

An Approach to Pharmaceutics Course Development as the Profession Changes in the 21st Century

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An approach to curriculum modification in the field of pharmaceutics is presented in this paper. Pharmaceutical education is gradually heading toward a new direction. With the emergence of the pharmaceutical care concept, modern day pharmacists are responsible for serving a multifarious role in patient-care management, often in a collaborative setting. Pharmacy schools are now required to meet revised accreditation standards mandated by the national pharmacy organizations, which direct them to train students to be competent in making judgments and therapeutic decisions by developing their problem-solving and critical thinking skills. This requires the integration of knowledge and a practical approach to education. Pharmaceutical science teachers therefore need to emphasize not only scientific principles that provide fundamentals to their students, but also the relevance of science to clinical practice and pharmaceutical care. An approach is presented here for re-designing the pharmaceutics course sequence so that it meets practice-based outcomes and develops student appreciation for the scientific rationale behind pharmaceutics-related therapeutic decisions. A paradigm shift from didactic teaching to more active learning has been implemented by introducing problem-solving exercises and presentations which are targeted to foster peer interaction and professionalism, enhance confidence and sense of direction, and

develop critical thinking, problem-solving, and decision-making skills in students.

Keywords: Pharmaceutics; Pharmacy education; Problem based learning; Active learning; Curriculum integration

INTRODUCTION

In the middle of the nineteenth century, when the first American educational institution for teaching of pharmacy, the Philadelphia College of Pharmacy, was founded, the preparation of medicines and compounding of dosage forms were considered to be the prime responsibility of a pharmacist. With the evolution of clinical pharmacology and therapeutics, and the emergence of the pharmaceutical care concept, modern day pharmacists are now responsible for serving a multifarious role in patient-care management, often in a collaborative setting. They are required to draw upon certain

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competencies and outcomes that enable them to perform desirable pharmaceutical care. Pharmacy organizations like the American Pharmaceutical Organization (APhA), American Association of Colleges of Pharmacy (AACCP), and American Council on Pharmaceutical Education (ACPE) have recently begun defining these competencies and outcomes, and adopting principles, skills, and standards for pharmacy education and practice. In the near future, most schools of pharmacy in the USA will be offering the Doctor of Pharmacy degree at entry level. This makes the present time an important juncture in the history of pharmacy education in the USA, as most schools are re-designing their curriculum according to the needs of the Pharm.D. degree, including more pharmaceutical care and disease-state-management-oriented education compared to 20 years ago. For all concerned faculty members, this means reevaluating courses and perhaps re-structuring and/or integrating them, in keeping with the individual school's perspectives. The College of Pharmacy at Idaho State University started offering the Doctor of Pharmacy degree at the entry level of the professional program since 1988, and we are currently re-designing our curriculum to incorporate an integrated educational approach rather than the traditional, didactic, lecture-driven format of individualized "capsular" (modular) courses. Currently, the institution is implementing ways to introduce more ability-based learning in the pharmaceuticals sequence, and an approach to pharmaceuticals curriculum modification is presented in this paper.

CONCERN REGARDING THE ROLE OF PHARMACEUTICS IN CLINICAL PRACTICE

"I hear and I forget, I see and I remember, I do and I understand" Confucius (Scholar, 6th century BC)

With the influx of new educational concepts in pharmacy curricula, future pharmacists are expected to become active learners, problem

solvers, and critical thinkers. As mentioned before, pharmacists are now responsible for therapeutic intervention. Therefore, most students in their final years of rotation focus on learning clinical therapeutics. They often forget to consider the importance of dosage forms in patient-care management until they face a real-life problem concerning the bioavailability, bioequivalence or design of a formulation. The problem is compounded by the fact that pharmaceuticals courses are generally taught early in the curriculum and may gradually lose relevance from the students' perspective by the time they graduate. The profound observation by Confucius remains relevant today. There are numerous references (outside the scope of this article) in educational journals and books that give mathematical definition to the efficacy of tutorial methods, and averaging those numbers gives us the following general statistics: "we remember about 20% of what we hear, 50% of what we see, but 80% of what we do." The average pharmacy school curriculum in the USA has largely obliterated laboratory or *hands on* experience in the basic sciences, in order to meet the increasing *clinical care* or *pharmaceutical care* oriented demands on the pharmacists. The curriculum credit load has been diverted in favor of more clinical experiential models that are expected to better prepare the professional pharmacy student for future job responsibilities. The truth of the matter is that clinical sciences are application oriented and dependent on the fundamentals of basic pharmaceutical sciences. Therefore, it is critical that we make the basic sciences in pharmaceutical education more function-driven so that the students are able to perceive the relevance of these subjects in their clinical applications (Alsharif *et al.*, 1999). If historical evidence and statistics are of value, unless students *do* usage-oriented active learning that directly affects their future career, it is probable that students would neither recognize nor remember the importance of the basic science subjects, including pharmaceuticals.

