Respiratory Care Education Annual

The American Association for Respiratory Care

Volume 17 Fall 2008

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Respiratory Care Education Annual
Volume 17, Fall 2008, 1-6

ADMISSION CRITERIA AS PREDICTORS OF STUDENT PERFORMANCE ON THE NATIONAL BOARD FOR RESPIRATORY CARE EXAMINATIONS

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Abstract

Respiratory therapy (RT) programs evaluate past academic performance in order to predict student success in their programs. The selection process for entry into RT programs is important because most students admitted to RT programs eventually graduate and work as respiratory therapists. Therefore, the purpose of this study was to understand the relationship between admission criteria including science GPA (SciGPA), non-science GPA (NSciGPA) and cumulative GPA (CumGPA), and student success on the certified respiratory therapist (CRT) and the written registry for respiratory therapist (WRRT) examinations. This study examined the records of a total of 375 students admitted to a 4-year RT program from 1995 through 2005. Pearson correlations and multiple regression analysis were utilized for the statistical analysis of this study, at a 0.05 level of significance. All admission criteria had a positive relationship with student scores on the CRT and the WRRT ($p<0.05$). SciGPA and CumGPA were the best predictors of student success on the CRT and accounted for 45% of the variance in student score on the CRT. Although no single admission criteria predicted student performance on the WRRT, regression analysis showed that student exit GPA and their scores on the CRT were responsible for 40% of the variance in the WRRT scores. By analyzing these variables in the admissions process, RT programs can ensure that only the most qualified students begin the path towards becoming a respiratory therapist. *Key words: admission criteria, GPA, CRT, WRRT, respiratory therapy, student success.*

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Admission Criteria as Predictors of Student Performance on the National Board for Respiratory Care Examinations

Introduction

Although selection criteria for entrance into respiratory therapy (RT) education programs vary greatly among institutions, all programs evaluate past academic performance as possible predictors of student success in respiratory therapy. RT programs are faced with the annual task of selecting the applicants most likely to succeed in the program. The selection process is important because most students admitted to RT education programs eventually graduate and serve as respiratory therapists in the profession. Presumably, students who succeed in RT programs will pass the National Board for Respiratory Care (NBRC) examinations, and will go on to be respiratory therapists. In order to determine how well a program achieves its goals in producing knowledgeable respiratory therapists, RT programs are assessed through program variables and student performance on the NBRC examinations.[1-7] Traditionally, admission decisions are based upon measures of students' past academic achievement and grade point average (GPA). These measures were considered to be a good indicators because they represents the student's prior academic performance.[8-12] The literature indicates that pre-professional GPA and science-math GPA are valid predictors of student success; these criteria have been used accordingly in the admission decisions of many RT programs.[13-15]

Although several studies have verified the importance of GPA for predicting academic success, research on the precise relationship of selected admission criteria to student performance on the NBRC examinations is lacking. Because RT programs expend a significant amount of resources to recruit students, when students do not matriculate in the curriculum or do not pass national credentialing examinations, the institutional expenditures on these students become financial losses. As a result, the respiratory therapy profession suffers from a shortage of qualified respiratory therapists. Although there is no evidence in the literature indicating that exam failure plays a significant role in workplace shortage, this is a problem presently as the demand for respiratory therapists is increasing. Understanding the relationship of admission criteria to student performance on the NBRC examinations may help programs select those RT applicants most likely to succeed on the NBRC examinations. Therefore, this research project is designed to determine which admission criteria are valid predictors of student performance on the NBRC exams. The objective of this study was to develop a model that predicts student performance on the WRRT by analyzing three admission criteria: science GPA (SciGPA), non-science GPA (NSciGPA) and cumulative entering GPA (CumGPA). Three important questions arose within the context of this study:

1. What is the relationship between admission criteria, including SciGPA, NSciGPA and CumGPA, and student success on the CRT and the WRRT examinations?
2. To what extent do admission criteria predict student performance on the CRT and the WRRT examinations?
3. To what extent do student exit GPA and student score on the CRT predict student success on the WRRT?

Methods

Sampling and Data Collection: Three hundred and seventy-five students admitted to a four year RT program from 1995 through 2005 at a southeastern university. Using existing records of all graduates, a longitudinal database was created.

Variables: Student scaled scores on the CRT and the WRRT examinations on the first attempt were the criterion measures of this study. The independent variables of this study included student SciGPA, NSciGPA, CumGPA and Exit GPA. SciGPA was calculated based on coursework such as biology, physics, mathematics and chemistry, while NSciGPA was determined by taking into account all other classes that were not used in calculating SciGPA. CumGPA refers to the overall entering GPA that was used to compute student academic standing before student enrollment at the RT program. Exit GPA indicates student GPA measures at graduation.

Data Analysis: In order to determine the relationship between admission criteria and student performance on the CRT and the WRRT, the Pearson product moment correlation coefficients were examined. Then, multiple regression analysis was utilized to establish which of the admission criteria performed best in predicting student performance on the NBRC examinations.

Results

Regarding our first research question, two separate sets of Pearson product moment correlation coefficients were conducted to determine the relationship between admission criteria and student success on the CRT and the WRRT examinations. All admission criteria had a positive relationship with student scores on the CRT and the WRRT ($p<0.05$). Table 1 and 2 provide Pearson product moment correlation coefficients between admission criteria and student scores on the CRT and the WRRT examinations, respectively.

In response to our second research question, two separate multiple regression analyses were conducted to understand the extent to which admission criteria predict student per-

Table 1

Pearson Product-Moment Correlation Coefficients between Admission Criteria and Student Scores on the CRT examination

Variables		Mean CRT	SciGPA	NSciGPA	CumGPA
SciGPA	r	.343*	1		
	Sig.	.000			
NSciGPA	r	.351*	.468*	1	
	Sig.	.000	.000		
CumGPA	r	.433*	.731*	.619*	1
	Sig.	.000	.000	.000	

** Correlation is significant at the 0.01 level (2-tailed).*

Table 2

Pearson Product-Moment Correlation Coefficients Between Admission Criteria and Student Scores on the WRRT examination

Variables		Mean WRRT	SciGPA	NSciGPA	CumGPA
SciGPA	r	.420*	1		
	Sig.	.000			
NSciGPA	r	.342*	.468*	1	
	Sig.	.000	.000		
CumGPA	r	.399*	.731*	.619*	1
	Sig.	.000	.000	.000	

** Correlation is significant at the 0.01 level (2-tailed).*

formance on the CRT and the WRRT examinations on the first attempt. The regression analysis for CRT scores resulted in an overall R = 0.673, R^2 = 0.452, and adjusted R^2 = 0.422 ($p<0.01$) and indicated that SciGPA (p=0.001) and CumGPA (p=0.039) were the best predictors of student success on the CRT. Together, they accounted for 45% of the variance in student score on the CRT. However, the multiple regression analysis for WRRT scores indicated that no single admission criteria predicted student performance on the WRRT ($p>0.05$).

As for our third research question, student exit GPA and their scores on the CRT predict student success on the WRRT by being responsible for 40% of the variance in the WRRT scores (R = 0.635, R^2 = 0.404, adjusted R^2 = 0.362, and $p<0.01$). None of the individual admission criteria predicted student performance on the WRRT.

Discussion

This study describes the importance of selection criteria when admitting students to a respiratory therapy program. Ultimately, students admitted to a RT program must pass the national examinations to qualify for practice. In this sample all students selected were required to pass the certifications exam prior to graduation. Findings were in agreement with previous literature that cumulative GPA and science GPA are good predictors of success in a RT program.[8-15]

In reviewing the literature it was noted that limited information exists about selection criteria in RT programs. Based on the present study, it may be possible to predict student success on national examinations. The results of this study were very similar to those of the study LeGrand and Shelledy conducted.[14] They reported an entering GPA correlation to the CRT of r=0.54, p=0.01, while in the current study, we found r=0.43, p=0.01. When considering prerequisite GPA, LeGrand and Shelledy[14] reported r=0.42, p=0.01, while we found r=0.34. p=0.01. When correlating GPA to the WRRT, LeGrand and Shelledy found r=.42, p=.01, and in the current study, r=0.399, p=0.01. Interestingly enough both studies found prerequisite GPA to the WRTT to be r=0.42, p=0.01. However, we defined the prerequisite GPA as science and math GPA. The current study finds the best predictor of success on the WRRT is the score on the CRT. The higher the CRT score, the higher the WRRT score.

Cumulative GPA and science GPA may be the most important variables on which to base admission if CRT exam success is the goal. Although we did not look at exit GPA as an admission criterion, a paper from Op't Holt and Dunlevy[13] suggest that exit GPA has a high correlation to cumulative and science GPA. This may explain why students with higher GPAs do better on national standardized examinations. However, in a paper by Gardenhire and Restrepo[15] it was noted that high school GPA had a low correlation (r=0.12) to the NBRC's CRT exam.

RT programs should look at GPAs when admitting students. The GPA of a student appears to be a good predictor of possible scores on the CRT, however, the exit GPA and CRT score may give more insight into the performance of a student on the WRRT. Also, RT programs can share the results of this study with their students in order to lead them to perform well in the program. Thus, RT students, who are encouraged to work harder once admitted, will have higher exit GPA and CRT scores which may increase their performance on the WRRT.

This study included a population of students admitted to a four year RT program from 1995 through 2005. Therefore, the results of this study can only be generalized to this group of students. Another limitation of the study is that some subjects in the study transferred courses, including science and math from another university or two year college. It may be interesting to differentiate students that completed all course work at a four year university from those students transferring from a two year college. Further research should continue in this area of study to allow educators and RT programs appropriate measures to predict success of students.

Conclusion

The identification of factors predicting student success on the NBRC examinations is an important task. This study identified SciGPA and CumGPA as the best predictors of student performance on the CRT. The best predictors of student success on the WRRT include student exit GPA and student performance on the CRT. By looking at these variables in the admissions process, RT programs can ensure that only the most qualified students begin the path towards becoming a respiratory therapist.

