Evaluation of Computerized Medicinal Chemistry Case Study Modules as Tools to Enhance Student Learning and Clinical Problem-Solving Skills[1]

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This national controlled study assesses the impact of computerized case studies that emphasize medicinal chemistry content on pharmacy students' ability to learn and apply chemical information and principles to solve complex therapeutic problems. Eighty-six student volunteers from five schools or colleges of pharmacy were assigned to Control and Experimental groups. There was no significant difference between these study groups with respect to all personal and academic characteristics measured except the extent to which they enjoyed the study of medicinal chemistry. Pre- and posttest case study essays were administered to all participants before and after the Experimental group worked through the computerized cases. These essays were scored in a blinded fashion by faculty coordinators at each participating institution, and the mean difference in score for seven performance criteria computed. Any difference in score between the control and experimental populations was attributed to the influence of the computerized medicinal chemistry case study modules. Statistical analysis documented that the performance difference exhibited by Experimental group students was significantly more positive than the Control group on four of the seven performance criteria, specifically: (*i*) identifying relevant therapeutic problems; (*ii*) conducting thorough and mechanistic structure-activity relationship (SAR) analyses of the drug product choices provided; (*iii*) evaluating SAR findings in light of patient needs and desired therapeutic outcomes; and (*iv*) solving patient-specific therapeutic problems. Formal evaluation of the case study modules by the Experimental group shows that students enjoy using them, find them helpful and relevant to their classroom studies, and believe they reinforce the importance of chemistry to the contemporary practice of pharmacy.

INTRODUCTION

For some time we have been involved in developing computerized case study modules designed to emphasize the importance of medicinal chemistry to rational, scientifically-grounded therapeutic decision-making. The computerized case study modules developed to date address clinically relevant issues in acid-base chemistry, H_1 receptor antagonists, reversible and irreversible cholinesterase inhibitors, muscarinic receptor antagonists, α and β adrenergic agonists, local anesthetics, and targeted drug delivery.

The structure and content of the computerized cases has been previously described(1). The cases are written to reflect professional decisions potentially encountered in a variety of

settings including, but not limited to, community, institutional and extended care facility practice, and the pharmaceutical industry. Each case study module places the student in the role of pharmacist or drug design expert, and presents a patient-oriented scenario requiring a therapeutic decision, drug product selection, or the provision of drug information. Questions addressing desired or anticipated therapeutic outcomes are posed, and students select answers that give chemically based explanations for clinical responses. When working the cases, students are expected to analyze how specific chemical functional groups and/or physicochemical properties influence receptor affinity and selectivity, distribution, metabolic vulnerability, in vitro stability, potential route(s) of administration, and patient compliance. Drug structures, rather than drug names, are provided so that chemical reasoning motivates student response to case questions. Wrong responses generate additional questions that guide students in correcting their mistakes, while correct answers are positively reinforced. A tutorial program is loaded with each case study, and is accessible from a pull-down menu. Humor and graphics are utilized liberally to enhance student appeal. The cases send the clear message that pharmacists are proactive providers of service to the public and to other health care professionals, and that they have the scientific and clinical knowledge base necessary to positively impact patient care outcomes.

We identified four major educational goals for the computerized medicinal chemistry case study modules. We hypothesized that they would:

1. effectively demonstrate to students the practical relevance of medicinal chemistry to the practice of pharmacy;
2. promote an appreciation for the scientific rationale behind therapeutic decisions;
3. increase student enthusiasm for, and enjoyment of, the study of medicinal chemistry; and
4. enhance students' critical thinking and problem solving skills.