In the traditional lecture-only format of teaching pharmaceuticals that is currently existent in many pharmacy schools, students have little opportunity of getting appropriate ability-based training that will converse them with the latest developments in dosage forms and how that could affect the therapeutic outcome. The impact of recent technological advances in pharmaceuticals, especially in the biotechnology and novel drug-delivery sectors, may be lost on students. As a result, future pharmacists may find themselves ill equipped to handle real-life formulation problems when the situation arises. Inability to provide service to the patient or co-healthcare practitioner when a formulation problem occurs may cause anxiety and frustration, perhaps even accompanied by resentment on not having met adequate educational outcomes (however unjustified that notion may seem at present) during their pharmacy education. Situations like these could foster feelings of ineptness and distress in the future pharmacist. As educators, it is our responsibility to provide our students with all the necessary abilities required of them to practice as worthy professionals. Therefore, we need to address this lack of problem-solving, interpersonal, and analytic skills required to solve problems in drug delivery and ensure dosage form quality, and to forge necessary links between fundamental background knowledge and clinical practice.

WHY IS A PROFESSIONAL CURRICULUM DIFFERENT FROM TRADITIONAL?

Judging by the history of pharmacy education, it is evident that the fundamental facets of education itself have undergone little change with time; what has changed is our perspective towards education, periodically appearing in a circular or wave pattern (Hepler, 1987). In 1956, Benjamin Bloom headed a group of educational psychologists who developed a classification of

levels of intellectual behavior important in learning. This became a taxonomy including three overlapping domains; the cognitive, psychomotor, and affective (Bloom and Krathwohl, 1956). During the era of this classic publication, when *didactic teaching* as we know it today existed in all curricula, Bloom and his coauthors reported that 95% of test questions encountered by students require them to think only at the lowest possible cognitive level, involving simple recall of information. Perspectives of education have changed significantly from the 50s, and professional programs now discourage exclusive emphasis on knowledge and attempt to direct learning towards the higher cognitive domains. A professional pharmacy curriculum is now designed to be different from traditional programs such as those found in most basic science or humanities degrees and the difference lies in student abilities and educational outcomes. In the present day, we need to reconsider the established views on the taxonomy of edu-

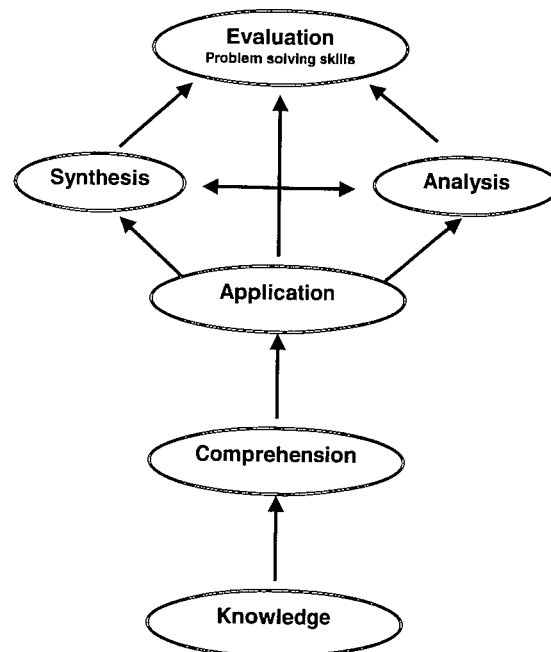


FIGURE 1 A hierarchy of the cognitive domain, as applicable to the Pharm.D. outcome expectations

cational objectives, and adapt the individual components according to the modified requirements of the professional curriculum (Fig. 1). In our opinion, the hierarchy of educational outcomes in the Pharm.D. program deviates considerably from the standard linear cognitive domain (knowledge → comprehension → application → analysis → synthesis → evaluation) as described by Bloom.

In a non-professional degree program, expectations from recipients are limited to knowledge and the ability to comprehend and apply principles to arrive at desirable conclusions. *Knowledge* represents the lowest level of learning outcomes in the cognitive domain as it involves the simple recall of material, from specific facts to complete theories. *Comprehension* constitutes the next level, as it requires the ability to grasp the meaning of material, characterized by translation, interpretation, and estimation of future trends. The ability to apply learned material such as rules, methods, concepts, principles, laws, and theories in new and concrete situations defines *application* skills. The acquisition of these first three skills described under the cognitive domain is generally considered sufficient for the success of a graduate in a non-professional degree program. This should not be interpreted as a conclusive statement that non-professional curricula *do not* develop the advanced student skills described next, rather that these additional skills are mandatory to the success of the professional student and must be impressed upon them.

