

RESEARCH ARTICLES

An Interactive Response System to Promote Active Learning in the Doctor of Pharmacy Curriculum

Douglas Slain, PharmD,^a Marie Abate, PharmD,^a Brian M. Hodges, PharmD,^a Mary K. Stamatakis, PharmD,^a and Sara Wolak, BS^b

^aSchool of Pharmacy, West Virginia University

^bCollege of Human Resources and Education, West Virginia University

Submitted February 24, 2004; accepted May 31, 2004; published December 2, 2004.

Objective. The purpose of this study was to evaluate the impact of an interactive student response (ISR) system on student learning, interest, and satisfaction.

Methods. Students enrolled in 3 courses, *Clinical Pharmacokinetics*, *Medical Literature Evaluation*, and *Pathophysiology and Therapeutics*, were taught using either a traditional lecture format (study year 1) or an ISR system format (study year 2). Primary outcomes of interest were performance on examinations and student attitudes.

Results. Students using the ISR system had better scores on the *Clinical Pharmacokinetics* examination questions (mean scores, 82.6% ± 9.6% vs 63.8% ± 8.3%, $p < 0.001$), on the cumulative final examination for *Medical Literature Evaluation* (82.9% ± 11.5% vs 78.0% ± 12.2%, $p = 0.016$), and on the evaluable “analysis type” examination questions in the *Pathophysiology and Therapeutics* course (82.5% ± 8.7% vs 77.4% ± 12.5%, $p = 0.0002$). Students using the ISR system in all 3 courses were positive about the system.

Conclusion. The ISR system was a useful tool for encouraging active student learning and was well received by students. This system can be efficiently used to gauge student understanding in the classroom and enhance student performance.

Keywords: audience response system, active learning, instantaneous feedback, classroom polling

BACKGROUND

Colleges and schools of pharmacy have undergone major curricular changes to better prepare first-professional degree doctor of pharmacy students for practice and to enhance problem-solving skills. The use of techniques that foster active learning and critical thinking are necessary to accomplish this task. Despite increased efforts to enhance active learning, many pharmacy educators have difficulty engaging and maintaining the interest of all students in large classrooms.¹ Engaging students throughout a lecture is believed to make them more active participants rather than passive listeners.² Lecturing alone often provides only factual information to students, without enabling them to apply the knowledge. Relying on hand-raising or volunteered responses to questions posed by instructors in class usually only secures responses from a small number of more outspoken students. Other techniques have been used to determine student under-

standing of concepts and areas of confusion during class (eg, short quizzes, asking students to write down questions they have, etc). However, it takes time to review the students' responses. Thus, it is difficult for instructors to fully assess the degree of student comprehension of the material as it is being presented.

Reports from as early as the 1970s on the use of electronic response systems in educational programs showed that such systems could serve as useful tools in large classrooms.³ Audience response systems (ARS) are electronic tools that provide instantaneous feedback to facilitators and audience members about participants' responses (anonymously) to multiple-choice questions. ARS technology has largely been used by the corporate sector at training meetings and conferences, or as interactive trivia gaming system in taverns. Studies of ARS in corporate training have reported enhanced trainee interest, attentiveness, and retention.⁴ The term *interactive student response* (ISR) system was coined for referring to these systems in the classroom setting. The typical ISR system includes a computer and specific software, a projector and screen, a radio signal receiver unit or a directly wired receiver unit, and personal hand-held units

Corresponding Author: Douglas Slain, PharmD. Address: Assistant Professor, West Virginia University, 1124 Health Sciences North, P.O. Box 9520, Morgantown, WV 26506-9520. Tel: 304-293-1462. Fax: 304-293-7672. E-mail: dslain@hsc.wvu.edu.



Figure 1. ISR handheld unit (used with permission of Option Technologies, LLC, Ogden, UT).

(Figure 1) that are used by individual students to respond to questions (Figure 2). Individual anonymous responses to questions can be compiled in aggregate as bar graphs or percentages and available instantaneously on a screen for viewing by the instructor and attendees (Figures 3 and 4). ISR systems appear to provide several benefits that can facilitate active learning in the classroom setting. All students have the capability of answering every question anonymously, without fear of mistake or ridicule. In addition, instructors can immediately assess student comprehension of concepts and address any misconceptions or areas of confusion. Because the ISR systems provide an almost game show-like atmosphere, an additional proposed benefit is that they can provide entertainment or friendly competition in the class and thereby increase student attention. Many of these systems have tracking features that permit the instructors to identify respondents and their answers in a saved database. Therefore, ISR systems may also provide a rapid, paperless alternative to quizzing, which can streamline the grading process.