A paper published in 1997 provided evidence that the first three of these project goals were met(1). There was broad-based student acceptance and enjoyment of the modules, and a general consensus that they underscored the practical relevance of the discipline of medicinal chemistry to contemporary pharmacy practice. Further, it was extremely gratifying to note that the modules were perceived by students as being valuable tools to help them learn medicinal chemistry. However, additional proof was required in order to claim that they actually had a positive impact on students' ability to use their knowledge of chemistry to think critically about clinical issues and solve patient-specific problems. The current national study was undertaken to identify the influence of these modules on: (*i*) the learning of medicinal chemistry concepts, and (*ii*) the ability to apply this knowledge to solve patient-specific therapeutic problems.

METHODS

Study Design

Faculty volunteers from six Schools or Colleges of Pharmacy agreed to participate in the evaluation of the computerized learning tool. The participating schools represented six distinct geographic regions (Northeast, Southeast, South, Midwest, Northwest, and Southwest) with half being private institutions. One private institution (from the Midwest region) withdrew from the project due to computer network failure. Therefore, a total of five institutions completed the study. The

volunteer faculty coordinators who completed the study were offered a modest honorarium for their efforts.

Faculty coordinators were sent a comprehensive packet of information on how the study was to be conducted. Included in the packet was:

- a colleague information letter which provided detailed instructions to the faculty coordinator for all phases of the study;
- study population reporting sheets to facilitate the reporting of information to the investigators;
- a letter to student participants explaining the purpose of the study, outlining their responsibilities as participants, and assuring their personal anonymity to the investigators;
- a participation agreement which students signed to indicate their consent to participate in the study;
- a demographic questionnaire; pretest and posttest case study problems, along with instructions to faculty coordinators and student participants;
- case study module evaluation forms;
- ten computerized medicinal chemistry case studies on compact disk.

Coordinators were asked to recruit at least twenty student volunteers who were currently enrolled in a medicinal chemistry course into the study. This proved to be a difficult request, as the students could not be directly compensated with either money or "extra credit" incentives for their participation. The number of students recruited by each of the five faculty coordinators ranged between nine and twenty-four. A total of 86 students participated in the study.

Participating students were assigned to either a Control group (which was not allowed access to the computerized cases) or an Experimental group (which was required to work through the cases). The composition of the two groups was matched by the coordinator with respect to size, gender, academic performance level, number of degree-holding students, and number of students with a pre-professional chemistry degree. Each student was randomly issued a participant number. It was by this number only that they were to be known to their faculty coordinator and to the investigators in all phases of the study. Coordinators were asked to ensure that access to the computerized medicinal chemistry case studies was restricted only to Experimental group students until the study was complete, at which time the Control group students were invited to review the cases. Forty-four students were assigned to the Experimental group, with the remaining 42 students participating in the study making up the Control group.

All 86 student participants completed a demographic questionnaire and an essay-based pretest case study problem (Appendix A). The essays were assessed in a blinded fashion by the faculty coordinator at the students' school, and Likert-scale scores on seven specific performance criteria were awarded to each student. The criteria evaluated included:

1. identification of the therapeutic problems impacting on the case;
2. prioritization of the patient-specific factors to be considered to achieve the desired therapeutic outcomes;
3. conduction of a thorough and mechanistically-oriented structure activity relationship (SAR) analysis of the therapeutic choices provided;
4. evaluation of the SAR findings against the patient-specif-

Table I. Academic and personal demographic characteristics assessed

Academic	Personal
Comfort with computers	Age
Comfort with factual recall	Sex
Comfort with integrating information	Marital status
Comfort with problem solving	Number of children
Pre-requisite chemistry performance	Race/ethnicity
Current grade point average	U.S. citizenship
Previous degree	
Effort expended to earn medicinal chemistry grade	
Extent of enjoyment of medicinal chemistry study	
Extent of agreement with statement: "Knowledge of drug chemistry is critical to the practice of pharmacy."	

ic factors and desired therapeutic outcomes;
5. appropriateness of the therapeutic decision;
6. quality of the monitoring recommendations and patient counseling provided; and
7. overall problem-solving ability