As shown in Fig. 1, all professional students, including Pharm.D.s, must possess the aptitudes of knowledge, comprehension, and application abilities as their foundation, and require the additional skills of analysis, synthesis, and evaluation. *Analysis* is the ability to break down material content into its component parts so that its organizational structure is understood. *Synthesis* refers to coalescence of individual parts in a singular composition, which may be a unique communication (theme or speech), a plan of

operations (research proposal), or a set of abstract relations (scheme for classifying information). Learning outcomes in this area stress creative behaviors, with emphasis on the formulation of *new* patterns or structures. *Evaluation* skills, reflected best by *problem-solving* abilities, are the highest learning outcomes in the cognitive domain, and develop gradually from the combined abilities to apply, analyze, and synthesize information. They contain elements of all the other categories, plus conscious value judgments based on clearly defined criteria. As indicated by Fig. 1, the authors' opinion regarding the skills of application, analysis, synthesis, and evaluation differ from the linearly modeled cognitive domain described by Bloom *et al.* We believe that these skills are inter-related and cannot be described as discrete attributes where one skill can only directly lead to another.

Skills such as those described above are acquired by practice: if we are not born with them, we can certainly acquire them with effort. In the case of pharmacy students, acquisition of these skills would help them integrate their knowledge database from the various subjects taught in the pharmacy curriculum. Rather than *compartmentalizing* knowledge under discrete subject headings, when faced with an individual drug or disease state, the successful pharmacy practitioner should be able to synthesize fragmented information that deal with that particular drug or disease state at different stages throughout the curriculum. For example, if a pharmacy student is asked to discuss insulin, he/she should be able to relate the drug to its discovery, synthesis, structure, mechanism of action, biopharmaceutics and pharmacokinetics, physicochemical aspects of the dosage form including the various ingredients, storage conditions, allergy and toxicology information, drug interactions, patient-oriented usage instructions, and socioeconomic factors. In order to advance our curricula, we need to train students to develop such integration skills. Several

pharmacy schools, including ISU, currently implement case study based learning in the Pharm.D. curriculum, which takes us a step forward in that direction. Some schools have also integrated medicinal chemistry and pharmacology with therapeutics coursework (coined under new terminology like *pharmacotherapy* or *pharmacotherapeutics* courses) to give the students a complete picture of disease-state management.

FEASIBILITY OF METAMORPHOSIS IN PHARMACEUTICS COURSES

A pharmacist is the unique member of the healthcare team who is expected to apply the knowledge of dosage forms in a therapeutic regimen, and this knowledge comes from the study of pharmaceuticals. Pharmaceuticals is a discipline that is associated with the design, development, and rational use of medications for the treatment and prevention of disease. It involves designing dosage forms for delivery of drugs, determining drug storage and stability, and evaluating the effects of physiological and formulation factors on the absorption, distribution, metabolism and excretion of drugs in humans. It is an interdisciplinary field of study that combines basic knowledge of chemistry, biochemistry, physics, mathematics and biology with human anatomy, physiology, disease states, and therapeutics in order to optimize patient drug therapy. Pharmaceuticals is also a unique subject of the basic pharmaceutical sciences that belongs to the pharmacy profession. Pharmacy curricula throughout the world have undergone several changes in the twentieth century, yet the importance of pharmaceuticals or the knowledge of dosage forms remains as one of the most integral responsibilities of a pharmacist. With the

recent curricular trends, the challenge is to make pharmaceuticals courses more relevant to clinical practice so that they appropriately satisfy the end-point competencies of the professional Pharm.D. program. Pharmaceuticals is mainly based on strong fundamentals of physical chemistry and formulation science, implemented in the past as the lecture-only format of teaching, therefore any change would be quite a challenge for most academics. Before implementing any changes, we need to consider the salient features of the subject matter and how it may lend itself to molding in a non-traditional framework.