Evaluation of ISR systems in the academic classroom setting has been limited to a few small studies in the physics, nursing, and medicine curricula. Poulis and colleagues studied the use of a single response hardwired (non-wireless) unit in physics lectures.⁵ The students



Figure 2. Students using the ISR system during class.

could signal “yes” in response to “yes/no” questions. Higher pass rates were reported with use of this system. Improved student attendance was reported by another physics course study when a multiresponse ISR system was used.⁶ Roy and colleagues studied the use of an ISR system in 8 medical lectures and reported increased student-lecturer interaction and student and faculty satisfaction with the ISR system vs traditional lecture.² They also reported that it took significantly longer to cover the same material with the use of the ISR system. A study of a small group of nursing students did not find a significant difference in total examination scores with a multiresponse unit, but they reported improved examination scores in the ISR group as the class became used to the technology.⁷ Performance on the third of 3 examinations was actually better in the ISR group. To date, ISR systems have not been formally studied in pharmacy curricula. The purpose of this study was to compare the use of an ISR system with a traditional lecture format in different courses to determine its effect on student learning and satisfaction.

What statistical test should be used to compare the results of bone mineral density tests in different groups of patients receiving either Fosamax or Actonel to prevent osteoporosis (assume data not normally distributed) ?	
Statistical Test	Student Answer
T-test	4%
One-way ANOVA	4%
Mann-Whitney U	48%
Chi-Square	7%
McNemar Test	12%
Repeated measures ANOVA	4%
Pearson r	7%
Wilcoxon signed-rank test	9%
Kruskal-Wallis	5%

Figure 3. Classroom polling results in percentage format for a typical question.

METHODS

This study was conducted over a period of 2 academic years (2001–2003). During the first year, first professional degree doctor of pharmacy students enrolled in 3 different courses: *Clinical Pharmacokinetics*, *Medical Literature Evaluation*, and *Pathophysiology and Therapeutics III* (Infectious Diseases and Nephrology modules only), were taught using traditional lecture and mini-case/examples formats. Class participation in this control group year was limited to student volunteers, those asking questions, or those directly called upon. In the second year, course material was taught essentially the same way, except that an ISR system (*Optionfinder*, Option Technologies Interactive, LLC, Ogden, UT) was used during multiple designated class sessions. Each student in the second year of the study used an assigned handheld unit that transmitted their queried responses to a computer, which then projected the aggregate student responses in histogram or percentage form on a viewing screen at the front of the classroom (Figures 3 and 4). After the students selected their answers, the instructors routinely asked for volunteers to explain their answer. This was intended to trigger a useful class discussion and allowed for clarification. In addition, if several students answered a question incorrectly, the instructors would review the rationale behind the correct answer. The handheld units were programmed to track in-class responses by individual students for subsequent data analysis for this study. The individual students' electronic responses could not be identified in class. The same 4 instructors taught all course work, and the same material was covered in both years. The 3 courses were selected because they represented 3 diverse types of coursework in a pharmacy curriculum and included subjects that previous students

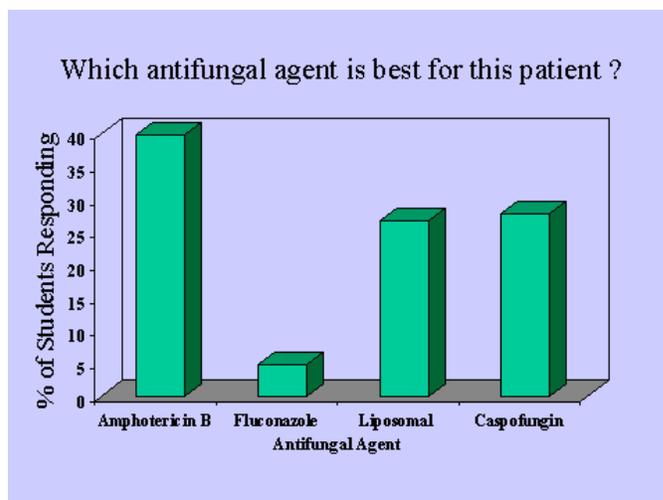


Figure 4. Classroom polling results in bar graph format.