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Inter-Rater Reliability Among Respiratory Care Clinical Instructors: Pilot Study

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Abstract

Background: Respiratory Care programs utilize a combination of didactic and clinical instructional methodologies. With clinical rotations students must demonstrate procedural competency in numerous skills. The reliability of the clinical evaluations is of utmost importance to the respiratory care program faculty. The purpose of this pilot study was to determine the inter-rater reliability of clinical evaluations among respiratory care clinical instructors.
Methods: The investigators filmed two students completing five competency procedures. The students were instructed to perform steps in the procedures correctly or incorrectly. Three of the videotaped procedures: hand washing, incentive spirometry, and vitals signs, were distributed to clinical instructors for evaluation. Instructors used the DataArc® clinical competency evaluation form when assessing student performance.
Data/Results: The intra-class correlation (ICC) among 9 instructors for hand washing was strong (ICC = .8663). The ICC among 9 instructors evaluating the incentive spirometry procedure was strong (ICC = .8030). The ICC among 9 instructors evaluating the vital signs procedure was also strong (ICC = .7664).
Conclusion: This pilot study revealed that evaluations completed by program clinical instructors were reliable. The inter-rater homogeneity was remarkably strong for the three procedures studied. All findings were significant at the .05 alpha level. Routine assessment of inter-rater reliability of clinical instructors is paramount to ensure proper mentoring.

KEY WORDS: Inter-rater Reliability; Intra-class Correlation; Clinical Evaluation; Clinical Performance

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Inter-Rater Reliability Among Respiratory Care Clinical Instructors

Introduction

Respiratory care standards require structured clinical experiences to accompany didactic course work.[1] In most educational programs these clinical experiences are fostered in hospitals affiliated with the program. Clinical rotations provide an opportunity for hands-on experience and reinforcement of information discussed in the classroom. With every clinical rotation students must demonstrate procedural competency to various clinical instructors. Full-time and part-time instructors employed by the educational program and/or full-time and part-time therapists employed by the hospital mentor students in the clinical setting. Clinical instructors are charged with providing an assessment of clinical competence to each student throughout the semester. These evaluations provide the student and the program with the strengths and weaknesses of clinical skills. Program faculty relies on these evaluations to gauge progression through the curriculum and comprehension of objectives. Clinical instructors possess diverse educational backgrounds and may interpret "acceptable" clinical performance differently. Commission on Accreditation of Allied Health Education Programs (CAAHEP) guidelines require routine assessment of inter-rater reliability among clinical instructors.[1] When the reliability of the clinical instructor evaluations are suspect then student achievement is likely to be affected. Routine assessment of inter-rater reliability is of utmost importance to student success as well as overall program success.

When assessing performance, inter-rater reliability is the agreement between two or more raters.[2] Objective measurement of performance cannot be achieved if evaluators provide unreliable ratings or there is highly variable ratings among clinical instructors.[3] Shrout and Fleiss acknowledge that reliability analysis is important to ensure that observations made by raters are consistent.[4] If multiple judges are used for assessment and there is little agreement in their ratings then the results will lose validity.[3] In addition, Semmler[3] recommends regular assessment inter-rater reliability to ensure consistency over time. Developing the instrument is also important to the process of inter-rater reliability. Morgan et al. investigated the inter-rater reliability of faculty assessments on medical student performance when using a simulator mannequin.[5] Students were videotaped while managing a patient simulation scenario related to anesthesia management in the operating room. Raters watched the video segment and provided a rating of student performance. Raters used a criterion-based checklist rating for each simulation scenario and a global rating for overall performance during the scenario. The authors discovered a higher inter-rater reliability for the checklist assessments compared to global assessment yet both proved to be reliable.[5] In a subsequent publication, Morgan et al. investigated the reliability and validity of medical students evaluations during competency assessments.[6] The investigators created video simulations to be evaluated by instructors. "Faculty members were asked to identify items that a medical student would be expected to perform. In addition, they were asked to identify critical performance items that, if omitted, would result in negative grading."[6(p389)] The methods used by Morgan et al. proved valuable when developing the methods for our study.[5-6]

The purpose of this pilot study was to determine the inter-rater reliability of evaluations among respiratory care clinical instructors. Our research question asked how reliable are clinical instructor ratings of students? Our hypothesis was the clinical evaluations used by Texas State University Respiratory Care Program have a high degree of reliability. The objective of this study was to gain a better understanding of the differences between clinical instructor competency evaluations. Once this was determined, the program faculty may develop a better understanding of how to ensure consistent and reliable evaluations.

Methods

Investigators applied for and received university institutional review board approval to conduct this study. Subjects included ten clinical instructors employed by the Texas State University Respiratory Care Program. Due to the limited number of clinical instructors, the investigators approached all instructors assigned to the spring course rotation for inclusion. The subject's ages ranged from twenty to forty years old. Their ethnic background included four Caucasians, four Hispanic, and two African Americans. There were six males and four females. Of the initial ten subjects nine returned evaluation forms. All subjects volunteered to participate and there were no exclusions. Prior to participation all subjects signed a consent form containing the requirements set forth by the university's Institutional Review Board.

The investigators initially selected five DataArc® competencies to include in this study: hand washing, incentive spirometry, vital signs, use of a metered dose inhaler, and arterial blood gas puncture. DataArc® (DataArc, LLC, League City, TX) is a Biomedical Education Database Service Provider developed to track several areas related to clinical instruction. The DataArc® system utilizes competency evaluations developed by two faculty members from the University of Texas Medical Branch-Galveston. The major competency statements are referenced to clinical practice guidelines, other national standards, and/or the most recent editions of textbooks.[7] The DataArc® competency evaluations were used as the guide when filming the videotaped segments. If a competency evaluation contained 18 different elements for evaluation, the investigators ensured all 18 elements were represented in the video. There were two students who participated in the research project and both were sophomores in the program. The students reviewed each DataArc® competency prior to filming the procedure. The investigators filmed one student performing each competency procedure in an attempt to maintain a believable and familiar scenario for the clinical instructors. In some performances the student would complete all competency requirements correctly. In other performances the student would intentionally perform a portion of the competency incorrectly. For example, when filming the hand washing procedure, the student was instructed to turn off the water using a bare hand versus a towel. The investigators developed a key for each competency to serve as the standard evaluation for the procedure.

Three of the videotaped procedures: hand washing, incentive spirometry, and vital signs, were chosen for this pilot study. All three videos were hand delivered to the clinical instructors along with the DataArc competency check-off sheets and a return envelope. Return envelopes were anonymous to protect identities. An information sheet with detailed instructions was also provided to each instructor. Instructors were required to watch each videotaped competency and evaluate the clinical performance using the DataArc® competency check-off sheet. Instructors ranked student performance as "satisfactory", "major or minor unsatisfactory", "not applicable", or "not observed" for each element. In addition, instructors provided a summative evaluation of the performance as either "satisfactory" or "major or minor unsatisfactory."

Results

A total of nine clinical instructors submitted completed evaluations. Data were analyzed using Statistical Package for the Social Sciences (Windows SPSS Program). Instructors evaluated the competency elements as well as providing a summative evaluation for each procedure. The number of key elements was determined by the procedure's complex nature, resulting in a varying number of elements for each procedure.

The hand washing procedure consisted of 18 competency elements. The inter-class correlation (ICC) among nine instructors evaluating the hand washing videotape was strong (ICC = .8663, df = 17, $p < 0.05$). The incentive spirometry procedure contained 26 competency elements. The ICC among 9 instructors evaluating the incentive spirometry procedure was strong (ICC = .8030, df = 25, $p < 0.05$). The vital signs procedure contained 21 competency elements. The ICC among 9 instructors evaluating the vital signs procedure was also strong (ICC = .7664, df = 20, $p < 0.05$).

Discussion

This pilot study revealed that the evaluation of student performance was consistent among the nine clinical instructors. The inter-rater homogeneity was remarkably strong for the three procedures studied. All findings were significant at the .05 alpha level. The findings reveal that program faculty can be confident that student evaluations among clinical instructors are reliable when using the DataArc instrument. As stated previously, in some videotaped segments, the students deliberately performed certain competency items incorrectly. These items were not analyzed individually in SPSS; however, the information was important to the investigators. For this pilot study, investigators were more concerned with the overall inter-rater reliability versus the reliability on individual items and the reliability between individual instructors. Nonetheless, the evaluation of these items by the instructors was interesting and warrants future research. When completing the hand washing procedure the student was instructed to turn off the water using a bare hand versus obtaining more towels to turn off the water. All clinical instructors evaluated this competency item as unsatisfactory for the student. When completing the vital sign procedure the student was instructed to palpate the patient's pulse using their thumb versus index and middle finger. All clinical instructors evaluated this competency item as unsatisfactory for the student. The investigators also evaluated the number of items with 100%, 89%, and 78% agreement (Table 1).

Table 1

The number of items with 100% instructor agreement, the number of items with at least 89% instructor agreement, and the number of items with at least 78% instructor agreement.

Competency Evaluation	100% instructor agreement	≥ 89% instructor agreement*	≥ 78% instructor agreement†
Hand Washing (18 competency items)	8	11	12
Vital Signs (21 competency items)	3	6	9
Incentive Spirometry (26 competency items)	8	13	18

*Note: 89% agreement occurs when only one clinical instructor rates differently compared to the group.

†Note: 78% agreement occurs when only two instructors rate differently compared to the group rating.

Conclusion

Skill assessment of a students' performance is, in itself, a form of learning and should provide guidance and support to address the needs of the learner. Epstein and Hunbert state "the outcomes of assessment should foster learning, inspire confidence in the learner, enhance the learner's ability to self-monitor, and drive institutional self-assessment and curricular change."[8(p231)] Meaningful assessments can be consistent regardless of the instructor.

Poorly prepared clinical faculty can result in inadequate student instruction. Inconsistent explanations among the clinical faculty of proper procedures may lead to confusion and poor performance by the student. Furthermore, inadequate supervision and unreliable feedback are examples of common problems associated with clinical teaching.[9] Thus, quality mentoring is of utmost importance in the clinical setting. Routine assessment of inter-rater reliability of clinical instructors is paramount to ensure proper mentoring. Equally, teacher development programs and workshops are recommended to ensure effective clinical teaching[10] and consistent evaluations.