The Experimental group then worked through the computerized cases in a sequence determined by the topics being presented in class. At the conclusion of the study all students completed a posttest case study essay (Appendix B) which was evaluated and scored by the faculty coordinator in a manner identical to that described for the pretest case study problem. Following the posttest, students in the Experimental group evaluated the modules by answering the Case Study Evaluation form (Appendix C). The difference in pretest and posttest scores was calculated for the Control and Experimental group populations. Any difference in score between the control and experimental populations was assumed to be due to the influence of the computerized medicinal chemistry case study modules. This assumption is based upon the following criteria:

1. each student completed both the pre- and the posttest, and thus served as his/her own knowledge control;
2. the participating students from each School were all enrolled in the same didactic medicinal chemistry class and therefore experienced the same knowledge and skill-enhancing instruction from the professors teaching in that class; and
3. inter-rater reliability was assured because the same individual was evaluating student performance on the pre- and posttests.

Statistical Methods
The data from the participants were analyzed using Statistical Package for the Social Sciences software (SPSS) for Windows (version 8.0). Frequency distributions were computed for all variables. A paired samples *t-test* was conducted to determine significant differences between the mean performance difference values for the Control and Experimental populations. A difference in means test was used to compare the mean change between the pre- and posttest scores of the Control group with the mean change in score of the Experimental group.

RESULTS

Demographics
The personal and academic characteristics identified in the study population are listed in Table I. There were no significant differences ($P<0.05$) between Control and Experimental group students with respect to all academic demographic variables assessed except the extent to which they enjoyed the study of medicinal chemistry. The Experimental group claimed a higher level of enthusiasm for this subject than the Control group, with 31.8 and 21.4 percent of the populations, respectively, claiming to enjoy it very much. The variables that were to be strictly controlled when assigning students to Control or Experimental groups (gender, academic performance, previous degree, and previous chemistry degree) were found to be statistically identical in both populations.

The age of the participating students ranged from 20 through 43 years with the majority (70 percent) being 25 years old or younger. Females comprised 54.8 and 63.6 percent of the Control and Experimental groups, respectively. The students were primarily Caucasian (69.7 percent) and 94.2 percent were citizens or permanent residents of the United States. The most commonly identified minority was Asian or Pacific Islander (20.9 percent) and all other ethnic minorities were represented by at least one individual in both the Control and Experimental populations. Seventy one percent of the population was single and 26.7 percent was married, and the majority (87.8 percent) of the students did not have children at the time of the study.

Computer literacy and comfort with various intellectual demands made of them in school could conceivably impact students' success with the modules and the pre- and posttest case study essays. Therefore, we asked participants to rank their level of comfort in working with computers, as well as with courses that required them to recall factual information, integrate information and problem-solve. While no significant differences ($P<0.05$) were noted between Control and Experimental groups on any of these parameters, the following population characteristics were noted. Eighty-five percent of the students in each group were either very or somewhat comfortable with computers. Six students per group claimed to be somewhat uncomfortable with computers while one student in the control group claimed to be very uncomfortable with this technology. A majority of the students were either very comfortable or somewhat comfortable with courses that required them to recall factual information (91 percent), integrate information (91 percent) and solve problems (92 percent). The Experimental group had the largest percentage of students that were very comfortable with problem-solving (41 percent) and the Control group had the lowest percentage of students that were very comfortable with integrating information (12 percent).

The mean professional grade point average (on a 0-4.0 scale) was 3.06 for the Experimental group and 3.20 for the Control group. There was no significant difference ($P<0.05$) in the number of students who had previously earned a college degree. The Experimental group had 13 students with a previously earned degree compared with six Control group students. Two of the Control group students and one Experimental group student had a previously earned Chemistry degree. Fifty-two percent of the Control group students and 59 percent of the Experimental group population claimed to be an above average (*e.g.*, "B") student in pre-professional chemistry courses. A greater number in each population rated themselves highly competent (*e.g.*, "A" student) than average ("C" student) performers in this discipline. Even with this self-professed high level of chemistry ability, 67 and 70 percent of the Control and Experimental group participants, respectively, said they worked somewhat or much harder to earn their grades in medicinal chemistry courses compared to other courses in the curriculum.