In a recent survey* of 31 pharmacy schools/colleges who have changed (or are in the process of changing) their curricula, it was noted that all 31 colleges have kept their pharmaceuticals courses separate from any integrated modules. In fact, pharmaceuticals is the only subject in basic sciences that appears to have retained an individual identity in *all* the cases studied. The average credits for pharmaceuticals taught at the 31 schools surveyed are 11.5 credit hours. It is very interesting to note that hardly any of the schools have attempted to integrate pharmaceuticals with disease-state based learning in their integrated pharmacotherapeutics courses. Perhaps it is because the basic material covered in pharmaceuticals is uniquely different from topics focused on a particular disease state. It is a technology-oriented subject which is based on an integrated approach to the development of dosage forms based on the physicochemical and biopharmaceutical properties of drugs. Consideration for the patient's disease state is vital in order to determine the suitability, feasibility, ease of administration, and the purpose of a particular dosage form, but the fundamental science of dosage form development does not vary from one disease state to another, or from one drug to another.

*"Survey of curriculum at 31 schools/colleges of Pharmacy," unpublished data presented at a faculty retreat on August 18, 1999, by Barbara Adamcik, PhD, College of Pharmacy, Idaho State University, Pocatello, ID 83201.

For successful integration of seemingly different subject matters, it is imperative that there exists some common thread or factual link between the subjects. For example, pharmacology, medicinal chemistry, and therapeutics have common features associated with individual drugs and/or disease states, and have lent themselves to successful integration as pharmacotherapeutics in many pharmacy schools. Unfortunately, pharmaceuticals does not offer us any such factual link that could be used to merge it with the integrated pharmacotherapeutics sequence. Hence, based on the current nationwide trend and the inherent nature of the pharmaceuticals courses, the authors' opinion (which is open to legitimate dispute) is that it may not be feasible, or even practical, to *completely* integrate pharmaceuticals into modular course designs based on individual disease states or organ systems. What may presumably be implemented with a considerable amount of success in the pharmaceuticals course sequences, or otherwise (for example, in the case study courses), are relevant formulation problem-solving exercises (Duncan-Hewitt, 1992) and pharmaceutical-care oriented topics that require a basic knowledge of pharmaceuticals. The problem-based learning (PBL) approach is an educational approach that greatly enhances active learning and life-long learning skills in the professional students (Barrows and Tamblyn, 1980; Vernon and Blake, 1993; Norman and Schmidt, 1992). The authors are indebted to Wendy Duncan-Hewitt and David Mount for the in-depth information on PBL provided by their internet web site†, and understanding the various facets of PBL has helped us to a large extent to develop our pharmaceuticals course sequence. Problem-based learning is being used globally and today over 80% of medical schools and many other professional programs, including pharmacy, use the PBL approach to teach

professional courses. With advances in electronic technology, faculties in pharmacy schools are beginning to use World Wide Web support to implement PBL in the Pharm.D. curriculum (Catney and Currie, 1999).

BRINGING PRACTICAL RELEVANCE TO THE PHARMACEUTICS CLASSROOM: PHARMACEUTICS-RELATED CASE STUDIES

A few models for case studies that could incorporate pharmaceuticals-related pharmaceutical care are given as follows:

- i) In a case involving calcium channel blockers in cardiovascular therapeutics, the pharmaceuticals faculty could reiterate the importance of osmotic drug delivery systems by means of Procardia[®], thus emphasizing the benefits to patients gained from dosage forms administered once a day;
- ii) In another scenario, involving the role of insulin in a suitable diabetes case, the pharmaceuticals faculty could discuss the parallel reaction pathways involved in the degradation of insulin. The effect of formulation factors like pH on reaction rates of each of the pathways could be emphasized, thus restating the relevance of chemical kinetics in the stability of pharmaceutical products; and
- iii) In a case where a parenteral admixture of diazepam had to be made for a patient and precipitation occurred in the process, the pharmaceuticals faculty can re-emphasize the relevance of solution phenomenon and the importance of cosolvents in formulation science.

Similarly, other examples dealt in group-discussion-type case studies would help students

†"Grian's approach to problem-based learning" by Grian Facilitations (1998), at <http://www.grian.com>.

to develop the problem-solving, interpersonal, and analytic abilities necessary to solve problems in drug delivery and ensure dosage form quality. Cases like these, discussed at a steady pace throughout the curriculum, can serve as constant reminders of the relevance and application of every subject learnt in pharmacy school. As has been mentioned before, pharmaceuticals is a subject unique to the pharmacy profession. It is also a subject that is included in the curriculum exclusively in pharmacy schools. The course content is built on the student's expected background of physics, chemistry, and biology, but the terminology involved in pharmaceuticals courses is completely new to the students entering the program. Hence, it becomes a necessity for the educator to first present a fundamental knowledge of pharmaceuticals, which would familiarize the student with terminology and background related to the subject. Following this, comprehension and application of those fundamentals to non-routine situations can be expected from the student. Challenging the students with real-life situations can further develop their integration, analytical, and evaluation skills. It is this final stage of educational outcomes where we need to concentrate our efforts in order to reap maximum benefits from a curricular change. For instance, an area in pharmaceuticals that could benefit from immediate metamorphosis is laboratory exercises. Traditional compounding laboratory exercises as part of most of the pharmaceuticals courses have consisted of routine formulations, the recipes for which are available in standard texts. In real life though, pharmacists must be prepared to address non-routine formulations requests, and information for the same may not be readily accessible. This requires the pharmacist to integrate fundamental knowledge of physical chemistry and formulation science, and also consider clinical practice aspects. The ability to professionally handle such situations would arise from appropriate preparation by the pharmacy