The small sample size and number of videotaped procedures limit the generalizing from the findings of this study. Also, the competencies selected may contribute to the high inter-rater reliability. Future studies involving more complex procedures should be used to further assess inter-rater reliability. A videotaped segment for each clinical competency seems plausible and would prove valuable in assessing clinical evaluation consistency. In spite of study limitations, the findings from this pilot study are encouraging. Nine clinical instructors demonstrated consistent evaluations for each procedure.

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Respiratory Care Education Annual
Volume 17, Fall 2008, 13-21

Analysis and Comparison of Pulmonary Function Laboratory Training Needs in the United States, Europe, and Latin America: Implications for Respiratory Care Education

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Study was funded by MannKind Corporation. The author is a consultant for MannKind Corporation. Coauthors are employed by MannKind Corporation.

Abstract

Background: The 2005 American Thoracic Society (ATS) and European Respiratory Society (ERS) guidelines outline the educational and competency requirements which must be met by staff performing pulmonary function testing (PFT). This study determined, in a preselected cohort of pulmonary function laboratories (PFLs), if staff adhered to the published standards and guidelines when performing and reporting PFT results. This study was conducted by training personnel from MannKind Corporation, who were contracted by the PFLs to provide staff training. Training included procedures for measuring and obtaining spirometry, lung volumes, single-breath diffusing capacity, and quality control. Implications from this study could possibly impact how PFT is taught in respiratory care educational programs. **Methods:** 109 PFLs were chosen to participate in the study. This cohort represented PFLs from the U.S., United Kingdom (UK), and the Netherlands. Areas evaluated and training provided to each PFL included: ability to perform quality control and interpret the results, adherence to ATS/ERS test performance standards and guidelines for spirometry, CO diffusion capacity (D_LCO), lung volumes by body plethysmography, and successful completion of a mechanical D_LCO simulation study for quality control of the D_LCO equipment. The intensity of training required for quality control and PFT was evaluated and scored. A Likert Scale of 1-3 indicating the intensity of training required for all PFL staff was recorded. An average intensity score was computed. D_LCO simulation studies were graded as acceptable (1) or unacceptable (2). During training sessions, gaps in practice between the current ATS/ERS standards

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and guidelines and actual practice in the PFLs were documented by each trainer. Documentation of educational needs for each of the participating PFLs was completed post-training by the on-site trainer. A minimum of eight hours of training related to pulmonary function testing and quality control was provided to each participating PFL. Each trainer was a Registered Pulmonary Function Technologist. A standardized training program was used by all trainers. **Results:** The intensity of training required for each component was evaluated for each PFL. Mean intensity training values were compared for U.S.:syringe QC 2.04, BioQC 2.04, spirometry 1.10, D_LCO 1.24, and lung volumes 2.14 and non-U.S.: syringe QC 2.28, BioQC 2.13, spirometry 1.21, D_LCO 1.51, and lung volumes 2.31. The D_LCO simulation study failure rate was 26% for the U.S and 46% for Non-U.S. sites. **Conclusions:** An evaluation of the actual PFT results, equipment quality control methods, and equipment performance suggests a significant gap exists between current standards and guidelines and how actual PFTs are conducted. Implications of these findings should guide respiratory care educational program to alter their pulmonary function testing curriculum.

Key Words: spirometry, pulmonary function tests, training, diffusing capacity, quality control

Analysis and Comparison of Pulmonary Function Laboratory Training Needs

Introduction

The American Thoracic Society (ATS) and European Respiratory Society (ERS) have published guidelines for pulmonary function testing (PFT) since the Snowbird Workshop on Spirometry in 1979.[1] Over the past 25 years, the standards and guidelines have been updated and expanded to cover all aspects of pulmonary function testing. In 1998, the ATS published the first Management and Procedure Manual for Pulmonary Function Testing. It was subsequently updated in 2005.[2] Five additional updated guidelines were jointly published in 2005 by the ATS and ERS.[3-7] The 2005 guidelines have laid the groundwork for the establishment of worldwide quality control and performance standards for pulmonary function testing. The 2005 document outlines educational and competency requirements for pulmonary function laboratory staff regardless of the location of the services. For this study, PFTs in the U.S.were conducted by certified or registered respiratory therapists and pulmonary function technologists. While testing in Europe and Latin America was performed by physicians or doctoral-prepared level personnel, individuals with pulmonary function experience unique to their country, individuals with an undergraduate degree or nursing education or by staff that no specific training could be identified. The increasing complexity of pulmonary function equipment and procedures was openly acknowledged by staff from participating PFLs. This translated into more complex training issues and the need for an increased depth and scope of training. The ATS/ERS suggests that, in order for them to completely understand and perform all duties required for pulmonary function testing, staff should successfully complete secondary education and at least two years of college. All staff must demonstrate competence in test performance, quality control methods, and any other areas relevant to their individual laboratory. This may be accomplished through formal training programs or be demonstrated through professional credentialing. Continuing education to remain aware of changes in PF testing or to maintain professional credentials is strongly encouraged. In the U.S., for example, PFL staff participates in continuing education to maintain professional credentials. In Europe, formal training and opportunities for continuing education varies from country to country. The United Kingdom (UK) and the Netherlands have formal training programs in pulmonary function training. Most other European and Latin American sites have training provided by the manufacturer of the PF equipment or on the job training. It may also be formally included in physician and doctorate training programs. The ERS regularly provides post graduate education for respiratory care providers through Assembly 9, the division pertaining to allied health and respiratory care. The ERS structure provides membership to specialty assemblies similar to the ATS and American Association for Respiratory Care (AARC). As noted above, the UK and the Netherlands have formal training programs. In the United States, PF training is provided by formal respiratory care programs. The pulmonary function component of these programs varies in length and scope. In the United States, practitioners working in pulmonary function laboratories can become credentialed by the National Board for Respiratory Care (NBRC) as a certified pulmonary function technologist (CPFT) or a registered pulmonary function technologist (RPFT).

Purpose of Study

The purpose of this study was to identify the current training needs of staff in pulmonary function laboratories in the United States, Europe, and Latin America. It attempted to determine the depth, breadth, and intensity of training needed for laboratories to achieve adherence to the current ATS/ERS standards and guidelines. Results of this study may assist and guide respiratory care program faculty to examine and strengthen curriculum related to pulmonary function testing. Specifically, faculty should assess teaching materials to ensure adherence to current standards of practice for spirometry, lung diffusion for carbon monoxide (DLCO) and lung volumes by plethysmography as published in 2005. This study also addresses quality control requirements for PFLs.

Methods

On-site pulmonary function testing training was provided to 109 PFLs who contracted with trainers from the MannKind, Coporation. All PFLs were pre-selected based on a qualification questionnaire and approval by MannKind Corporation for participation in the study. Seventy PFLs were located in the United States and thirty-nine PFLs were located in Europe and Latin America. Each PFL limited the actual testing to one to three staff members. Laboratories in the U.S. were staffed or supervised by credentialed therapists (e.g., CRTs, RRTs, CPFTs and/or RPFTs). For the purposes of this study, testing in Europe and Latin America was performed by a physician or doctorial-prepared individuals (58.5%), individuals with PF credentials (17%), or an individual with an undergraduate degree or nursing education (5.7%). For 18.9% of the staff performing testing, no specific training could be identified. A minimum of eight hours and maximum of sixteen hours of training was provided to the PFL staff to complete the training goals. The training goals included demonstration of ability to calibrate the PF device, perform spirometry, D_LCO measurements, and lung volumes according to the ATS/ERS standards and guidelines, perform quality control, and D_LCO simulation studies. Basic troubleshooting techniques were also reviewed. All U.S. training sessions provided participants with 6.5 hours of continuing education credits granted by the AARC. All trainers were credentialed by the National Board for Respiratory Care as an RPFT. New trainers were taught and evaluated by the initial two trainers and a standardized approach to the material was developed and implemented. The PFLs performed testing using their own PF equipment that was currently used for patient testing. Systems included Jaeger and Sensormedics (Cardinal Health, Yorba Linda, CA) Collins (nSpire Health™ Longmont, CO) Morgan (Morgan Scientific, Inc. Haverhill, MA), and Medical Graphics (Medical Graphics Corporation, St. Paul, MN). The training objectives, resources and teaching methods used are identified in Table 1.

Table 1
Training objectives, resources, and methods

Training objectives	**Resources and methods**
Achievement of at least minimum ATS/ERS requirements and manufacturers recommendations in the areas of spirometry, D_LCO, and plethysmography.	Reference materials provided by ATS/ERS, and pertinent educational materials available.
Performance of spirometry, D_LCO, and lung volumes by plethysmography in accordance with ATS/ERS guidelines.	Demonstration of skills provided by faculty and students/learners. Provision of a comprehensive pulmonary function manual based on pertinent ATS documents, manuals, and checklists.
Achievement of a level of test performance recognized by ATS/ERS. Acceptability, repeatability, and linearity will be evaluated during actual patient testing.	Reference to a pulmonary function manual as previously identified.
Competence in the use of mechanical and biologic quality control methods for spirometry, D_LCO, and plethysmography as identified by evaluation during patient testing.	Demonstrations and reference to manuals as identified.
Competency in performance of D_LCO simulations using the Hans Rudolph simulation device.	Training materials available for use of the Hans Rudolph device.
Accurate and complete entry of simulation results into a statistical program, and subsequent evaluation of results for accuracy.	Education in use of Easy Lab QC software.