Table II. Difference in pre- and posttest performance of the study population

| Criterion | Control (N=42) | | Experimental (N=44) | |
	Mean performance difference (Posttest score - Pretest score)	SD	Mean performance difference (Posttest score - Pretest score)	SD
1. Problem-Solving Ability*	0.29	1.15	0.43	1.40
2. Identify Therapeutic Problems*	0.05	1.50	0.36	1.50
3. Prioritize Patient-Specific Factors	0.02	0.98	-0.02	1.59
4. Thorough SAR Analysis*	0.17	1.12	0.91	1.44
5. Evaluation of SAR Findings*	0.33	1.14	0.61	1.62
6. Appropriate Therapeutic Decision	0.24	1.12	0.32	1.84
7. Monitoring and Counseling	0.50	1.17	0.66	1.20

* Significantly different at $P < 0.001$.

Table III. Medicinal chemistry case study evaluation by experimental group students (N = 39)

| | Percent | | | | |
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Relevant to information taught in medicinal chemistry*	52.5	45.0	2.5	0	0
Reinforces important medicinal chemistry concepts	48.7	48.7	2.6	0	0
Reinforces importance of chemistry knowledge to pharmacy practice	46.1	38.5	15.4	0	0
Required me to think beyond level of medicinal chemistry course	23.1	30.8	28.2	12.8	5.1
Cases were "doable" with my chemistry/medicinal chemistry knowledge	23.1	53.8	20.5	2.6	0
Cases were readily understandable	51.3	35.9	12.8	0	0
Cases were easy to follow	43.6	43.6	12.8	0	0
Cases were fun	43.6	33.3	15.4	5.1	2.6
Cases were visually attractive	33.3	51.3	12.8	2.6	0
Reinforces importance of chemistry knowledge to pharmacy practice*	42.5	40.0	12.5	5.0	0

* One Control group student responded (N = 40).

All study participants were asked if they agreed with the following statement: "Knowledge of drug chemistry is critical to the optimal practice of contemporary pharmacy." Eighty-three percent of the Control group and 82 percent of the Experimental group either agreed or strongly agreed with the statement. The three students who disagreed or strongly disagreed with this concept were in the Experimental group.

Pre- and Posttest Case Study Performance
The Control and Experimental groups were evaluated for their performance on each of the seven criteria listed in Table II. The mean difference in performance on the pretest and posttest case study essays was calculated by subtracting each participant's pretest score from the posttest score and averaging the results. The mean differences obtained are reported in Table II. A positive mean difference value indicates improved performance on the posttest essay as compared to the pretest, while a negative mean difference reflects the opposite situation. Both groups showed positive differences in performance on the seven criteria, with the exception that the Experimental group demonstrated a decrease in Prioritizing Patient-Specific Factors. As previously noted, a paired samples t-test was conducted to determine significant differences between the mean performance difference values for the Control and Experimental populations.

The improvement exhibited by the Experimental group students was significantly greater than the improvement achieved by the Control group students on four of the performance criteria ($P<0.001$). Specifically, significantly enhanced performance was noted in the Experimental group's ability to: (*i*) identify the relevant therapeutic problems; (*ii*) conduct thorough and mechanistic SAR analyses of the drug product choices provided; (*iii*) evaluate SAR findings in light of patient needs and desired therapeutic outcomes; and (*iv*) problem-solve. No significant differences between Experimental and Control groups were observed with respect to students' ability to: (*i*) prioritize the patient-specific factors important to achieving the desired therapeutic outcomes; (*ii*) make an appropriate therapeutic decision; and (*iii*) provide monitoring recommendations and patient counseling.