were known to have difficulty learning. The *Medical Literature Evaluation* course is taught in the spring semester of the second year of the professional curriculum, and the *Pathophysiology and Therapeutics* and *Clinical Pharmacokinetics* courses are in the fall and spring semester, respectively, of the third professional year of the curriculum. The Infectious Diseases and Nephrology modules comprised 50% of the *Pathophysiology and Therapeutics* course. There was some material in the *Pathophysiology and Therapeutics* and *Clinical Pharmacokinetics* courses that was not taught using the ISR system in the second year of the study. None of the examinations were returned to the students to limit sharing of examination material with the subsequent classes being evaluated. All students in the second year of the study were asked to sign a letter stating their interest in using the ISR handheld units to comply with the requirements of the West Virginia University Institutional Review Board.

The primary outcome measure was performance on examinations for students taught by traditional lectures compared with those taught with the ISR system. Only examination material that corresponded with material that was covered during the study segments of the courses was considered evaluable. Individual ISR in-class question correct answer response rates were collected to test for a relationship with examination scores. A survey with Likert-type and non-Likert-type questions was administered to students in both years at the end of the courses to evaluate their satisfaction with the corresponding teaching-learning format. The 4 faculty members using the ISR system also completed a brief 8-question open-ended survey.

Differences in examination scores and baseline grade point averages (GPAs) between the traditional and ISR system classes were evaluated using an unpaired, 2-tailed *t* test. Linear regression with calculation of the Pearson

correlation coefficient and coefficient of determination (r^2) were employed for studying the relationship between in-class ISR system scores and examination scores. The Mann-Whitney U test was used for analysis of categorical data (student attitudinal survey results).

RESULTS

Students and ISR System Response Data

Cumulative pharmacy GPAs between the students in both years of the study were not significantly different prior to the course work being evaluated (3.45 ± 0.33 vs 3.45 ± 0.38 , $p = 0.91$ for the *Medical Literature Evaluation* classes, and 3.33 ± 0.37 vs 3.43 ± 0.34 , $p = 0.08$ for the *Clinical Pharmacokinetics* and *Pathophysiology and Therapeutics* classes). Class sizes for the *Clinical Pharmacokinetics* and *Pathophysiology and Therapeutics* courses were 65 in the first year and 66 in the second year. Class sizes for the *Medical Literature Evaluation* course were 66 in the first year of the study, and 75 in the second year. Three students requested not to participate with the ISR handheld units in the *Pathophysiology and Therapeutics* and *Clinical Pharmacokinetics* classes and only 1 student opted not to use the ISR units in the *Medical Literature Evaluation* course. Throughout the semester there were 43 in-class ISR questions asked in the *Clinical Pharmacokinetics* course, 127 in the *Medical Literature Evaluation* course, and 70 in the *Pathophysiology and Therapeutics* course. Most of the in-class questions used with the ISR system were also used for the in-class discussion during the traditional "lecture" year of the project. The correct in-class ISR response rate based on the single "best" answers was $59.8\% \pm 20.1$ for *Clinical Pharmacokinetics*, $56.8\% \pm 18.9$ for *Medical Literature Evaluation*, and $52.2\% \pm 13.0$ for *Pathophysiology and Therapeutics*.

Examinations

Students using the ISR system in the *Clinical Pharmacokinetics* course achieved significantly higher examination scores on the evaluable questions than students who did not use the ISR system (mean scores: $82.6\% \pm 9.6$ vs $63.8\% \pm 8.3$, $p < 0.001$). Although this difference is substantial, the significantly different number of evaluable test questions used for the first- and second-year students' study groups may have influenced the difference (115 vs 225, respectively). The difference in the number of evaluable questions is mainly because individual student answers were not available for the first examination in the first-year group. When examination (midterm and final) scores were combined for the *Medical Literature Evaluation* course, no statistical dif-