Post-training reports were completed and submitted to MannKind Corporation as the managing sponsor for the clinical study. Areas evaluated included: ability to perform mechanical quality control (QC) and interpreting the results, performing PFTs , adherence to ATS/ERS standards and guidelines for spirometry, measuring D_LCO, and lung volumes by whole-body plethysmography, and successful completion of a D_LCO simulation study. Mechanical QC included assessing the performance of syringe flow-volume loops and syringe D_LCO. The D_LCO simulation device is a method of mechanical QC used to assess equipment function across a defined volume range and the D_LCO results expected in a given patient population. A protocol was developed and used for this study to control the accuracy of D_LCO measurements using a D_LCO simulator (Hans Rudolph, Kansas City, MO) that mimics a patient test and creates an exact known D_LCO value. The laboratories are required to test their PFT equipment every eight weeks for accuracy. Data recorded from the D_LCO device under patient testing was compared to the target values generated by the simulator. Test performance procedures were assessed by each trainer for adherence to the 2005 ATS/ERS standards and guidelines which are accepted as the minimal practice standard for PFLs. The ATS/ERS standards and guidelines outline equipment quality requirements, test performance methods including acceptability and repeatability criteria, and reporting of results for each PFT performed. Separate standards addressed spirometry, D_LCO, and lung volumes by plethysmography. A checklist was provided to each PFL that reviewed acceptability and repeatability requirements for spirometry, D_LCO, and lung volumes. The checklist served as a basis to evaluate each PFL for adherence to the ATS/ERS standards and guidelines. The intensity of training required for quality control and PFT methods was graded by each on-site trainer and reviewed by two additional trainers. The level of training intensity was scored using a Likert Scale. Post-training reports were evaluated and discussed by the training group to determine agreement. Post-site monitoring of each site also included a review of adherence to ATS/ERS test performance standards and QC standards. Each PFL was required to complete ten acceptable biologic QC tests. Biologic QC is the practice of testing a normal subject to determine variance. Agreement between trainers was consistent and supported by the ability of the PFL to complete the required QC prior to testing subjects in the clinical study. The intensity score used the following Likert Scale used: 1 = minimal training and review for the procedure were required, 2 = moderate training and review of the procedure were required and/or the procedure were infrequently performed, 3 = extensive training and review were required and/or the procedure was not previously performed.

The D_LCO simulation study was graded as acceptable or unacceptable and the average failure rate was calculated. The D_LCO simulation device and calculation software were supplied by Hans Rudolph Corporation, Lenexa, Kansas. Only one site had previously performed D_LCO simulation studies so it was accepted that all sites would require extensive training for the procedure.

Results

The results from seventy PFLs in the U.S. and thirty-nine PFLs in Europe and Latin America were evaluated. Table 2 reflects the number of U.S. sites requiring minimal, moderate or intense training as related to QC methods and testing methods for spirometry,

D_LCO, and lung volumes. Table 2 also documents the average intensity training score for each type of test. Table 3 reflects the results from European and Latin American PFLs. Table 4 compares the mean values for the training intensity score between U.S. and non-U.S. PFLs. In addition this table reports the D_LCO simulation study failure rate for each group of PFLs. Each area of training was scored separately for each PFL by the on-site trainer provided MannKind Corporation.

Table 2

The number of U.S. PFLs requiring different levels of intensity of training and the average training intensity score for various components of PFT

Intensity Score	Mechanical QC (Syringe Loops and D_LCO)	BioQC	Spirometry Test Performance	D_LCO Test Performance	Lung Volumes Test Performance
1	20	22	64	55	17
2	30	23	5	13	26
3	20	25	1	2	27
Mean Value	2.04	2.04	1.10	1.24	2.14

Table 3

The number of European and Latin American PFLs requiring different levels of intensity of training and the average training intensity score for various components of PFT

Intensity Score	Mechanical QC (Syringe Loops and D_LCO)	BioQC	Spirometry Test Performance	D_LCO Test Performance	Lung Volumes Test Performance
1	4	7	32	11	3
2	20	20	6	16	21
3	150	12	1	2	15
Mean Value	2.28	2.13	1.21	1.51	2.31

Table 4

Comparison of mean intensity training scores between U.S. and non-U.S PFLs

	US	Non-US
Syringe QC	2.04	2.28
BioQC	2.04	2.13
Spirometry	1.10	1.21
D_LCO	1.24	1.51
Lung Volumes	2.14	2.31
D_LCO Simulation failure rate	26%	46%

Despite stated adherence to ATS/ERS standards and guidelines, the PFLs in this study demonstrated a failure rate of 26% and 46% for the U.S and non-U.S. sites respectively for the initial D_LCO simulation study during on-site training. Data recorded from the D_LCO device under patient testing were compared to the target values generated by the simulator. Devices were considered in control if within ±10% of target values. The failure rate was associated with equipment malfunction and inaccurate test gas concentrations. Equipment malfunction included lack of routine maintenance such as changing gas conditioning parts, gas analyzers, and volume measuring devices. Review of routine maintenance by PF staff was noted as a training need due to the high failure rate and was shared with equipment manufacturers. Each manufacturer included D_LCO test gas specifications in percentage based on the specific type of equipment used. The concentrations required varied based on the specific manufacturer. Either the specifications were not followed or the gas supplied was not of sufficient accuracy for carbon monoxide and the tracer gas. One site had the tank independently analyzed and found the gas was not mixed properly despite a certificate of analysis verifying tank concentrations.

Discussion

The intensity of training required at each site exceeded initial trainers' expectations for adherence to and understanding of test performance and quality control methods. Sites lacked a thorough understanding of how to interpret spirometry, D_LCO measurement and lung volumes for acceptability and repeatability criteria. Many PFLs did not understand or perform any type of equipment quality control. The understanding of acceptable biologic control testing was limited. This occurred despite the PFLs employment of credentialed practitioners and indicating on the qualifications questionnaire that ATS/ERS standards and guidelines were followed. The subsequent review of test quality from these laboratories revealed a significant gap between what staff stated occurred in the PFL compared to the actual trainer evaluation. The evaluation was based on a comparison of test and QC performance expectations based on the ATS/ERS standards and guidelines and the ATS Pulmonary Function Laboratory Management and Procedure Manual and actual observed performance. Based on previous survey results in an abstract presented at the 2007 European Respiratory Society in Stockholm, Sweden and this study, it is apparent that quality control methods, performance, and appropriate trouble shooting actions are lacking in many laboratories. The ability to evaluate and respond appropriately to equipment malfunction is essential to reliable test results. Basic understanding of equipment maintenance and troubleshooting, particularly as related to D_LCO measurements, was lacking as evidenced by the D_LCO simulation study failure rate. Although the failure rate was associated with equipment malfunction, an understanding of basic equipment maintenance and prevention would have substantially decreased the failure rate. The use of basic QC methods as recommended by ATS would also have identified and resolved major equipment malfunctions. An interesting finding was the comparison of training needs between U.S. and non-U.S. PFLs. The training needs and intensity of training were nearly identical. The challenges related to education, training, and adherence to practice standards appears to be a global challenge.

In the absence of regulatory requirements, PFLs must voluntarily review their quality control methods on a continuous basis. An evaluation and subsequent revision of the portion of respiratory care program curriculums related to these deficiencies may also be useful.

Test performance methods used in the PFLs appear to adhere to ATS/ERS standards and guidelines primarily for spirometry, but more intense training was required for D_LCO measurements and lung volumes. The weakest area for the majority of sites appears to be performance of lung volumes by whole body plethysmography. Most laboratories did not adequately understand acceptability and repeatability criteria for spirometry, D_LCO measurements, and lung volumes by plethysmography. A checklist was provided to each PFL and reviewed in detail. In addition, tests were reviewed post-training to evaluate adherence to the checklist. Trainers also noted that sites had difficulty calculating the variability between functional residual capacity (FRC) trials. The 2005 ATS/ERS standards and guidelines state that the within-test variability for FRC trials cannot exceed 5%. Acceptable FRC results are averaged and variability calculated. [3] Calculation of variability of any parameter in the PFL is a basic required skill. There may be a lag between the publication of the 2005 guidelines for lung volume measurements and adherence by the PFLs. However, the AARC and ATS have had previous documents available for several years to provide guidance.

The PFLs in this study had been preselected based on type of PF equipment, software and listed qualified staff. One would expect a bias towards less versus more intense training. This study indicates a significant gap between what PFLs report as adherence to minimum standards and actual performance in a subset of sites deemed to be at a higher level initially. These gaps in learning reflect a need for improved education in respiratory care programs, advanced courses, and continuing education to maintain minimum standard of practice in adherence to current guidelines. Once MannKind, Corporation completed staff trainings, all sites began weekly monitoring by an independent company staffed by registered respiratory therapists and pulmonary function technologists to assess adherence to quality control expectations and PFT performance quality standards on subjects during the course of this study. Technical support and additional education were available to all sites by the MannKind Corporation and two additional companies monitoring the study (TechEd Consultants, Mason, MI, provided all the centralized review of biologic and mechanical quality control while MedGraphics, Inc, St. Paul, MN, provided administrative support and oversight of the comprehensive pulmonary function data base). All companies contracted for the study employed RPFTs for technical support. In addition, all of the authors were available to provide technical support to the PFLs post-training. Specific attention was given to the areas of need identified in the study.

All respiratory care education programs should have the ATS/ERS standards and guidelines and the 2005 American Thoracic Society and European Respiratory Society standards readily available as primary reading material in curricula.[2] These documents clearly outline minimum requirements for test quality and quality control Competence in quality control methods and test performance is required to maintain reliable test results. Additional formal continuing education by an outside source is highly recommended by the ATS/ERS and should be available in the Untied States as in Europe. Continuing education could be provided by respiratory care programs, manufacturers, professional societies and other independent providers of education. Understanding the educational needs of PFLs will provide a format for improvement in university-based programs, continuing education, and accreditation programs. This study also suggests that data collected without sufficient quality control measures in place and on-site evaluation by well trained personnel with full understanding of ATS/ERS test quality recommendations may provide questionable results for both patient care and clinical trials. Errors in testing translate into misdiagnosis and inappropriate treatment interventions. Respiratory care educators can influence the validity of PF test results by understanding the educational needs in PFLs and better preparing students to work in this specialty area. It is likely that the gaps in practice also impact the clinical experiences that students may be exposed to outside the classroom. This has additional potential to perpetuate the practice gaps in future therapists if they are not recognized and addressed by the respiratory care programs.