student, starting early in the curriculum. This could be facilitated by supervised PBL sessions, either in class discussions or the case-study format already implemented in the school's curriculum.

DEVELOPMENT OF THE "NEW" PHARMACEUTICS SEQUENCE

The authors have been experimenting with pharmaceuticals courses for the past few years by introducing various components and evaluating their success in meeting the educational goals and outcomes of the Pharm.D. curriculum. Our plan to structure the pharmaceuticals sequence is shown in Fig. 2. The flowchart is based on the premise that any knowledge, comprehension, analytical, and synthetic skills acquired during a curricular semester would form the students' composite background and abilities for the subsequent semesters. This includes the knowledge the student is expected to have acquired from their pre-pharmacy curriculum preparation. The premise is based on the hypothesis that in order to build knowledge with greater longevity, new knowledge must be built on the knowledge the students already possess, and because material that is learned will be applied in the same context (Coles, 1990). Students would be expected to recall concepts previously learned and thus minimize the time spent in recapitulation. Planning to implement the learning components has helped us streamline the sequence so there is a continuum between topics, with minimal to no repetition, and the learning process continuously builds on the abilities acquired in the previous semesters.

As shown in Fig. 2, once the decision to re-design the pharmaceuticals sequence was taken in conjunction with the Idaho State University College of Pharmacy's general goals, the process was initiated by identifying endpoint educational outcomes necessary to generate successful professional practitioners. The authors first