Computerized Case Study Module Evaluation
All experimental group students were asked to complete an evaluation of the computerized case study modules, and 39 (89 percent) complied. One Control group student who reviewed the cases at the end of the study provided feedback by completing the first and last questions of the assessment survey. Results of the case module assessment completed by the participants are presented in Table III, and are consistent with the positive evaluation routinely given the cases by students at Creighton University and St. John's University(1). Forty percent of the student evaluators had completed all ten of the computerized case studies, and 75 percent had completed seven or more modules. While there was strong agreement that the cases were relevant to the information being taught in the students'

medicinal chemistry courses, over half agreed or strongly agreed that the cases required them to think beyond the level demanded of them in the classroom. Ninety-seven percent agreed or strongly agreed that the cases reinforced important concepts in medicinal chemistry, and 84.6 percent agreed or strongly agreed that the importance of the discipline to the practice of pharmacy was effectively illustrated in the case modules. There was a general consensus that the cases were easy to follow (87 percent), readily understandable (87 percent) and fun to work through (77 percent). Eighty-five percent of the student evaluators enjoyed the case study graphics and found the cases visually attractive, 82.5 percent appreciated the humor, and three-quarters found the screens easy to read. Thirty-five percent of those responding thought the case study tutorials were a valuable resource, and 72.5 percent viewed them as effective SAR summaries. Ninety and 97.5 percent, respectively, thought access to the cases would help their peers succeed in their medicinal chemistry courses and assist them in understanding the content presented in those courses.

Eighty-two percent of the respondents agreed or strongly agreed with the premise that knowledge of drug chemistry is critical to the contemporary practice of pharmacy, and 57.5 percent claimed that the cases promoted the extent of their agreement with that concept. None of the respondents claimed the cases negatively influenced their belief in the importance of chemistry to pharmacy practice.

DISCUSSION

The schools asked to participate in this national study were chosen to represent all geographic areas of the United States, and to include an equal number of public and private institutions. While the faculty coordinators were willing to assume responsibility for organizing their students into groups, monitoring access to the cases, and grading student performance on the pre- and posttest case study problems, a few had to decline to participate or withdraw due to an inadequate number or insufficient memory/speed of the computers available for student use at their institution.

In some cases it was difficult to secure an agreement to participate in the study, as the student participants were truly volunteers, and were not remunerated or otherwise rewarded for their participation. The inability to randomly select the study population could conceivably introduce bias into the results. However, demographic parallels between the study group and the national pharmacy student population support the ability to generalize findings to students studying in other schools and colleges. Specifically, the gender, ethnic and U.S. citizenship distribution of the participating students closely parallels that of the national pharmacy student population(2). The percentage of students in the study population with previously earned baccalaureate degrees is also highly consistent with the percentage of degree-holding students making application to pharmacy programs). While the study population was composed predominately of young, unmarried individuals, mature learners, identified as individuals 32 years old and older or with children, comprised 16.5 and 12.2 percent of the study group, respectively.

Three of the five institutions which completed the study were public institutions and two were private colleges. Two of the participating programs utilized "pen and paper" case studies extensively in their didactic courses while three did not. However, student familiarity with the case-based approach to medicinal chemistry instruction would not have influenced the outcome of this study since each student served as his/her own knowledge control, and only the difference in performance on

the seven criteria was used as an indicator of the success or failure of the computerized cases in advancing student learning. The other demographic factors which could have influenced performance on the pre- and posttests, and thereby the perceived impact of the computerized cases (previous degree [especially a previous chemistry degree] and grade point average), were strictly controlled so as to be statistically equivalent in both Control and Experimental groups. Whether the Experimental groups' enhanced enthusiasm for the discipline of medicinal chemistry contributed to their significantly higher performance difference in four of the seven criteria is unknown. However, we believe it unlikely that this self-assessed, subjective value played a significant role in the results obtained.