ference was detected between the 2 classes. However, when grades from only the cumulative final examination (ie, omitting the midterm examination scores) were compared, the class using the ISR system performed significantly better ($82.9\% \pm 11.5\%$ vs $78.0\% \pm 12.2\%$, $p = 0.016$). A statistical difference in examination scores for the *Pathophysiology and Therapeutics* course was not found when all evaluable questions were analyzed together. However, when the evaluable examination questions for the *Pathophysiology and Therapeutics* course were analyzed by type of question, significantly higher scores were seen with ISR use for those questions that required "analytical" type thinking consistent with Bloom's taxonomy of questioning⁸ ($82.5\% \pm 8.7\%$ vs $77.4\% \pm 12.5\%$, $p = 0.002$). The examination grades were not significantly different for questions that required strict memorization. The *Clinical Pharmacokinetics* and *Medical Literature Evaluation* courses used only analytical type questions on their respective examinations, so comparisons between different question types were not possible.

Scatter plots of corresponding student in-class ISR scores and examination scores appear in Figures 5a, 5b, and 5c. There did not appear to be a strong relationship between in-class ISR scores and examination scores in any of the classes. The strongest correlation was in the *Medical Literature Evaluation* course (Figure 5b) where approximately 20% of the variability of examination scores can be explained by the performance of students using the ISR system in class ($r^2 = 0.20$).

Student Survey Results

Student responses on a Likert-type scale to the survey items are shown in Tables 1, 2, and 3. The students using the ISR system in all 3 courses uniformly reported more positive rates of satisfaction with the teaching-learning format than the students who were taught by traditional methods. Overall, students using the ISR system had positive remarks about its use. Most respondents believed that the ISR system enhanced their understanding of the material and made them more active class participants. Student-reported attendance did not appear to be different between any of the groups. Students in the *Medical Literature Evaluation* and *Clinical Pharmacokinetics* courses were specifically asked if the ISR system should continue to be used, and 91% and 87% of students in the 2 respective courses either "agreed" or "strongly agreed." Responses from students in the *Clinical Pharmacokinetics* course generally indicated that the ISR system helped them secure answers to their questions more thoroughly and in a non-intimidating way. Responses from students in the *Medical Literature Evaluation* course indicated that compared with