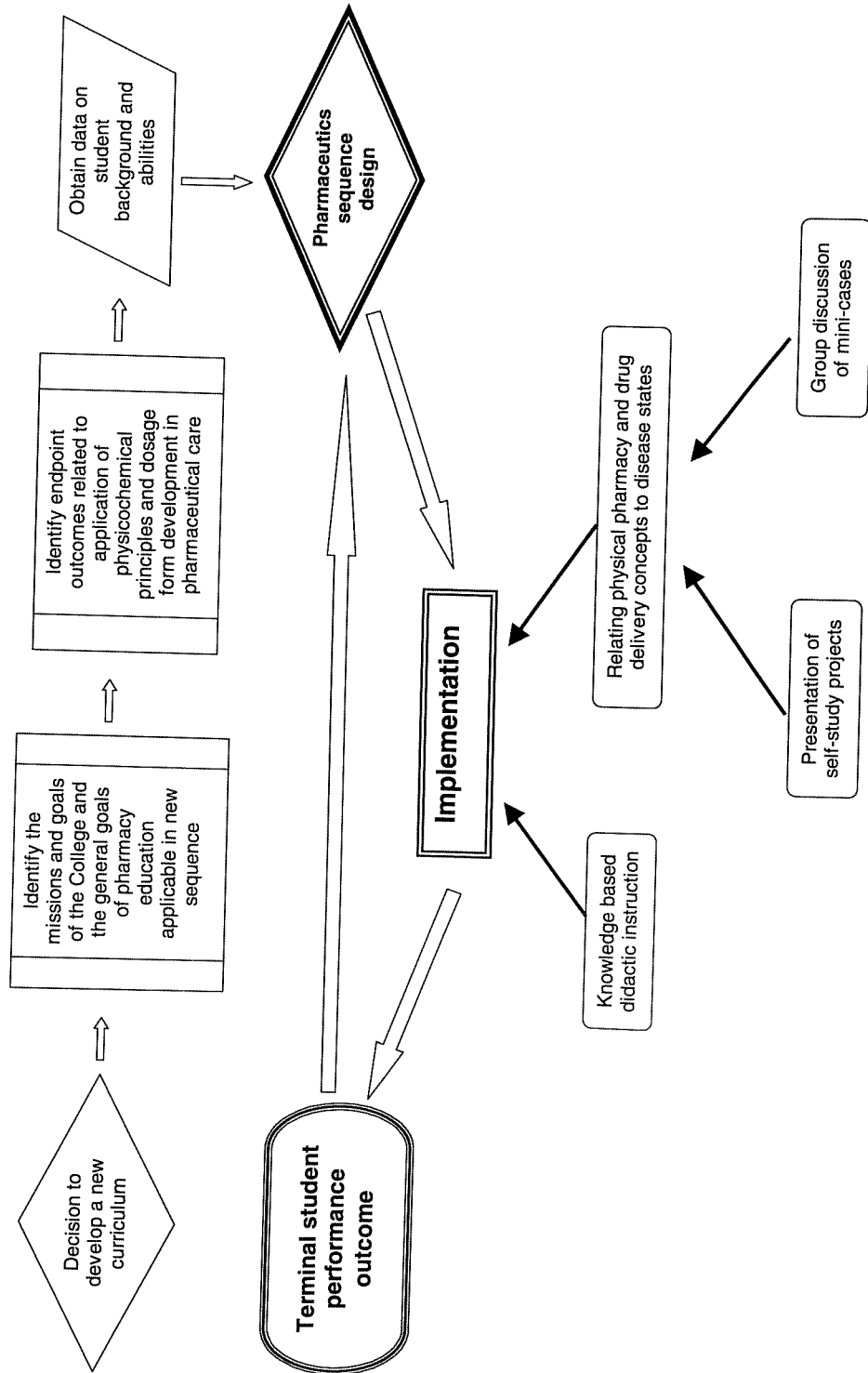


FIGURE 2. A flowchart to design a pharmaceuticals course sequence

tried to explore what basic knowledge and skills in pharmaceuticals might be expected from a graduated Pharm.D. for implementation in clinical practice, in purview of the CAPE (Center for the Advancement of Pharmaceutical Education) outcomes. The most important *outcomes* in our judgment are as follows:

- an integrated *knowledge* of pharmaceuticals based on a solid foundation of pathophysiology, pharmacology, medicinal chemistry, and therapeutics;
- understanding of what the human body does to a drug or excipient in a formulation;
- ability to apply physicochemical concepts to *solve* a pharmaceuticals *problem* in a disease management arena;
- professionally handle non-routine formulation problems, solutions to which may not be available in standard texts;
- ability to design stable formulations by understanding the causes of instability in a product;
- ensure that a dosage form reaches the target site in the human body in the desired state;
- recognize valid *in vitro* dissolution and *in vivo* bioavailability factors;
- select drug products on the basis of bioequivalence and therapeutic equivalence;
- capably interact with patients and peers to discuss formulation issues and salient features of various drug delivery systems in the market, or those awaiting approval;
- ability to design *tailor-made* drug-delivery systems that could address the patients' special needs; and
- proficiency in pharmaceuticals concepts and calculations, in order to be able to provide safe and efficient drug-dispensing services to patients in today's increasingly pharmaceutical care-conscious healthcare system.

Once we analyzed the skills that a graduated Pharm.D. is expected to possess and present during clinical practice, we drafted guidelines

for implementing more ability-based learning issues in the pharmaceuticals sequences. The pharmaceuticals courses have been redesigned with student background, abilities, and future expectations in mind. Keeping the above-mentioned educational outcomes in perspective, we decided to set the following *goals* for ourselves in the process:

- shift the focus of pharmaceuticals teaching from an exclusive knowledge base to an upper level of analyzing problems and synthesizing concepts;
- develop the students' problem-solving skills by enhancing their evaluation abilities;
- train the students to be critical thinkers by motivation and interaction through peers;
- be aware of the students' background and their ability to learn a newly introduced concept;
- challenge the students with real-life situations and test their ability to handle non-routine pharmaceuticals-oriented problems during future clinical practice; and
- encourage the students to become self-learners and take an active role in the learning process (Grow, 1991).

With a draft of the "new" pharmaceuticals sequence in place, the process of implementation began in Spring 1999. We are currently assessing the learning outcomes that were achieved over the past year and utilizing that data to continuously evolve the pharmaceuticals sequence design. The individual components of implementation outlined in Fig. 2 are discussed in detail below.

IMPLEMENTATION

Any educational development is a challenge and shifting the focus from total knowledge-based lecture-driven courses to the novel aspects of integrating disease-state management in pharmaceuticals is not easy. The framework of our course design retains didactic instruction, with the added components of self-directed learning,

peer interaction, and advanced analytical and synthetic exercises which allow students to relate physical pharmacy and drug delivery concepts to disease states.