Further investigation should include an evaluation of the time required to move a PFL from suboptimal performance to a level consistent with current agency and clinical trial requirements. The time required to identify and remove barriers should also be considered. Correlation of these additional evaluations will further enhance our ability to define and correct deficiencies in educational protocols. Effective education and quality training are pivotal to assure valid test results used for clinical decision making.

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Respiratory Care Education Annual
Volume 17, Fall 2008, 23-33

Multiple Comparisons among Mechanical Lung Simulators Using Differences in Pre-and Post Scores of Allied Health Students

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Abstract

Background: Selection of the best instructional methods for teaching is fundamental to achieve desired outcomes of allied health educational programs. Little attention has been given this issue with respect to the literature in respiratory care education. **Purpose:** This study was designed to compare differences in allied health science students' pre- and post-test results when engaged in different methods of instructional delivery: (1) traditional lecture format, and (2) using lung simulations. **Method:** After completing a questionnaire, thirty-eight students were randomly selected and assigned to one of four groups and received instruction on mechanics of ventilation using traditional lecture format (Group 1), and laboratory instruction supplemented with demonstrations using the Medishield LS 122 lung simulator (Group 2); and Michigan Instrument TTL 2600i dual lung simulator using a desk top computer system with a DOS driven 2.2 version of Pneumo View© software (Group 3), and Group 4 received no instruction. **Analyses:** Differences computed for pre- and post-test scores were 4.5 for Group 1, 5.0 for Group 2, 0.75 for Group 3, and 1.18 for Group 4. A one-way ANOVA was used to analyze the data and to compare differences in means between pre- and post-test of group scores ($p \leq 0.05$). To determine which of the group's test scores was significantly different from the others, multiple comparisons in pre-and post-test means were conducted using the least difference analysis. **Results:** The results indicated that Group 1 and Group 2 scored significantly higher than Group 3 and Group 4 on the post-test ($p = 0.009$). Results of the post hoc analysis indicated a statistical significant difference ($p = .015$) among group scores similar to that observed in results from the ANOVA. **Conclusion:** Contrary to reports in the literature, use of highly technological resources in instructional delivery is not essential for effective instruction. Findings of this study indicate that students benefited equally from instruction given by lecture or use of the Medishield LS 122 lung simulator. Use of the TTL 2600i lung simulator and desktop computer contributed least to differences in pre- and post-test results when used in the initial introduction to respiratory mechanics. The initial phase of teaching mechanics of ventilation might be better served when introduced using a combination lecture complemented by laboratory demonstrations using a simple lung simulator model.

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Multiple Comparisons among Mechanical Lung Simulators Using Differences in Pre-and Post Scores of Allied Health Students

Background

An important goal for allied health programs is to provide effective instruction and reliable evaluation techniques for measuring student performance. Innovations in technology are forcing instructors to rethink teaching strategies. Compared to other health professions, [1-13] little, if any, investigation has been conducted comparing methods of instructional delivery in respiratory care education. There is a presumption that technology, when appropriately used, increases student achievement. From the time computers were first used in the classroom, investigators have attempted to evaluate the use of educational technology to determine if its use has a significant and reliable impact on student achievement.[2, 6, 7] Programs across the U.S. are developing and implementing technology plans and investing in computers and other newer technologies. Searching for an answer, researchers are realizing that technology cannot be treated as a single independent variable, and that student achievement is gauged not only by how well students perform on standardized tests, but also by students' ability to use higher order thinking skills (e.g., thinking critically, analyzing, making inferences, and solving problems). [1]

In using technology for educational purposes, four major assumptions are made regarding its use to improve learning: (1) technology can be used as a tutor, (e.g.,drill and practice software, tutoring systems, instructional television, computer-assisted instruction, and intelligent computer-assisted instruction); (2) technology can allow a means to explore (e.g.,CD- ROM encyclopedias, hypermedia stacks, network search tools, and microcomputer-based laboratories); (3) technology can be a tool to create, compose, store and analyze data (e.g.,word processing and spreadsheet software, database management programs, graphic software, desktop publishing systems, hypermedia, network search tools, and videotape recordings and editing equipment); and (4) technology can be a means to communicate with others (e.g., electronic mail, interactive distance learning through satellite systems, computer modem, and cable links).[6]

The value of technology may be conceptualized as the extent to which the tools, techniques, and applications of technology can support integrated inquiry-based learning. The idea of technology as media can be categorized with four different focuses: (1) media for inquiry (such as modeling, spreadsheets, access to online databases, access online observatories, and microscopes, and hypertext), (2) media for communication (such as word processing, e-mail synchronous conferencing graphics, software, simulations and tutorials), (3) media for construction (such as robotics, computer aided design, and control systems) and (4) media for expression (such as interactive video, animation software, and music composition).[7] Likewise, the use of technology is increasing in healthcare education and training to teach and evaluate providers. Previous studies indicate that teaching and training simulation exercises can be effective in determining performance levels of providers.[8] In searching the literature, investigations involving comparisons among methods of instructional delivery in respiratory care education are sparse.[8-13]

A number of studies in respiratory care education examined the use of technology. Meyer (1993) investigated the use of literature reviews as a means of improving training of students in the non-technical aspects of respiratory care with an aim to improve the quality of the patient care experience.[14] Hagan (1996) examined whether peer-instructor conferences improved the quality of respiratory care student papers.[15] Shelledy, Valley, Murphy, and Carpenter (1997) compared the effects of content instruction, process instruction, computer-assisted instruction, and critical thinking ability on student performance on a written latent-image clinical simulation problem.[16] They found significant improvement associated with student understanding of the exam process and students' information gathering scores, while content knowledge and computer assisted instruction improved decision making scores of students. In an evaluation of problem-based learning (PBL) as an educational method, Op't Holt (2000) reported that use of PBL demonstrated improved student performance on the National Board for Respiratory Care (NBRC) Entry Level examination.[17] In preparing baccalaureate level respiratory care students as care giver educators, Hoberty and Douce (2001) observed no difference in evaluation results of students who taught CPR in an educational methods course compared to the same of students who taught CPR to other allied health students.[18]

Purpose

This study was designed to evaluate different types of instructional formats when providing instruction to allied health students on mechanics of ventilation. The study compared students' pre- and post test results on this topic following each of the different instructional formats: (1) traditional lecture format, and (2) using two different laboratory lung simulators (Medishield LS 122©, and Michigan Instrument TTL 2600i©.).

Research question: When teaching mechanics of ventilation, does the method of instructional delivery influence student's comprehension as measured by pre- and post-test scores?

Methods

Validity of Instructional Content, and Pre and Post-Test. A table of specifications was developed (Table 1). Development of a table of task specification helps in forming content validity of test.[20] Specific tasks relative to mechanics of ventilation were derived from the content outline of the Certification Examination for Respiratory Therapist (CRT) published by National Board for Respiratory Care, (NBRC) Inc.[19] The table of specifications has two dimensions. One dimension lists the content areas, and the other lists the levels of cognition assigned the content area and number of test items for each. The levels of the cognitive domain on the content outline are recall, application and analysis.[19] The content and test questions were developed to correspond with the form and content of that in respiratory care textbooks to develop a Microsoft PowerPoint presentation on mechanics of ventilation.[21-25] The table of task specifications was the blueprint used for developing the lesson plan, in PowerPoint form, and pre- and post-tests. The pre- and post-tests consisted of the same test items, the determination of an acceptable correlation coefficient was required.[20] To improve "parallel form reliability" between the tests, the same items were used for both test, but items were placed in different order.[20] To ensure content validity, four Cardiopulmonary Science educators reviewed and judged whether the lesson

Table 1
Task Specifications

	Pre- and Post-Test		
Content Area	Number of items		
	Recall	**Application**	**Analysis**
1. Monitor, determine, and record respiratory mechanics:			
A. Peak inspiratory pressure	1	1	
B. Plateau pressure	1		
C. Positive end expiratory pressure	1		
D. Airway resistance	2	1	
2. Collect, review evaluate/interpret pertinent respiratory mechanics data on:			
A. Peak airway pressure		1	
B. Plateau pressure		1	1
C. Airway resistance			1
3. Evaluate/interpret clinical information and determine pathophysiologic state of a patient's condition:			
A. Normal and noncompliant lung and thorax			1
B. Normal and abnormal airway caliber	1		1
C. Increased secretions	2	1	
D. Bronchospasm		1	
E. Accumulation of alveolar fluid	2		
Total	10	6	4

Levels of Cognition:
R = Recall
Ap = application
An = Analysis

plans and test questions were relevant, representative, and matched the table of specifications. Revisions were made until all evaluators were in an agreement.[20] The content in the lesson plan and tests were judge valid to the degree that they matched the table specifications. Content relative to the table specifications, lesson plan, and test items included an introduction to principles of mechanics of ventilation that included defining, calculating, measuring, and interpreting airway resistance, dynamic, and static and dynamic lung compliance. [19, 21-25]

Table 2
Distribution of the Number of Students in Treatment Groups by Academic Major

	Health Care Management	**Health Information Management**	**Health Science**	**Occupational Therapy**	**Respiratory Therapy**
Group					
Group 1					
Lecture	1	1	2	2	4
Group 2					
LS 122	2	1	2	2	2
Group 3					
TTL 2600i	2	1	1	2	2
Group 4					
Control	2	1	2	2	2

Subjects

A survey was developed and used to identify, obtain consent, and exclude students who may have prior respiratory care (RC) education and/or experience. To avoid introducing bias into the study, students who failed to complete all sections of the survey or had prior background in RC education were excluded (See Appendix A). Of sixty-one students who completed surveys, thirty-eight consented to participate and were randomly selected and assigned to one of four groups. Data collected from the surveys were used to derive descriptive statistics presented in Tables 2 and 3.

