The Earlier the Better: An Evaluation of Changes to Teaching Year 1 Nuclear Medicine

Edwina J. Adams, Elisabeth Kilburn-Watt and Simon F. Cowell

School of Medical Radiation Technology, Faculty of Health Sciences, The University of Sydney, Lidcombe, Australia

Objective: In 1996 changes were made to the nuclear medicine content and mode of delivery in the Year 1 degree program at The University of Sydney, Australia. The aim was to evaluate whether changes made to the program raised the clinical abilities of students entering their clinical placement in Year 2.
Methods: Questionnaires to assess the students' perception of how well Year 1 had prepared them for their clinical Year 2 were distributed to both the 1995 and 1996 students. The clinical supervisors also were surveyed to determine if the 1996 students demonstrated any difference in their understanding and application of nuclear medicine technology principles.
Results: The 1996 students were more positive about their clinical readiness and the clinical supervisors observed an increased level of understanding and application by the 1996 students.
Conclusion: Changes in the Year 1 curriculum provided students with a higher level of clinical readiness at the commencement of their Year 2 clinical placement.
Key Words: nuclear medicine technology education; curriculum design; assessment of learning outcomes

Teaching in any discipline requires that the educators understand the learners. To teach successfully the educator must plan the learning experiences for the students and determine the extent to which these objectives are being achieved. Evaluation of teaching methods and outcomes is necessary to guide educators and enable them to base their decisions on information that is accurate, relevant and comprehensive (*1*).

As educators in nuclear medicine it is important to plan and evaluate the extent to which teaching strategies achieve worthwhile educational outcomes. Nuclear medicine students at the University of Sydney study a three-year bachelor of applied science degree. The underlying knowledge and principles learned in the academic program are reinforced by the clinical education component. Clinical education is an assessable subject during which students attend nuclear medicine practices and are assessed and supervised by educators at both the clinical center and the university.

In 1996 changes were made to increase the nuclear medicine component of the Year 1 subject medical radiations. Changes included the introduction of problem-based learning (PBL), an overview of the indications, performance and interpretation of commonly performed nuclear medicine studies (i.e., bone, lung and myocardial perfusion studies). A brief introduction to basic instrumentation principles of the gamma camera was also added to the curriculum.

The aim of the changes was to increase the first-year students' understanding and knowledge of nuclear medicine practice thereby allowing earlier development of clinical skills in the Year 2 program. The overview of nuclear medicine was developed to help the students conceptualize principles more easily and build clinical skills more rapidly. As an educator it is important to create a learning context that facilitates conceptual understanding. Coles (*2*) states, "educational research has demonstrated that students find abstract concepts difficult to understand if they are presented out of the context in which they are to be applied and used."

Ten hours of PBL content were introduced as it has been shown to be an appropriate method of teaching clinically based subjects. This learning strategy has been found to encourage students to take responsibility for their learning (*3*). Students are presented with a clinical scenario that causes them to hypothesize about a range of situations or conditions. It encourages students to be active by theoretically adopting the role of a qualified practitioner with a simulated clinical situation (*4*). PBL encourages students to use resources, share information, learn independently and become self-directed learners.

Questionnaires were used as an evaluation tool. Gronlund (*1*) states, "evaluation can be defined as the systematic process of determining the extent to which instructional objectives are achieved by the students." A questionnaire can be "used to measure attitudes, opinions or achievements" (*5*). Quantitative and qualitative evaluation of these results determines the extent to which the objectives for change have been achieved.

The aim of this project was to evaluate whether the changes made to the Year 1 curriculum achieved an increased level of clinical competence when the student enters Year 2. An increased level of competence would include both a theoretical understanding of the principles and an ability to quickly learn to perform the studies.

MATERIALS AND METHODS

A questionnaire was administered to 1995 and 1996 Year 1 undergraduate students during their following year. A separate questionnaire was presented to all clinical centers that supervised both groups of students. Each questionnaire included a cover letter that explained the purpose and value of the survey to the undergraduate program.

Student Questionnaire

The student questionnaire was designed to assess the student's initial perceptions of how well Year 1 had prepared them for their first clinical placement in Year 2. Many factors can alter the rate of a student's clinical development. These include the type of center, either private or public, sole technologist center versus a larger center with numerous technologists, and the natural aptitude of the student. Responses were required for the early period of the clinical placement to reduce the effect of variables at different clinical centers.