In 1996, Test and Banahan(3) reported that students at their institution expressed mixed opinions on the use of computers in pharmacy school. While almost half owned a personal computer, most did not think that they were being taught the skills they needed to maximize their use of this technology in practice-related activities. While we did not ask this precise question of our Experimental and Control group students, it would appear that things are looking up, as only 15 percent of the 86 students from the five institutions participating in this study expressed any degree of discomfort working with computers.

It was not surprising, given the intensive chemistry-related content provided in the computerized cases, to find that students who used them developed a significantly enhanced ability to conduct a thorough and mechanistic structure-activity relationship analysis of the therapeutic choices we provided in the cases. However, while knowing SAR for SAR's sake may be gratifying to medicinal chemists, it does the pharmacist little practical good if this important knowledge does nothing to enhance the quality of life of the patients s/he serves. Therefore, we think it highly important that the Experimental group students were actually better able to apply these findings to improve "patient" care and achieve their desired therapeutic outcomes. Likewise, since one cannot begin to solve therapeutic problems until they are first identified, the positive impact of the computerized cases on students' ability to recognize real and potential therapeutic misadventures argues convincingly for their value in professionalizing the student.

The Commission to Implement Change in Pharmaceutical Education proposed that problem-solving was an essential competency for the performance of professional practice functions(4), and many Schools and Colleges of Pharmacy have embraced that concept by including problem-solving among their programmatic outcome objectives. Contemporary pharmacists will spend most of their professional lives identifying, preventing and (either prospectively or retrospectively) solving problems. Educational tools that inculcate this essential skill, which the computerized medicinal chemistry case studies have been shown to do, should help academicians meet their pedagogical mission to develop practitioners who can think clearly and constructively about complex clinical issues, and arrive at solutions which are satisfactory for all concerned.

While the computerized cases identified (or asked student users to identify) patient specific factors that could influence therapeutic choices, and provided counseling tips that the student-pharmacist could or should share with the patient in question, this was not the major thrust of the program. Therefore, we were not too disheartened to find that our modules had no significant impact on the participants' ability to engage in these practice skills. However, it was somewhat disappointing to find that the cases had no significant influence on their ability to make an appropriate therapeutic decision, especially given the

highly significant impact they had on students' ability to identify relevant clinical issues and solve problems. Both the pre- and posttests were complex case studies that required a significant amount of thoughtful, scientific analysis. While the computerized cases attempt to bring in aspects of pharmacology, pharmacetics, physiology, biochemistry, and therapeutics, they are admittedly highly focused on promoting an in-depth understanding of SAR and clinically relevant chemical properties. The ability of the Control group to do as well as the Experimental group in selecting the most appropriate agent for a patient from a limited list of options may simply be a reflection of the complex nature of that decision, and the important role played by several disciplines, chemistry among them, in making appropriate professional choices.

CONCLUSIONS

In order to be a valuable component of the professional education of future pharmacists, the discipline of medicinal chemistry must lay a solid foundation of basic science principles. Through these concepts and principles, pharmacy students gain a true understanding of drug action on the molecular level, and have a scientific basis upon which to build clinical decision-making skills. Unfortunately, although the practical utility of medicinal chemistry is readily apparent to those who teach this subject matter, students do not always appreciate its relevance to practice. Without proper guidance in applying chemical knowledge to therapeutic situations, the important clinical utility of this pharmaceutical science may be lost to students, and they can leave the course having only memorized the minimum number of structures and SAR rules necessary to pass.

There are a number of creative techniques currently being employed by medicinal chemistry faculty to ensure that students reap clinical relevance from this pharmaceutical science. Case studies are an increasingly popular vehicle to promote student learning, and many medicinal chemistry faculty are using them in class, in recitation, on exams, and as homework(5-7). The Structurally-Based Therapeutic Evaluation has recently been described as another mechanism for introducing clinical relevance into the medicinal chemistry classroom(8). Faculty colleagues have introduced computerized tutorials on acid-base chemistry, drug nomenclature and introductory principles in biochemistry, organic and medicinal chemistry to their students[2](9), and these tools have reportedly been well-received. Computer-aided instructional tools have also been regularly employed in pharmaceutics, calculations, pharmacology and therapeutics courses(10-14). What we believe our computerized medicinal chemistry case studies bring to the classroom that is novel is an interactive and in-depth guided discussion of the impact of structure on drug behavior both in vivo and in vitro, which dictates how that drug can and will be used in the clinical setting.