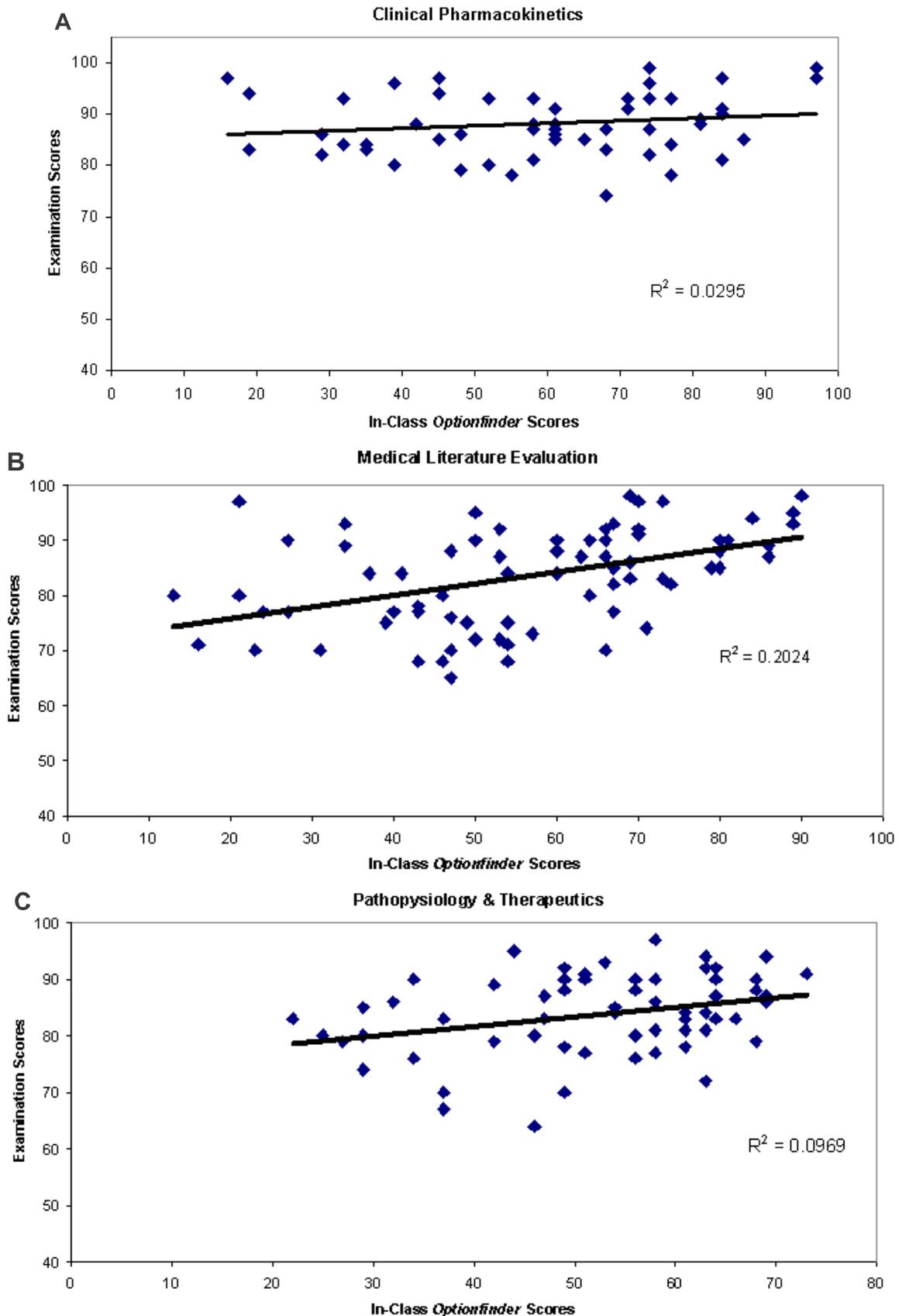


Figure 5. Evaluation of the relationship between examination scores and in-class ISR scores. (A) *Clinical Pharmacokinetic* course. (B) *Medical Literature Evaluation* course. (C) *Pathophysiology and Therapeutics III* course.

Table 1. Student Responses Regarding a *Clinical Pharmacokinetics* Course Taught Using Either a Traditional Learning Format (N=65 Students) or an Interactive Student Response System (N=67 Students)

Question	Learning Format	Percent Responding					P
		Strongly Disagree		Strongly Agree			
		1	2	3	4	5	
I enjoyed the teaching/learning format used in the course.	Traditional	4	17	26	28	26	0.002
	Interactive	3	0	2	62	33	
The class format encouraged active learning on the part of the students.	Traditional	2	9	19	43	28	
	Interactive	2	2	7	57	33	
The instructors obtained sufficient feedback from students during class to assess student understanding of the class materials.	Traditional	0	2	19	57	21	
	Interactive	2	0	5	62	31	
The instructor often moved through concepts faster than I could understand them.	Traditional	17	49	21	11	2	
	Interactive	26	50	16	5	3	
A sufficient number of clinical examples or case studies were used to emphasize important concepts.	Traditional	0	6	4	60	30	
	Interactive	2	0	10	57	31	
I am confident in my ability to evaluate and recommend drug therapy as a result of the material covered.	Traditional	0	6	38	38	17	
	Interactive	3	5	35	45	12	
The amount of material covered in these areas was appropriate.	Traditional	0	0	11	60	30	
	Interactive	2	0	7	67	24	
I completed the required reading assignments before coming to class	Traditional	50	20	24	7	0	
	Interactive	55	24	12	3	5	
The questions I had about the material were answered during class sessions.	Traditional	2	4	36	45	13	0.042
	Interactive	3	5	12	59	21	
I was an active participant in class.	Traditional	13	19	28	32	9	
	Interactive	19	26	26	17	12	
I had difficulty paying attention in class.	Traditional	13	15	40	26	6	
	Interactive	10	31	35	16	9	
I felt comfortable asking questions during class about material I didn't understand.	Traditional	15	26	26	17	17	0.018
	Interactive	2	14	31	35	19	
I had a good understanding of the material as it was being discussed in class.	Traditional	0	11	34	36	19	
	Interactive	2	3	24	52	19	

