no problems exist at their institutions.

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