The student questionnaire contained nine questions that referred to both the application and understanding of the material studied in Year 1 nuclear medicine classes. The survey was designed with a select response format following the Likert scale but omitting the neutral response. The neutral response was omitted to force students to be decisive about their responses. The scale included strongly disagree, disagree, agree and strongly agree. To ensure items in the student questionnaire were not ambiguous or confusing, the survey was piloted by members of the academic staff. The questionnaire was presented during class to Year 2 students who had completed the initial clinical placement. Students who had repeated Year 2 were excluded from the survey. The questionnaire was retrospective for the 1995 students and was conducted in November 1996. The questionnaire for 1996 students was conducted at the completion of their initial clinical placement in March 1997.

Analysis of the student survey data involved compiling responses to the statements and separating response results into questions related to understanding or application. Responses were compiled as either positive or negative percentile results. The Mann-Whitney U Wilcoxon Rank Sum W Test was used to determine the statistical significance of the results.

Clinical Center Questionnaires

Clinical center questionnaires were faxed to centers which had supervised both 1996 and 1997 Year 2 students during their first clinical placement. A pilot survey was sent to a clinical center which had supervised only one of the Year 2 student groups, this excluded them from completing the clinical center survey but was helpful in gaining objective data regarding the clarity of the survey.

The clinical center questionnaire contained six questions including multiple parts designed with a select response format. A select response format was used as it is less time consuming to complete and would result in a higher return rate. The questionnaire was designed to determine if there was any difference between the 1997 student group and the 1996 student group in their understanding and application of nuclear medicine practice studied during the previous year (Year 1 of the undergraduate program). The items were written to gain a response that indicated either yes or no to an increase demonstrated by the 1997 students for specific areas of nuclear medicine practice. An open-ended question was included for general statements regarding the student's overall readiness or capabilities. This question was included to gain additional information.

Analysis of clinical center data involved compiling the number of positive responses to the 1997 students' increased level of understanding and application to areas of nuclear medicine practice studied in Year 1. Results were compiled as percentile increases in the 1997 group. A chi-square test with one degree of freedom was applied to determine the significance of these results.

RESULTS

The November 1996 student questionnaire had a 63% response rate with 17 surveys returned from a total of 27 students. The March 1997 student questionnaire had a 74% response rate with 14 of the 19 students responding. The response rates from the student surveys fell within an acceptable rate as a 70% response rate is deemed acceptable when surveying a professional group (5). The response rates were similar for both groups of students, thereby reducing any bias that may have been introduced by nonresponse from either group. Statistically the group numbers were small, thereby reducing the effectiveness of determining the significance of the results.

The student questionnaire with percentile results is given in Table 1. Analysis of the responses was grouped into questions relating to either understanding or application. Questions relating to how students felt they understood clinical concepts were in Questions 1, 3, 5, 6 and 9. Questions relating to how students perceived they could apply clinical skills were in Questions 2, 4, 7 and 8.

The positive versus negative results for responses to the questions related to understanding are given in Figures 1 and 2. Application-related responses are given in Figures 3 and 4.

The combined understanding responses in Figure 2 showed the 1997 group to have an increased positive response to the level of understanding in all aspects surveyed, with an increase ranging from 20% in Question 9 to a 38% increase in Question 1. There were no areas for the 1997 group where the response was equal to or reduced compared to the 1996 group. Questions 1 and 6 proved to be statistically significant because of the substantial difference in the scores using the Mann-Whitney U Wilcoxon Rank Sum W Test. Question 1 was significant at the level of $p = 0.0378$ and Question 6 at the level of $p = 0.0218$. Using the Mann-Whitney U Wilcoxon Rank Sum W Test results are rated significant at $p < 0.05$.