Subjects in this study were students enrolled in the first or second semester of baccalaureate level studies in allied health programs that included cardiopulmonary science, occu-

Table 3
Descriptive Statistics by Treatment Group

Group	**n**	**X Age**	**X GPA**	**X Pre-Test Score**	**X Post-Test Score**	**X Test Difference**
Group 1						
Lecture	10	22.5	2.82	6.40	10.9	4.50
Group 2						
LS 122	9	22.3	2.90	4.66	9.67	5.00
Group 3						
TTL 2600i	8	23.2	2.62	7.12	7.87	0.750
Group 4						
Control	10	22.0	2.58	4.36	5.54	1.18

pational therapy, health science, health information management, and health care management. None of the participants had more than two semesters of anatomy and physiology. This study was conducted the second week of the first semester of the Cardiopulmonary Science Program so that these students had no advantage over any of the other participants.

From results obtained from stepwise regression, Johnson reported that grade point average (GPA) of graduates of RC programs contributed 11.4% to variation in the mean of raw scores of NBRC Entry-Level Certification Examination.[26, 27] Student t test on participant's GPA from each instructional group were conducted to determine whether statistical differences existed among groups. It was presumed that students' academic ability would be an important variable that could also have an inadvertent effect on result and outcome.[26-29]

Procedures

The mechanical lung simulators and portable volume ventilator were calibrated according to manufacturer specifications. Students were taught selected topics in mechanics of ventilation using (1) traditional lecture format and with laboratory instruction supplemented by demonstrations using the Medishield LS 122 © lung simulator or (3) Michigan Instrument TTL 2600i © dual lung simulator using a desk top computer system with DOS driven 2.2 version of Pneumo View© software. Prior to instruction, a pre-test was administered to all participants. Following the pre-test, Group 1 was given a traditional lecture on selected topics in mechanics of ventilation. Group 2 received a laboratory recitation accompanied by topic related demonstrations using the LS 122 lung simulator. Group 2 obtained numerical data from the pressure gauge and volume scale of the simulator. Group 3 was given a laboratory recitation modified to coincide with the TTL lung simulator and desktop computer and obtained numerical data from the screen of the computer monitor connected to the TTL dual simulator. Breaths delivered by the volume ventilator were identical in volume (0.5 L), rate (10 BPM) and inspiratory flow rate (40 LPM). The simulators were manipulated augmenting normal and abnormal changes in airway resistance and lung compliance. Once the lecture and laboratory exercises were completed, a post-test was administered. Participants in the control group received no treatment and also completed a post-test.

Table 4

Results of One-way Analysis of Variance Comparing Differences Between Pre- and Post-Test Scores of Treatment Groups

	Sum of Squares	***df***	***X Square***	***F***	***p***
Between Groups	138.077	3	46.026	4.504	0.009*
Within Groups	357.667	35	10.219		
Total	495.74438				

Denotes $p \leq 0.5$

Table 5
Results of Multiple Comparison Between Treatment Groups Using Least Significant Difference Analysis

Treatment Type	Treatment Type	X Difference	Standard Error	p
Group 1 Lecture	**Group 2** LS 122	-.5000	1.468	0.736
	Group 3 TTL 2600i	3.750*	1.516	0.018
	Group 4 Control	3.333*	1.368	0.020
Group 2 LS 122	**Group 3** TTL 2600i	4.250*	1.553	0.010
	Group 4 Control	3.833*	1.409	0.010

* *denotes* $p < 0.5$

Analyses and Results

There were no statistical significant differences among the participant's grade point average (GPA) so there was little concern about the effect GPA may have on study outcomes. SPSS© version 11.0 was used in conducting sampling and statistical procedures. For internal consistency of the tests, [20] the K-R 21 analysis yielded an *r* value of -0.031 for the pre-test and 0.61 (moderate) for the post-test. To test for consistency between the pre- and post-test, an alpha coefficient was calculated. The alpha coefficient for differences between the mean of the pre and post-test scores was 0.58 (moderate). Results of paired t-test analysis indicated that the pre-test scores were significantly less than those of the post-test (p = 0.009). Results of test scores were entered into SPSS 11.0 version data editor. Differences in group pre- and post-test scores are provided in Table 4. Results of one-way ANOVA indicated significant difference in the mean difference in pre- and post-test scores between groups (p = 0.015). Results from ANOVA are presented in Table 4. Test for homogeneity indicated that variance approached a level of significance (p = 0.07). For post hoc analysis, the least significant mean difference analysis was performed to determine which of the four treatment groups contributed to differences in pre- and post-test scores. Results of the significant mean difference analysis are presented in Table 5.

Discussion

An assumption an educator may make would be to think that instructional delivery using sophisticated educational technology would yield the best student test performance, however such was not the case for results observed in this study. A number of confounding variables may have inadvertently affected the outcomes of this study. Differences in pre-and post-test scores reported in this study could have been influenced by the selected topics presented in the study may not have been relevant to students enrolled in other disciplines other than Cardiopulmonary Science. Diversity among individual backgrounds and learning styles of students, differences in levels of academic preparation, students inundated with too much information may have been negatively impacted students scores. Some students may not have had the technical savvy or skills needed to perform the tasks specified in this study. Test anxiety is another factor that can inadvertently influence test performance. Research indicates content inappropriate to students' level of preparation or to much information delivered in an appropriated allotted time contributes to student anxiety and poor test performance.[20]

Students from disciplines outside of Cardiopulmonary Science were brought into an unfamiliar environment and taught by a teacher unfamiliar to the participants. Another consideration was that sampling might have been bias due to convenience sampling. The author admits that these confounding variables are valid concerns and should be controlled providing the practicality and availability of resources.

The restricted representations of the student population and the study results have limited generalization for other student groups and academic disciplines. Results of statistical analyses indicated that there were no significant difference between means of pre- and post-test scores of students taught by the lecture format (Group 1) and those taught using the LS 122 simulator (Group 2). Means of pre- and post-test scores for students who received both the lecture format (Group 1) and LS 122 lung simulator (Group 2) were statistically higher than scores of the TTL 2600i© lung simulator (Group 3). The control (Group 4), as expected, had the least difference in mean pre-and post-test scores. The implications of these findings are contrary to the idea that use of sophisticated educational technology will provide better student achievement. [6, 7]

Conclusion

Contrary to the literature reviewed in this report, use of highly technological resources in instructional delivery is not essential to effective teaching and higher student test scores. Findings from this study suggest that an introductory course on mechanics of ventilation may yield better results when lecture is accompanied by laboratory demonstrations using a simple mechanical lung simulator. Instructional plans for achieving successful outcomes should be logically sequenced based on the degree of complexity of the content being taught, level of prior knowledge, and educational experiences of the learner. This study should be replicated with a larger sample size and controlling for learning styles of group participants.

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Appendix A
RESEARCH QUESTIONNAIRE

I am conducting educational research titled "A Comparison Between Methods of Teaching Respiratory Mechanics" and request voluntary participation by students enrolled in programs in the School of Allied Health Science. It will take approximately 2 ½ hrs of your time to complete the study. The study is designed to compare test results of students prior to and after experiencing two different instructional methods: (1) traditional lecture format (1½ hrs), and (2) the application of one of two different lung simulators. (1 hour). Students selected as the control group will take the pre and post-tests only. The time allotted includes testing. The research question: Is there a difference in results of students test performance after experiencing different instructional methods?

The project will include students enrolled in their first year of study in the professional level of an Allied Health Program at _____________. To be eligible to participate, you must have taken at least one course of human anatomy and physiology. Persons who have experience in monitoring mechanical ventilation are not eligible to participate in the study. Students will be assigned to one of three groups.

The tests have been developed to measure comprehension and application of knowledge specific to the content presented in lecture and laboratory settings. The test format is 20 multiple-choice questions. Individual test scores will be kept confidential. Only mean average group scores will be reported. Students interested in participating in this study must complete and sign the section below.

Please provide the following information:

1. Age ___ Gender ___ Classification ___ (Soph, Jr, Sr) Overall GPA ____
2. What is your major? _________________________
3. What semester of your program of study are you enrolled? _______

Check one from each of the following:

Yes	*No*	
❑	❑	I have had work experience or taken course (s) in monitoring mechanical ventilation.
❑	❑	I have taken a minimum of 3 semester credit hrs of human anatomy and physiology.
❑	❑	I understand that my decision to participate or decision not to participate will not effect my grade (s).

_______________________________ _____________________________ ________

Print name Signature Date

Respiratory Care Education Annual
Volume 17, Fall 2008, 35-46

Overview of Concept Mapping and V Diagrams as Effective Heuristic Devices in Respiratory Care Education

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Introduction

Teaching with the traditional lecture format in the allied health classroom may be promoting passive learning. Passive learning occurs when the teacher provides instruction while the student takes notes, or the students are provided a complete set of teacher generated notes, and are unengaged. Use of lecture format can overemphasize verbatim information, encourage rote memorization, and limit teachers' effort to ensure students are learning the presented material[1]. Classroom strategies such as open-book tests, reference to material that will be tested, and in-class worksheets are examples of activities that are often can promote passive learning[1].

Replacing the traditional lecture with educational technology still does not ensure effective teaching. Presenters in today's classrooms commonly employ computer generated slides to present their lecture. These slides, however, are often too wordy and contain bulleted ideas that are unrelated to each other. Instructors often distribute copies of their computer-generated slides further encouraging students to be passive and not engaged in the learning process[2]. Furthermore, with these computer slide handouts, students may actually take little or no notes and fail to capture many of the ideas presented in the class[2].

Learning outcomes appear to be related to how material is presented and not the mode of delivery (e.g., overhead projector, computer generated slides, white board)[3]. Thus, the use of traditional lecture without engaging the student by questioning, discussion, and probing understanding, may actually discourage the respiratory care student from learning complicated subject matter.

This paper presents alternative methods to encourage teacher-student interaction, self-learning, and metacognition. Metacognition is the learner's awareness of their learning and how best to understand course concepts. Metacognition is the deliberate connection of what the learner already knows to new incoming information. The more aware students are about what and how they are learning, the more connections can be made between new and existing information, resulting in deeper understanding of the material and greater retention [3].

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A strategy that encourages metacognition in the classroom is the use of heuristics. A heuristic device is a learning tool that enhances learning and improves conceptualization[3]. This paper reviews two such devices: concept mapping and V diagrams.