Didactic Lectures

Certain topics in pharmaceutical sciences curriculum, including pharmaceuticals, have to be taught in the traditional lecture format in order to inculcate basic knowledge in the students. Total lack of didactic instruction would amount to injustice to the students, as they are unfamiliar with most of the concepts in pharmaceuticals. However, the major problem with this approach is that the students tend to become passive learners. They feel inclined to memorize concepts rather than having any passion for application of the knowledge in a clinical setting. Fortunately, due to the relatively manageable class sizes, the instructors were able to be more interactive in the class. The message that memorization as the sole means of learning would fail to render adequate results in assessment exercises, was made clear to the students. It was also emphasized that we believe in the paradigm shift from "teaching" to "learning", and the students should not look upon us merely as *teachers* but also as *learning facilitators*.

Relating Physical Pharmacy and Drug Delivery Concepts to Disease States

Self-directed Learning: Peer Interaction, Critical Thinking, Presentations, and Reports

A pharmacist in real-life clinical or retail setting very often needs to interact with their peers to solve questions related to drug therapy. Also as a life-long learner in an active learning situation, it is absolutely essential to effectively communicate with peers to solve a problem. Therefore, we adopted a concept of self-directed study in our course. The model is based on a study by Zatz, modified to fit our situation (Zatz, 1995). In this

exercise, the first year pharmaceuticals students select specific dosage forms of the same drug and compare their bioavailability and clinical efficacy based on their physicochemical properties. In the second year exercise, small groups of students select a topic for more in-depth analysis and presentation to their peers. The topics are based on a specific drug in a particular disease state, and they are required to critically analyze the pros and cons of different dosage forms available. For the most important exercise, the students are required to come up with suggestions for improvement of the dosage form based on the principal and associated disease state condition and also the physicochemical properties of the drug and excipients. Important consideration must be given to dissolution, absorption, and bioavailability related to the drug and the carrier system or excipients. At the end of the exercise, the student groups are required to present a short PowerPoint[®]-based seminar covering their written report. The exercise is evaluated by a team of faculties consisting of the course coordinator, one or two non-pharmaceuticals basic sciences faculty and one or two clinical sciences faculty, and comments and feedback are provided to the students to help them assess their own performance.

Active Learning: Critical Thinking, Problem Solving, and Decision Making Through Group Discussion on Pharmaceuticals Related Therapeutic Interventions in Mini-cases

Group discussions during early curricular years help to unravel the students' ability of effectively communicate and develop the correct attitude to interact with fellow professionals. It helps participants to learn to respond effectively to new situations and adapt to change, and develops the ability to deal with complex systems (Williams, 1992). Brazeau *et al* reported a study where second year students and faculty participated in problem-based discussion sessions

to demonstrate the basic pharmaceutical sciences related to the use of dosage forms in pharmacy practice (Brazeau *et al.*, 1999). We tried to merge this attitude-based peer-interaction ability to the application-based educational outcomes. In this exercise, we focus on 2–4 common disease states (for example, hypertension, diabetes) and present problematic (drug delivery or bioavailability) patient cases. Faculty facilitators helped to initiate the discussion and guide the student groups to select a suitable drug dosage form based on pharmaceuticals and therapeutics principles. We focused on guiding the students through basic steps in problem solving and encouraged them to plan carefully and concentrate on the problem-solving process rather than waste time in feeling a sense of lack-of-direction, helplessness, and panic. Open-ended questions that required critical thinking were asked, and all members of the group were encouraged to provide feedback rather than pinpointing a specific student (Hurd, 1994). The major difference of this exercise from the previous one is that this one is done within the 50 min class time and the students have to come up with the final conclusion within that time limitation, whereas for the earlier exercise, they are given 2–3 months of time to prepare.

ASSESSMENT TOOLS: SHORT CASE-ORIENTED QUESTIONS IN THE EXAMINATIONS

For the educator, the ultimate means to evaluate the success or failure of any new course component is assessment. For the open-minded and optimistic instructor, student opinion, comments, and criticism also serve to judge the efficacy of a newly implemented technique. Integrated "pharmacotherapeutics" courses have already been oriented in several pharmacy schools, and the NAPLEX exams are traditionally formatted on individual patient charts, therefore, it is essential to familiarize the

students to case study-oriented questions. A diversion from the conventional multiple choice type questions is necessary in order to encourage and train students to build-up their confidence in a problem-solving situation. In order to familiarize students with the nature of questions in the exams, short practice sessions of case-study quizzes were given throughout the semester.