TABLE 1
1996 and 1997 Student Questionnaire with Percent Responses

	Strongly disagree		Disagree		Agree		Strongly agree	
Statement	1996 %	1997 %	1996 %	1997 %	1996 %	1997 %	1996 %	1997 %
1. Year 1 gave me enough preparation to allow me to learn and build on my knowledge in the clinical setting.	5.9	0	52.9	21.4	35.3	71.5	5.9	7.1
2. Year 1 gave me enough preparation to apply basic clinical skills.	5.9	0	41.2	28.6	52.9	57.1	0	14.3
3. Year 1 lectures prepared me for understanding the use of gamma cameras.	0	0	41.2	28.6	52.9	64.3	5.9	7.1
4. Year 1 lectures prepared me for using the gamma cameras for bone and lung studies.	0	0	23.5	14.3	76.5	71.5	0	14.3
5. Year 1 lectures gave me an understanding of the principles of bone imaging.	0	0	35.3	0	52.9	85.7	11.8	14.3
6. Year 1 gave me an understanding of the principles of lung imaging.	0	0	29.4	0	64.7	78.6	5.9	21.4
7. Year 1 practical sessions gave me knowledge that could be applied directly to the clinical placement.	17.6	0	35.3	28.6	47	57.1	0	14.3
8. Year 1 practical sessions gave me skills that I could use in the clinical placement.	11.8	0	47	42.9	41.2	42.9	0	14.3
9. Year 1 medical radiations gave me enough basic knowledge to retain information obtained in the clinical setting.	5.9	0	35.3	21.4	58.8	64.3	0	14.3

Response numbers: 1996 n = 17; 1997 n = 14.

The combined application responses in Figure 4 showed the 1997 group to have an increased positive response to the level of application in all aspects surveyed, with an increase ranging from 9% in Question 4 to a 24% increase in Question 7. There were no areas in which the 1997 group gave responses equal to or less than those of the 1996 group. These results were not significantly different, however.

The clinical center questionnaire was divided into understanding and application-related questions. The results are displayed as a percentage of the increased positive response to the 1997 student group's increased level of performance compared to the 1996 group. Understanding-related questions were

Questions 1, 2a, 2b and 2c with responses to these questions displayed in Figure 5. Application-related questions were 3, 4a, 4b and 5 with responses to these questions displayed in Figure 6. All yes responses were counted and assessed by chi-square test with one degree of freedom to determine if there was statistical significance. Statistical significance for $p = 0.05$ was rated when the chi-square result was ≥ 3.84.

The clinical center's response to understanding questions showed a positive response ranging from 28% to 87.5%. Significance was demonstrated in Questions 2a (chi-square test result of 24.5) and Questions 2b and 2c (each with a chi-square test result of 12.5).
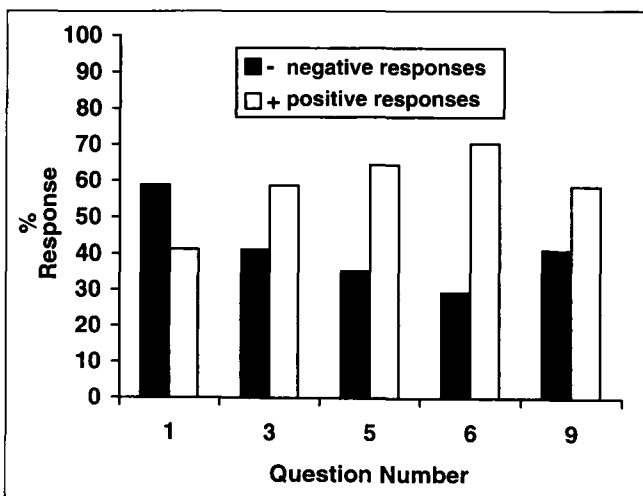

FIGURE 1. Overall 1996 positive versus negative responses to understanding questions.
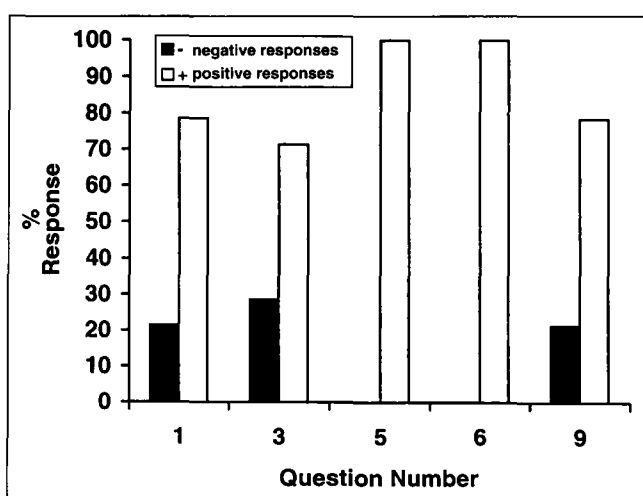