traditional instruction, the ISR system encouraged more active learning, provided the instructor with more feedback to assess student understanding of material, and helped hold their attention in class. In addition, students in the ISR group reported a significantly higher percentage rate of compliance with the required reading assignments in the *Medical Literature Evaluation* course ($p = 0.029$). Despite these benefits, they also believed that there was a less than sufficient amount of clinical or case examples used in the ISR group to emphasize important concepts. Responses from students in the *Pathophysiology and Therapeutics* course indicated that compared with traditional instruction, the ISR system encouraged active learning. In addition, the ISR students felt more strongly that the instructor was provided with sufficient feedback on student understanding of material, that there was a sufficient amount of clinical or case examples to emphasize important concepts, and there was a better pace for student comprehension. Students

using the ISR system in the *Pathophysiology and Therapeutics* course reported that they did not answer as many questions aloud in class. Nonetheless, there was considerable nonverbal class participation with the ISR units. In addition, students in the *Pathophysiology and Therapeutics* ISR group indicated a lower rate of reading prelecture assignments.

Overall, the students that used the ISR system had positive remarks about its use (Table 4). Most respondents believed that the ISR system enhanced their understanding of the material and made them a more active participant in class.

Faculty Survey Results

All 4 instructors believed that the ISR system was beneficial to student learning. Three of the instructors believed that the ISR system improved student participation and attentiveness. Being able to instantly assess student compre-

Table 2. Student Responses Regarding a *Medical Literature Evaluation* Course Taught Using Either a Traditional Learning Format (N=65 Students) or an Interactive Student Response System (N=67 Students)

Question	Learning Format	Percent Responding					P
		Strongly Disagree		Strongly Agree			
		1	2	3	4	5	
I enjoyed the teaching/learning format used in the course.	Traditional	15	29	27	27	2	0.024
	Interactive	10	16	29	31	13	
The class format encouraged active learning on the part of the students.	Traditional	0	24	27	36	13	0.01
	Interactive	2	4	27	44	24	
The instructors obtained sufficient feedback from students during class to assess student understanding of the class materials.	Traditional	2	7	47	33	11	0.029
	Interactive	2	9	25	41	24	
The instructor often moved through concepts faster than I could understand them.	Traditional	11	46	22	20	2	0.021
	Interactive	10	35	21	21	13	
A sufficient number of clinical examples or case studies were used to emphasize important concepts.	Traditional	0	0	16	53	31	0.021
	Interactive	2	7	24	49	19	
I am confident in my ability to evaluate and recommend drug therapy as a result of the material covered.	Traditional	6	24	36	27	7	0.013
	Interactive	4	15	35	43	19	
The amount of material covered in these areas was appropriate.	Traditional	11	27	27	29	6	0.005
	Interactive	12	18	21	40	10	
I completed the required reading assignments before coming to class	Traditional	4	24	22	36	15	0.005
	Interactive	12	15	32	25	16	
The questions I had about the material were answered during class sessions.	Traditional	0	6	29	51	15	0.013
	Interactive	3	8	30	48	12	
I was an active participant in class.	Traditional	9	29	31	27	4	0.013
	Interactive	4	15	31	44	6	
I had difficulty paying attention in class.	Traditional	2	20	31	33	15	0.005
	Interactive	10	34	25	24	6	
I felt comfortable asking questions during class about material I didn't understand.	Traditional	2	20	35	33	11	0.005
	Interactive	6	10	27	47	10	
I had a good understanding of the material as it was being discussed in class.	Traditional	0	9	38	40	13	0.005
	Interactive	3	9	34	47	7	

hension of concepts and address misconceptions were believed to be major advantages of the system. Each instructor also believed that they needed to become more proficient at using the ISR system and at developing better ISR in-class questions. Some of the instructors were concerned that less material was covered in-class when they used the ISR system. They also believed that students had to come to class prepared for discussion (ie, completion of reading assignments, etc) for the system to be of most benefit.

DISCUSSION

Faculty members need to continue to use techniques that foster active learning and critical thinking in students. The use of an ISR system in the classroom setting was a well-received and effective tool for creating such an environment. To our knowledge, this is the largest published study evaluating the use of ISR systems in academic classrooms and the only one reported by a school of pharmacy.