Our previous experience with the computerized case studies indicated that they had the potential to be effective tools to enhance learning of medicinal chemistry, particularly as it applies to therapeutic decision making. Students at Creighton and St. John's Universities who have employed the cases to assist them in mastering medicinal chemistry course content have been universally enthusiastic about their positive impact on their understanding of major chemical concepts and principles. In their 1996 study, Test and Banahan(3) found that the majority of students in their study population thought pharmacy students wanted and needed more exposure to computers in pharmacy education and practice. Our study has shown that the cases may also be effective in enhancing student comfort with computer technology, as 85 percent of the respondents found them readily understandable and easy to follow.

In summary, this national study has demonstrated that, in addition to being entertaining and attention-holding educational exercises, the computerized medicinal chemistry case studies actually improve students' ability to identify relevant therapeutic problems in cases of differing complexity, to conduct thorough and mechanistic SAR analyses, to evaluate their findings in light of patient needs and desired therapeutic outcomes, and to solve patient-specific therapeutic problems.

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APPENDIX A. PRETEST CASE STUDY PROBLEM

VR, an 89 year old widow who lives alone with her cat, has developed a mild allergy to the animal. The cat is very important to her as a companion, and the thought of giving it up is highly distressing. VR has a history of bradycardia, and is somewhat unsteady when walking. She now uses a walker after having suffered a couple of bad falls. Her M.D. has placed her on low dose Diazepam in an attempt to control vertigo. Recently she began using OTC Tagamet HB® for "heartburn". VR is mentally alert and active, but is now complaining of daytime sleepiness. She doesn't have much money to spend on medications. The antihistaminic structures shown as compounds 1-4 are in your pharmacy. The structures of Diazepam and Tagamet® are also provided.
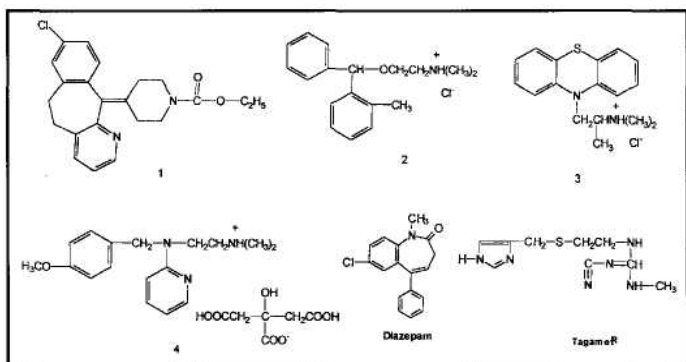
1. Identify the therapeutic problem(s) where the pharmacist's intervention may benefit the patient.
2. Identify and prioritize the patient specific factors that must be considered to achieve the desired therapeutic outcomes.
3. Conduct a thorough and mechanistically oriented structure-activity analysis of all therapeutic alternatives provided in the case.
4. Evaluate the SAR findings against the patient specific factors and desired therapeutic outcomes.
5. Make a therapeutic decision.
6. Provide monitoring/assessment recommendations and patient counseling as appropriate.