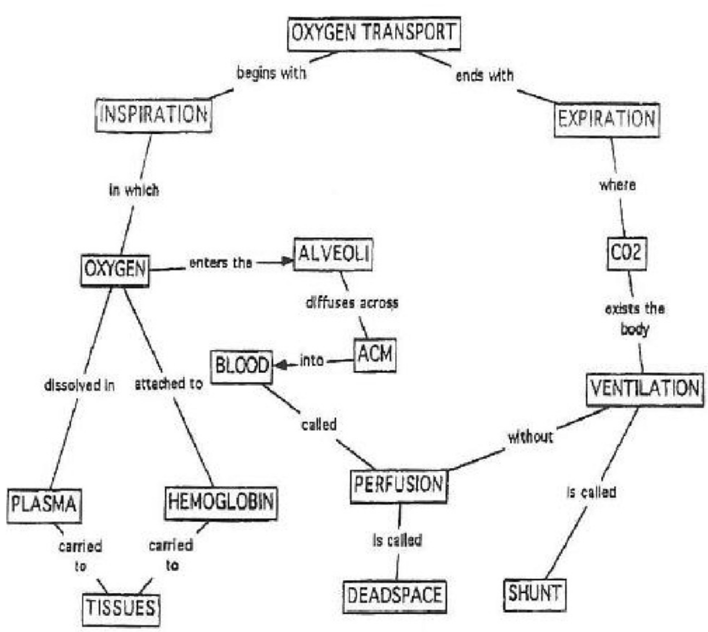
Concept Maps

Concept maps are visual representations of knowledge[4]. According to constructivist teachings, knowledge is built or constructed from our prior knowledge through interaction with objects, people, nature, and opportunities for learning. Furthermore, each person constructs a slightly different meaning from the same experience[5]. Concept maps created by students can illustrate their knowledge and understanding about a topic. As students are educated, they should move from simplistic ideas to the more complex ideas. Instructors hope learners will eventually demonstrate an understanding that reflects what experts believe to be true about the topic. Concept maps allow educators to evaluate where learners are in the process of acquiring a particular concept or understanding of a new construct. Concept maps are also particularly helpful for instructors to detect student's alternative conceptions[6]. An alternative conception, frequently referred to as a misconception, is a set of ideas about an object or event that is at odds or inconsistent with current accepted theory or explanation. Students frequently hold alternative conceptions that can be tenacious and difficult to alter. Concept mapping allows alternative conceptions to be identified and hopefully corrected by the instructor.

Concept mapping begins with a proposition. A proposition is several concepts connected by a linking word, usually a verb or preposition. For example in Figure 1, "oxygen transport"

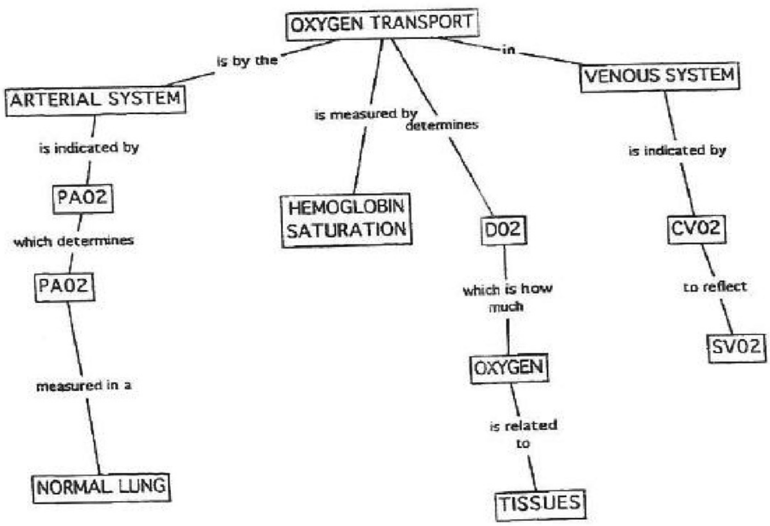
Figure 1

Expert's Concept Map on Oxygen Transport



is the main concept whereas "Inspiration and expiration" are related concepts. The two concepts are linked to the main idea to create a proposition. In a concept map, the most important idea or subject of the map is placed at top center. From this main concept, other concepts radiate in a hierarchical fashion going from general to more specific. The bottom-most concepts are usually examples and elaborations. The more intricate the map, the more expanded and differentiated is the knowledge of the learner. Although Figure 1 is a map constructed by an expert, a student-created map can quickly provide the instructor with a graphic representation of what the student understands. The authors have effectively used student-generated concept mapping as a tool to promote students' metacognition and for assessing understanding. Figure 2 is a student-generated map illustrating several alternative conceptions. This map demonstrates the student's belief that oxygen transport is reflected by hemoglobin saturation and likewise oxygen content of venous blood is reflected in mixed venous oxygen saturation. Once the alternative conceptions are identified on the student map, they can be corrected with remediation.

Figure 2
Student's Concept Map on Oxygen Transport



Theoretical Background

Concept maps were developed by Novak in the early 1970s, but not fully described until Novak and Gowin wrote about concept mapping in their landmark book, *Learning How to Learn*[7]. The underpinning theory driving concept mapping was David Ausubel's theory of meaningful learning. In this theory, Ausubel differentiated learning into discovery and receptive learning[8]. Discovery learning is where content is not given to the student but must be discovered by the learner. Receptive learning is presented to the student in its final form.

Either receptive or discovery learning can be meaningful according to Ausubel. Most education is receptive because it is efficient and less labor intensive. Ausubel's theory also differentiates between rote memorization and meaningful learning. Meaningful learning requires the learner to actively make connections between what they already know and what they need to learn. Without robustly incorporating new information into the learner's cognitive structure, it is not available for solving problems and critical thinking. Memorized information is often isolated, unconnected, and easily forgotten. Students are able to learn meaningfully, but may revert to rote memorization when they fail to understand the learning task or lack the prior knowledge needed for anchoring it.

In order for meaningful learning to occur, three conditions must be met. First, the information must be potentially meaningful. In other words, it cannot be nonsense; it must be organized, presented well, and relevant. Second, students must be inclined or motivated to learn meaningfully. They have to be willing to put forth the required effort. Most importantly, they must anchor new ideas to other relevant ones in their cognitive structure. Without a well-developed, integrated body of knowledge to which to attach the new information, students will fail to understand the new material well enough for it to be meaningful to them.

One of the greatest challenges for teachers is to motivate students to put forth the effort to learn meaningfully. Initially, concept mapping can be challenging for students. However, teachers can demonstrate and model how to map and show the advantages of using this heuristic, thus recruiting student's willingness to create maps. The authors have found with practice and encouragement, students can create reliable concept maps and learn to appreciate this form of learning. Group work may provide interpersonal interactions that some learners find appealing or may provide peer pressure to work diligently on their map. Learners should be introduced to concept mapping in way that imparts success. Learners are much more likely to put forth effort where they know they can be successful.

According to Ausubel, the principal way for information to be added to our cognitive structure is by subsumption or incorporating new information with existing information which is anchored in long-term memory[9]. These ideas can be new examples of concepts already learned or elaborations and modifications to those concepts. The interaction between the new and previously learned information can change the learner's understanding of the original concept. Ausubel's theory of learning provides a rationale for the use of concept maps as a teaching tool. The teacher can visualize students' cognitive thought processes by the evidence of the concept maps they create. Furthermore, the act of creating a map is an active learning strategy because it involves the student to engage new incoming information from lecture, laboratory, or demonstration. Instead of simply recording information, the student must make sense of it, connect it to other ideas, and think about it more deeply.

Concept mapping plays a major role in promoting student metacognition. As previously stated, metacognition is awareness of one's own thinking-learning process (e.g., knowing what knowledge or understanding one has gained and what is left to learn). It is the ability to control one's own learning through awareness of what is being learned and what yet needs to be learned. Metacognition also includes knowing what learning strategies work best for oneself and when to use them[10].

Table 1

Benefits of Teaching Concept Mapping to Your Students

- Promotes meaningful learning
- Fits with constructivism
- Promotes metacognition
- Evokes prior knowledge
- Identifies alternative conceptions
- Presents the "big picture"
- Prioritizes learning tasks
- Communicates complexity and nonlinear relationships

Teaching Concept Mapping

There are a number of benefits associated with teaching students concept mapping (Table 1). There are several approaches for teaching the creation of maps. One method many educators have found to be effective is to begin by partially structuring the process for the students[4,6,7]. The teacher provides the superordinate concept to be placed at the top of the map. This topic should be familiar to the student and focused on a question that clearly indicates the learning task[4]. Then 10-12 subordinate concepts are provided by the instructor. The students write each concept on a separate sticky note or index card. Next, students arrange these concepts from most general at the top to the more specific as mapping develops downward. Once the students are satisfied with the arrangement, they connect the concepts with lines labeled with linking words (verbs, prepositions, prepositional phrases) that characterize the relationship among concepts. Every line is labeled. Parts of the map can cross link to another part to demonstrate further understanding and differentiation. Examples can be added to the concepts and "e.g." used as the linking word. It is recommended that examples and crosslinks be written in dashed lines to distinguish them from concepts and other propositions. Lastly, the students should review the maps they made to ensure they reflect their understanding, and then redraw the map on paper[6].

Caputi and Black recommended teaching concept maps to nursing students by first providing them with a completed map without linking words. Students could then choose their own linking words or from a list of possible linking words supplied by the instructor (11). Another approach was to provide a map with selected concepts removed and having the students fill them in to complete the map.

Students can also make concept maps using computer software. Cmap Tools is available for free downloading from http://cmap.ihmc.us and was developed at the Institute for Human and Machine Cognition. Another widely used software is a relatively inexpensive product called Inspiration. A free 30-day download can be found at www.inspiration.com/home.cfm. Maps are never really completed, but should be revised frequently as new understanding and information modify the concepts. These computer programs make this process particularly easy and effective. With computer programs, concept maps can include multimedia with the incorporation of pictures, graphs, videos, and other visuals, as well as words. Furthermore, these programs can facilitate collaboration and exchange of ideas among learners in the classroom and at great distances[4].