FIGURE 2. Overall 1997 positive versus negative responses to understanding questions.
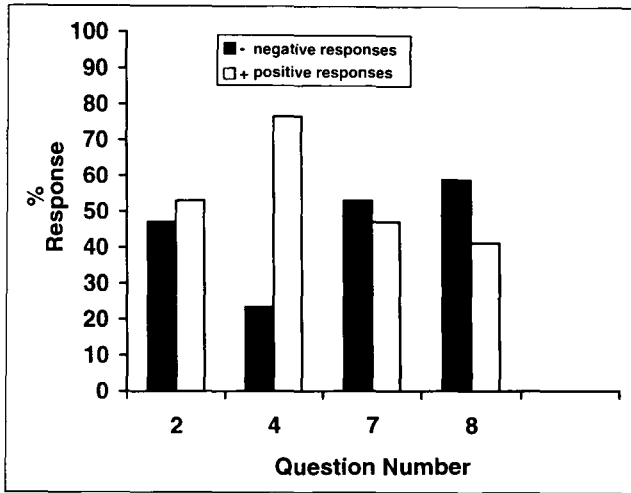
FIGURE 3. Overall 1996 positive versus negative responses to application questions.

The clinical center's response to application questions showed a positive response ranging from 12.5% to 37.5%. Significance was demonstrated in Question 3 (chi-square test result of 4.5).

DISCUSSION

The data obtained from both the students and clinical center questionnaires showed an overall increase in positive responses for performance in understanding and application. The 1997 Year 2 student questionnaire received no responses in the strongly disagree category to any of the questions.

Questions 1 and 6 of the student questionnaire proved to be statistically significant and demonstrated that the 1997 Year 2 students felt more positive about Year 1 material preparing them for the clinical in Year 2. Year 1 provided enough understanding of the principles of lung imaging to learn and build on their knowledge in the clinical setting. Questions 5 and 9 may show a tendency towards Year 1 material improving
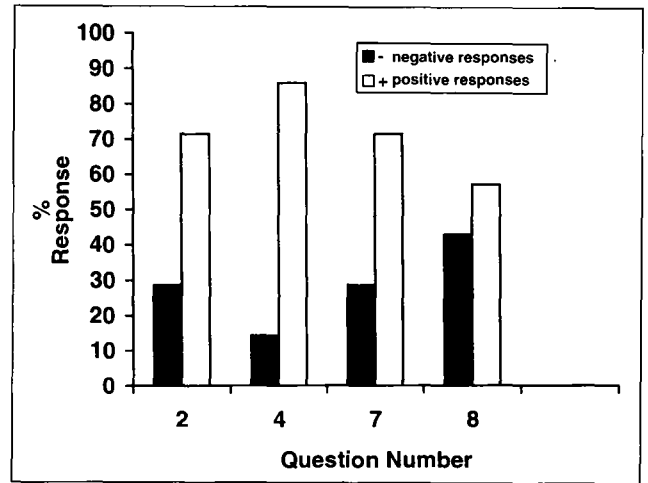

FIGURE 4. Overall 1997 positive versus negative responses to application questions.

the understanding of the principles of bone imaging, although not significant. While none of the application responses in the student questionnaire were statistically significant, they did demonstrate a positive increase for all questions by the 1997 group.

The clinical center questionnaire results followed a similar trend to the student questionnaire results by demonstrating an overall positive improvement. Questions 1, 2a, 2b and 2c all related to whether the 1997 group of students appeared to have an appreciable difference in their level of understanding to the principles of bone, lung and thallium myocardial perfusion imaging. Questions 2a, 2b and 2c demonstrated a statistically significant increased level of understanding.

Question 3 in the application-related questions of the clinical center questionnaire proved to be statistically significant. This question demonstrated that the 1997 group had an increased level of ability in patient positioning and patient communication. This demonstrates that the increased level of nuclear medicine content delivered in Year 1 assisted students in gaining concepts of clinical practice more readily. This concurs
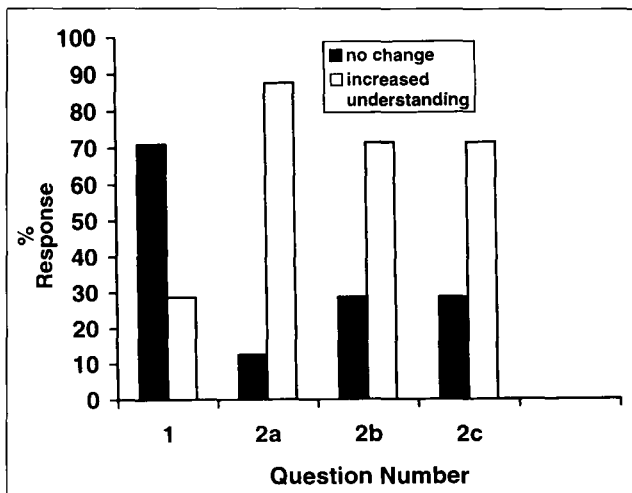