PROBLEMS ENCOUNTERED BY THE INSTRUCTORS

"People in a hurry cannot think, cannot grow, nor can they decay. They are preserved in a perpetual state of puerility" Eric Hoffer (Philosopher, 1902–1983)

Teaching of basic pharmaceutical sciences is struggling to come out of total knowledge-based didactic instruction. It involves time and effort by educators to implement any change in the existing course structures. Yet we are still merely attempting to change the students' concept of rote memorization to conceptualization and synthesis of knowledge. Given an arena of a relatively metamorphosed pharmaceuticals course design as portrayed above, initially the students were resistant to the *abrupt* change. They complained about the amount of work and time that they had to put in the pharmaceuticals courses in comparison to other basic science courses. For the first few weeks during the semester, the students (even in the second year) seemed to be confused because of their unfamiliarity to the *altered* structure of the pharmaceuticals courses, especially since they appeared *different* than what their seniors had described the courses to be! Once the students realized that the altered course structure is benefiting their understanding of the subject, they gradually became more receptive to the instructors' efforts. We optimistically envision that in the near future, as all the basic pharmaceutical science courses change from a knowledge-based tutorial approach to a problem-solving based learning approach,

student attitude towards learning—which requires both work and time—will change for the positive.

FEEDBACK FROM COLLEAGUES AND STUDENTS

The active learning approaches and group presentation of projects have received resounding support and encouragement from our peers. During the fourth year of clinical rotations, responsibilities of our students include constant interaction with their peers to come up with well-judged therapeutic interventions. From the clinical faculty's viewpoint, the learning tools employed in the pharmaceuticals courses would give an early interactive experience to students prior to their fourth-year clerkships. The students were initially reluctant and unproductive during the 50-min class discussions but gradually became enthusiastic when they realized that it basically aids their development of problem-solving skills. There were several complaints about the Power-Point® presentation as the students grudged that it takes much time to develop a good presentation, especially since they are not yet experts in using the software. Also, presenting meant that they were not only graded based on the written *group effort* reports but also their individual presentation skills, which made their level of understanding of the material clearly evident to the evaluator, causing considerable dissatisfaction among a select few students. On the other hand, several students reported that the active learning exercises greatly enhanced their confidence and understanding of the subject, and gave them the ability to cope with ambiguity and the "unknown." Ample encouragement for students when they came up with positive clues in the critical-thinking exercises was received with much enthusiasm, as the group felt energized, excited about the topic, and wanted to learn more. It provided them with a sense of triumph that was reflected in comments like "wow, I can actually do

this!" Overall, the majority of student comments at the end of the semester were positive about their experience, and we are optimistic that their attitude will improve further after these new learning tools have been implemented for more years and the benefits noted.

FUTURE DEVELOPMENTS

The authors have developed pharmaceuticals web pages in which homework exercises will be posted in the future. We have installed pharmaceuticals software in the student computer kiosks that will help them considerably in calculations and interactive problem solving. Open-book, open-discussion type quizzes involving pharmaceuticals-based therapeutic intervention in mini-cases have already been implemented in the classroom. These will be converted to fully web-based exercises, in order to familiarize the students with expected outcomes during class time group-discussions. The authors feel that background preparation at this stage of the student's career will further enhance the value of the class discussions.

CONCLUSIONS

Pedagogy in the Pharm.D. curriculum is now geared towards meeting competencies and outcome objectives for the professional student, which would enable them to perform appropriate pharmaceutical care as part of their future ethical and career responsibilities. Practical approaches like collection, organization, interpretation, analysis, and synthesis of available information to arrive at rational and logical conclusions pertinent to therapeutic intervention, problem solving and patient care, need to become integral approaches for the basic pharmaceutical science subjects, including pharmaceuticals. By introducing students to the practical relevance of pharmaceuticals in meeting

practice-based outcomes, we could develop student appreciation for the scientific rationale behind pharmaceuticals-related therapeutic decisions they will make in the future. Case studies and problem-solving exercises involving pharmaceuticals-related therapeutics problems were introduced in the classroom and treated via faculty-facilitated group discussions. A self-directed learning approach was implemented by having small student groups select specific dosage forms of a drug and compare their bioavailability and clinical efficacy based on physicochemical properties. The first-year pharmacy students were required to submit a written report on their chosen topic, whereas the second-year students had to present a PowerPoint® seminar in addition to the written report. In the second-year exercise, the students were also required to come up with suggestions for improving the dosage form based on the physicochemical properties of the drug and excipients in formulation, and the principal and associated disease state conditions the drug is effective in. The paradigm shift from exclusive classroom teaching to active learning enhanced the students' overall understanding of the subject, presenting a statistical treatment of which is our future goal after the present pharmaceuticals sequence has been in effect for more years.

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