The results of this study are compelling in one particular respect. Students that used the ISR system in class had better examination scores on the *Clinical Pharmacokinetics* examinations, on the *Medical Literature Evaluation* cumulative final examination, and on the "analysis" type examination questions in the *Pathophysiology and Therapeutics* course. These findings are suggestive of improved material comprehension, application, and retention beyond the short term (ie, "cramming"). The impact of the ISR system on various outcomes was not identical across the 3 courses. Differences in results between the 3 courses can be attributed to many factors including individual instructors and type of coursework. The *Medical Literature Evaluation* course covers biostatistics and study design, and each segment builds upon previous segments. In the *Pathophysiology and Therapeutics* course, material tends to be more compartmentalized (eg, organ system involvement, type of pathogen, etc). Material in the *Clinical*

Table 3. Student Responses Regarding a *Pathophysiology & Therapeutics III* Course Taught Using Either a Traditional Learning Format (N=65 Students) or an Interactive Student Response System (N=67 Students)

Survey Item	Learning Format	Percent Responding					P
		Strongly Disagree		Strongly Agree			
		1	2	3	4	5	
I enjoyed the teaching/learning format used in the course.	Traditional	0	2	22	56	20	0.001
	Interactive	0	2	3	45	50	
The class format encouraged active learning on the part of the students.	Traditional	2	2	18	51	27	0.001
	Interactive	0	0	5	35	60	
The instructors obtained sufficient feedback from students during class to assess student understanding of the class materials.	Traditional	0	11	22	44	22	0.009
	Interactive	0	2	8	55	35	
The instructor often moved through concepts faster than I could understand them.	Traditional	7	24	29	29	11	0.001
	Interactive	23	57	12	8	0	
A sufficient number of clinical examples or case studies were used to emphasize important concepts.	Traditional	0	4	16	64	16	0.001
	Interactive	0	0	2	50	48	
I am confident in my ability to evaluate and recommend drug therapy as a result of the material covered.	Traditional	2	11	47	40	0	
	Interactive	2	8	55	32	3	
The amount of material covered in these areas was appropriate.	Traditional	7	11	24	38	20	
	Interactive	2	3	23	57	15	
I completed the required reading assignments before coming to class	Traditional	24	27	38	9	2	0.001
	Interactive	48	37	12	3	0	
The questions I had about the material were answered during class sessions.	Traditional	0	2	29	53	16	
	Interactive	2	2	25	60	12	
I was an active participant in class.	Traditional	2	18	40	33	7	
	Interactive	7	7	30	40	17	
I had difficulty paying attention in class.	Traditional	36	44	7	13	0	
	Interactive	22	53	13	7	5	
I felt comfortable asking questions during class about material I didn't understand.	Traditional	9	9	18	46	18	
	Interactive	7	17	27	37	13	
I had a good understanding of the material as it was being discussed in class.	Traditional	0	7	24	58	11	
	Interactive	2	0	23	67	8	

Pharmacokinetics course has some aspects that build upon earlier material. This course uses foundational material and applies it to individualized agents and situations.

Despite the positive findings of this project, there was a significantly lower rate of reading prelecture assignments in the ISR group in the *Pathophysiology and Therapeutics* course. The reasons for this are unclear. Perhaps students believed that with use of the more “anonymous” ISR system, they would not be called upon by name to answer questions. In contrast, ISR students in the *Medical Literature Evaluation* course reported reading a larger percentage overall of reading assignments.

An evaluation was performed to determine whether the in-class ISR question scores of individual students could predict performance on examinations. Examination performance can be influenced by many other factors, so it is not surprising that strong correlations between in-class ISR scores and examination

scores were not found. Nonetheless, the fact that 20% of the variability in examination scores from the *Medical Literature Evaluation* course can be explained by the variability in ISR scores may attest to the usefulness of such a tool with that particular type of coursework.