FIGURE 5. Clinical center responses to increased understanding demonstrated by the 1997 Year 2 student group.
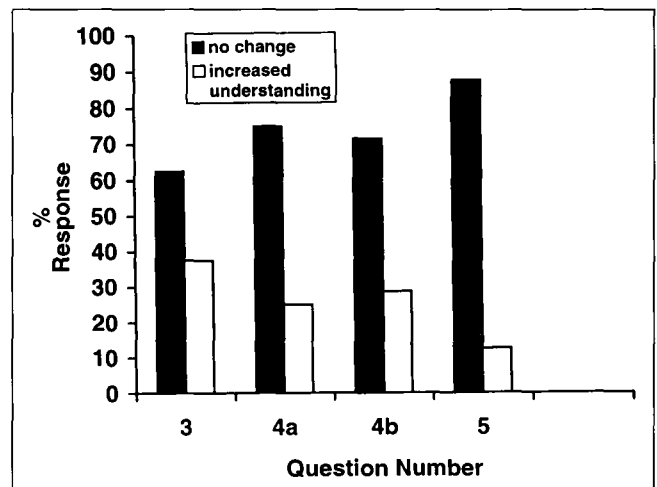

FIGURE 6. Clinical center responses to increased application demonstrated by the 1997 Year 2 student group.

with Coles' (2) findings that show the importance of facilitating conceptual understanding to enable the student to apply skills. While other questions relating to the application of skills did not show a statistically significant increase they all did demonstrate a positive trend.

The 1996 data were collected retrospectively compared with the 1997 data which were collected immediately after the first clinical placement. This was a limitation of the study, as the 1996 students were asked to recall perceptions they had experienced 9 mo earlier. The 1996 students may have had their recall influenced by external factors that did not relate to their Year 1 learning and Year 2 clinical experiences.

Ideally the clinical center survey should have been administered immediately after each Year 2 clinical rotation in 1996 and 1997 to obtain specific information regarding the performance of each student group. As the project was initiated in late 1996 a comparison of 1997 versus 1996 had some limitation as clinical centers were asked to recall their perceptions of the 1996 student group after a delay of 9 mo. The clinical and student questionnaire items differed slightly with the omission of questions relating to myocardial data on the student survey. The omission of myocardial imaging on the student questionnaire meant that perceptions of performance in cardiac nuclear medicine were limited to the clinical centers' responses only.

CONCLUSION

The results from both the student and clinical center questionnaires show a rise in the level of understanding demonstrated by the group of students who had the content and mode of delivery of their Year 1 curriculum changed. The clinical center responses showed an increase in the students' application of patient positioning and patient communication skills. Student responses demonstrated that changes to the practical sessions aided them in applying clinical skills. These results will encourage implementation of further changes to the Year 1 program to further improve each student's ability to apply principles of nuclear medicine technology and to build clinical skills more rapidly.

As an educator it is important to create a learning environment that facilitates conceptual understanding and to evaluate learning experiences. This study effectively assessed learning outcomes and directed the teaching program to ensure continued development and excellence in teaching.

REFERENCES

1. Gronlund, NE. *Measurement and evaluation in teaching,* 4th ed. New York: MacMillan;1981:3–28.
2. Coles C. The role of context in elaborated learning. In: Balla JI, Gibson M, Chang A, eds. *Learning in medical schools: a model for the clinical professions,* Hong Kong:University Press;1989:1990.
3. Cox J, Rinks M. Early experiences with problem-based learning in a radiation therapy program. *Radiologic Science and Education* 1996;3:24–30.
4. Hengstberger-Sims C, McMillan M. Problem-based learning packages: considerations for neophyte package writers. *Nurse Education Today* 1993;13: 73–77.
5. Wiersma W. *Research methods in education: an introduction,*5th ed. Boston: Allyn and Bacon;1991:165–202.