APPENDIX B. POSTTEST CASE STUDY PROBLEM

O.P. is an alert 80 year old male who lives with his wife at the Pennbrooke skilled nursing facility. A smoker his entire life, he suffers from severe emphysema and requires oxygen. His routinely elevated blood pressure is being controlled with the ACE inhibitor enalapril **1**, and he was started on a regimen that includes benztropine mesylate **2** one month ago for the treatment of early Parkinson's Disease. Since starting his anti-Parkinson's regimen he has complained of sleep disturbances, and the nursing staff has charted uncharacteristic delusional and confused behavior. Central benztropine side effects are suspected. O.P. and his wife have remained sexually active, and he has been further upset by a recent inability to perform. O.P. has recently suffered a mild M.I., and his physician plans to institute p.o. therapy with a β adrenergic blocking agent. Consider the structures of the six β adrenergic structures, **3-8** drawn below.

1. Identify the therapeutic problem(s) where the pharmacist's intervention may benefit the patient.
2. Identify and prioritize the patient specific factors that must be considered to achieve the desired therapeutic outcomes.
3. Conduct a thorough and mechanistically oriented structure-activity analysis of all therapeutic alternatives provided in the case.
4. Evaluate the SAR findings against the patient specific factors and desired therapeutic outcomes.
5. Make a therapeutic decision.
6. Provide monitoring/assessment recommendations and patient counseling as appropriate.

APPENDIX C. MEDICINAL CHEMISTRY CASE STUDY EVALUATION INSTRUMENT

Please indicate the extent to which you agree with the following statements about the medicinal chemistry computerized case studies you have previewed. Your honest response to these items will be of great value to the authors in making this teaching tool both educational and enjoyable for pharmacy students across the country.

The computerized case studies in medicinal chemistry which I previewed:

	Strongly Agree 5	Agree 4	No Opinion 3	Disagree 2	Strongly Disagree 1

1. were relevant to the information I was taught in my medicinal chemistry course(s)
2. reinforced important medicinal chemistry concepts
3. reinforced the importance of chemical knowledge in the actual practice of pharmacy
4. required me to think beyond the level that was required of me in my medicinal chemistry course(s)
5. were "doable" based on my knowledge of basic and medicinal chemistry concepts
6. were readily understandable (in terms of word usage, chemical terms, language)
7. were easy to follow (in terms of thought processes and ideas)
8. were fun to work through
9. were visually attractive

Additional questions (circle all applicable answers for each question):
10. The information contained on each case study screen was:
    a. too abbreviated for a good understanding of the concepts
    b. too wordy to follow....I got lost!
    c. just right.
11. The graphics contained on the case study screen:
    a. made the case studies more enjoyable to run.
    b. did not add anything to the value of the case study programs.
    c. were distracting to me.
12. The format of the case study screen (*e.g.*, placement of text boxes, answer buttons, graphics, etc):
    a. made it easy to follow the ideas being presented
    b. was distracting to me
    c. was confusing to me
13. The case study tutorials:
    a. were a valuable resource in working through the case study problem
    b. summarized effectively the important SAR of the class of molecules under study
    c were written in a style that was easy to read
    d. were confusing and difficult to follow
    e. were not helpful
14. I found the attempts at humor in the case studies:
    a. appealing (*e.g.*, made the cases more fun to work through)
    b. irritating
    c. intimidating
    d. ineffective (*e.g.*, not funny)
15. Do you believe having access to these computerized medicinal chemistry case studies would help students in your School better understand medicinal chemistry?
    a. Yes   b. No
16. Do you believe having access to these computerized medicinal chemistry case studies would help students in your School succeed in medicinal chemistry courses?
    a. Yes   b. No
17. What did you like best about the computerized medicinal chemistry case studies?
18. What suggestions for improvement do you have for the authors?
19. How well do you agree with the following statement? "Knowledge of drug chemistry is critical to the optimal practice of contemporary pharmacy."
    a. Strongly agree   d. Disagree
    b. Agree   e. Strongly disagree
    c. Neutral
20. How did the computerized case study modules influence your extent of agreement with the statement from the previous question?
    a. The cases did not influence my opinion about the statement
    b. The cases promoted my extent of agreement with the statement
    c. The cases negatively impacted my extent of agreement with the statement.