Overall, the student and faculty attitudinal responses to the ISR system were very positive. Survey results indicated that the ISR system encouraged active learning and provided instructors with sufficient feedback. Although 2 of the 4 faculty members felt that use of the ISR system reduced the amount of material covered, this was not apparent from the students’ perspective. Precisely quantifying the reduction in course material taught was difficult. Different courses covered the material in different ways. For example, in the *Medical Literature Evaluation* course, the same amount of material was covered with the ISR system since the students used a computer instructional program outside of class time for the course content and

Table 4. Comparison of Survey Responses Among Students Using Interactive Response Systems in a *Clinical Pharmacokinetics* Course (n=39), *Medical Literature* Course (n = 67), and *Pathophysiology & Therapeutics* Course (n = 60)

Survey Item	Course	Percent Responding				
		Strongly Disagree		Strongly Agree		
		1	2	3	4	5
I enjoyed the use of the audience response system used in this course.	<i>Clinical Pharmacokinetics</i>	3	5	10	31	51
	<i>Medical Literature</i>	0	0	6	28	66
	<i>Pathophysiology & Therapeutics</i>	0	0	3	33	63
I believe the use of this audience response technology enhanced my understanding of the material covered in this course.	<i>Clinical Pharmacokinetics</i>	3	3	21	23	51
	<i>Medical Literature</i>	0	6	10	22	61
	<i>Pathophysiology & Therapeutics</i>	0	2	5	47	47
I believe that use of the audience response system allowed me to be a more active participant in this course.	<i>Clinical Pharmacokinetics</i>	3	3	13	41	41
	<i>Medical Literature</i>	0	3	6	25	66
	<i>Pathophysiology & Therapeutics</i>	0	0	5	33	62

the ISR system was used for discussion/question and answer sessions. In the *Pathophysiology and Therapeutics* course, in which most content is taught in-class, both instructors believed they covered about 5%-10% less material when using the ISR system. Despite the many positive results with the ISR system, significant differences in student confidence in evaluating and recommending drug therapy or in understanding material as it was being discussed in class were not identified.

ISR systems have tremendous potential as tools for assessing the extent to which students grasp important concepts. They may also provide a paperless alternative to quizzing. ISR systems will likely have a significant role in the classroom of the future, which will probably employ individual personal digital assistants (PDAs) or laptop computers as response units. Since there are many different ISR system manufacturers, products, options, and pricing arrangements available, the cost of these systems can vary. Faculty members must remember that ISR technology is only a tool and as such requires dedicated faculty members to develop useful cases and questions, and to facilitate discussions and foster an active student-learning environment. It takes time to design questions that appropriately assess student mastery of key concepts and applications as they are addressed in a course. This must be kept in mind if an ISR system is used. The faculty members who used the ISR system plan to continue using it. We have not yet solicited the interest or involvement of additional faculty members.

CONCLUSIONS

ISR systems are useful tools for encouraging active learning in pharmacy courses. These systems can facilitate active student participation in the classroom in an

enjoyable way. ISR systems can be effectively used to gauge student understanding in the classroom. Use of the ISR system resulted in significant improvement on certain examination scores. Student and faculty member opinions were generally favorable to ISR system use.

ACKNOWLEDGEMENTS

This research was supported by grants from West Virginia University Research Corporation and Ortho-McNeil Pharmaceuticals. The authors wish to thank Option Technologies, LLC, for the training provided on the use of the *Optionfinder* system. This paper was presented at the American Association of Colleges of Pharmacy Annual Meeting, July 18–23, 2003, Minneapolis, MN.

REFERENCES

- Reddy IK. Implementation of a pharmaceuticals course in a large class through active learning using quick-thinks and case-based learning. *Am J Pharm Educ.* 2000;64:348-355.
- Roy KH. Pilot investigation of the utility of a student response system in medical student lectures. *J Audiov Media Med.* 1996;19:27-32.
- Littauer R. Instructional implications of a new low-cost electronic student response system. *Educ Tech.* 1972;12:(Suppl),69-71.
- Horowitz HM. Student response systems: interactivity in a classroom environment [Report]. Ogden, Utah: Option Technologies, LLC; 1997-98.
- Poulis J, Massen C, Robens E, Gilbert M. Physics lecturing with audience paced feedback. *Am J Phys.* 1998;66:439-441.
- Burstein RA, Lederman LM. Report on progress in using a wireless keypad response system. In Proceedings of the International Conference on Undergraduate Physics Education (ICUPE) 1996. 531-8.
- Halloran L. A comparison of two methods of teaching: Computer managed instruction and keypad questions versus traditional classroom lecture. *Comput Nurs.* 1995;13:285-288.
- Bloom BS, ed. *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I, Cognitive Domain.* New York:Longmans, Green; 1956.