Concept maps can also be constructed as a whole class project using a projector or within small groups. Once students understand the process and gain skill, their concepts maps can be shared and used for studying.

When concept mapping is implemented, some students will be somewhat resistant to using this heuristic device. Many high performing students have succeeded in school by memorizing information. A few are unwilling to change what has worked for them previously. Other learners are linear thinkers and find it difficult to adjust to concept mapping. Some students are simply unwilling to put forth the effort required. Novak and Canas stated that it may take one to two years for students to become proficient at creating concept maps. The authors have found with sufficient instruction and practice, many students can become successful creators of concept maps within a semester.

Assigning a Grade or Score to Concept Maps

Various methods have been described in the literature for quantifying the quality of students' concept maps, all of which tend to be subjective and even arbitrary[6,7,11,12]. Novak and Gowin proposed that maps be scored by assigning points for valid relationships, hierarchy, crosslinks, and examples. Because the levels of hierarchy indicate progressive differentiation of concepts, Novak and Gowin suggested counting the number of concepts that were mapped and assign a point value to each concept while examples should count the least[7].

Trowbridge and Wandersee published a checklist of items to consider when evaluating a map of 10-12 linked concepts. They included a scoring rubric assigning points to the map. For example, meaningful propositions received one or two points based on their precision while each level of hierarchy was assigned five points. Significant, valid crosslinks scored 10 points whereas examples only received one point each[6].

West, Park, Pomeroy, and Sandoval compared two scoring systems, structural and relational methods, to measure conceptual development in pediatric medical residents. The structural method weighted concepts, hierarchy, and crosslinks similarly to Trowbridge and Wandersee while the relational method measured the quality or importance of each proposition without taking the overall structure into account[6]. These researchers found the structural method to be more accurate when assessing changes in the residents' cognitive structures after instruction or based on level of the residents' experience. They found scoring maps structurally better demonstrated the residents' progress from novice to expert[12].

McClure, Sonak, and Suen reported on the use of the relational model for scoring maps. In the relational method, each proposition was rated separately and scored from one to three points. All points were totaled for a final score. They also compared student maps holistically to a master map created by an expert[13]. Novak and Canas have also used the master map comparison method. There is a feature in Cmap Tools software which allows comparison of student maps to an expert map[4].

Caputi and Black recommended developing a scoring rubric to grade student concept maps[11]. Scoring rubrics were described by Britton and Wissing in this journal and are applicable to a wide range of subjective assignments. Rubrics ensure consistency among faculty when more than one is grading a student's map. Furthermore, they promote reliability and validity to the scoring method[14].

Other Applications of Concept Maps

Besides enhancing and evaluating student learning, concept maps may be used in a number of other ways. For example, concept maps can be applied to designing and coordinating curriculum By mapping each course's content, then connecting all the maps, faculty can easily find gaps and overlaps in content. The essential information required by accrediting agencies to be taught could be demonstrated more effectively using a concept map compared to a typical table[4].

Mapping content can also help to integrate and bridge disciplines. Hoffman, Trott and Neely used online software to make a multimedia concept map for teaching women's health to medical students. Their map was created so students could take the information and apply it over a variety of clinical settings. Their purpose was to emphasize the interdisciplinary nature of women's health and the wide range of "normal"[15]. Similarly, Weiss and Levison used concept mapping to develop a case-based curriculum for teaching women's health in medical school. Concept maps of the content were the basis for developing curriculum goals and learning objectives[16].

Nursing has applied concept mapping to teaching students how to plan patient care. For example, Hinck et al. used concept mapping to demonstrate the key concepts involved in planning nursing care in the community. They found concept mapping care plans significantly improved students' ability to more effectively organize care, evaluate what further information was needed, and demonstrate interactions among the social, cultural, and health issues of their patients[17]. Furthermore, the maps could make the relationship between theory and practice clearer to students. Caputi and Black reviewed this idea in detail[11].

Concept mapping has been shown to be an effective tool to promote metacognition in the science classroom. Students who master the art of creating maps can, while working with the teacher, often correct their alternative conceptions with the additional instruction or remediation.

V diagrams

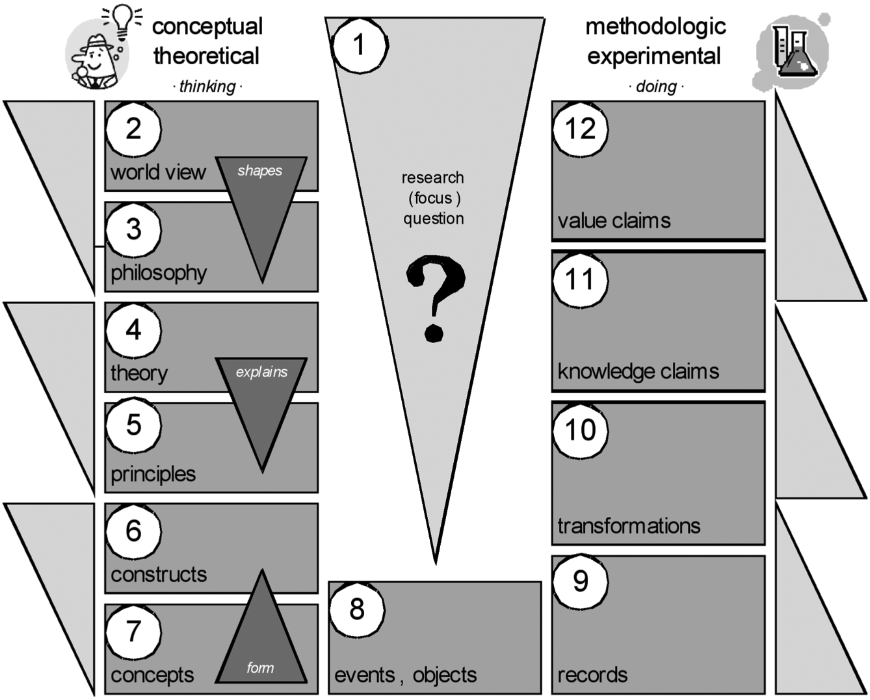
Like concept mapping, V diagramming is a metacognitive procedure that provides the learner with a framework for organizing information and resolving complex problems[7,18,19]. A V diagram is a schematic that identifies a central focus question, and documents factors that motivate or define the question, as well as procedures that are used to answer the question. As an instructional tool, the V diagram may be utilized in several ways. For example, V diagramming may aid students' ability to comprehend scientific writing and to evaluate texts critically[20]. Additionally, V diagrams have been used in the allied health professions to enhance and evaluate clinical procedures, to guide the design of research projects, and to foster ethical problem solving[20,21,22].

Overview

As presented by Gowin and Alvarez[18], the V diagram consists of 12 elements that correspond to the scientific method. The schematic presented in figure 3 identifies these key elements, as well as relationships among them. Although several adaptations of the V diagram have been developed[21,22,23], the general structural principles are invariant. Information of a conceptual or theoretical nature is always organized on the left side of the diagram, whereas

Figure 3

Schematic representation of the V diagram in relation to the scientific method.



methodologic and experimental variables are presented on the right side. These two major sections are separated by a V-shaped wedge that defines the purpose of the study or procedure. In addition, broad elements (i.e., those with widespread or abstract implications) are located toward the top of the page and details that are specific to the study (or procedure) are at the bottom of the diagram.

Gowin and Alvarez differentiate among 12 elements that define a typical V diagram[18]. These elements are identified in figure 3, beginning with the central V and moving counterclockwise around the schematic. These 12 elements are described briefly in this manuscript; however, more detailed descriptions have been published elsewhere[7,18].

Research (focus) question (1). A well-defined question is essential for successful inquiry[24]. The centrality of the question is reflected by its prominence on the V diagram. The question is motivated and defined by the elements on the left side of the diagram. In turn, the question will dictate the appropriateness of the procedures outlined on the right side of the diagram, as well as the implications of the findings.

World view (2). Ultimately, the value of a project or procedure is judged relative to the ideals and goals of a culture or society. The world view statement is intended to summarize generally accepted beliefs and social values that are germane to the area of study.

Philosophy (3). According to Novak, one's philosophy reflects beliefs about knowledge. Although individuals may agree on the goals of a society (i.e., the world view), they may differ in their philosophy concerning the best approach to achieve those goals. Philosophies are shaped by world views, and these factors combine to provide a rationale for the project and to motivate the central questions.[19]

Theory (4). A primary purpose of a theory is to provide a framework for explanation. Theory enables investigators to speculate as to why a given result was obtained. Theories also help to stimulate new ways of approaching old problems[18]. To quote Johnston [1983, pp. 56-57], '…theories are not mere amusement for scholars, nor the unfortunate burden of reason; they are powerfully practical tools that serve our clinical endeavors.[25]

Principles (5). Recurring patterns that describe relationships among concepts or events are recognized as principles. The identification of scientific principles is important because it enables one to make predictions, which can then be tested empirically. Principles may be interpreted relative to a theory, thus providing a framework for the project.

Constructs (6). According to Gowin and Alvarez, constructs are "conceptual creations that connect sets of concepts."[18]. Psychologists use the term construct to refer to conventionally recognized abstractions that distinguish among groups or individuals. Constructs may serve as a convenient grouping of related skills. For example, the construct aptitude is not directly observable, but it may be inferred on the basis of discrete (but presumably interrelated) abilities such as memory, vocabulary, abstract reasoning, etc.[26].

Concepts (7). Concepts are a perceived pattern or regularity in objects or events. Discrete concepts combine to form constructs and these relationships may, in turn, be explored using concept mapping[19]. The identification and exploration of relevant concepts and constructs should result in operational definitions, which are essential for scientific enquiry[24].

Events, objects (8). The scientific method dictates that procedural details and materials must be clearly specified[24]. Relevant events and objects are documented at the bottom of the V diagram to define the investigator's protocol and to enable evaluation of the project and replication.

Records (9). Objective quantitative or qualitative data are at the heart of the scientific process. The specific measurement procedures to be used are documented on the V diagram to help define methodology and to enable appraisal of reliability and validity of measurement.

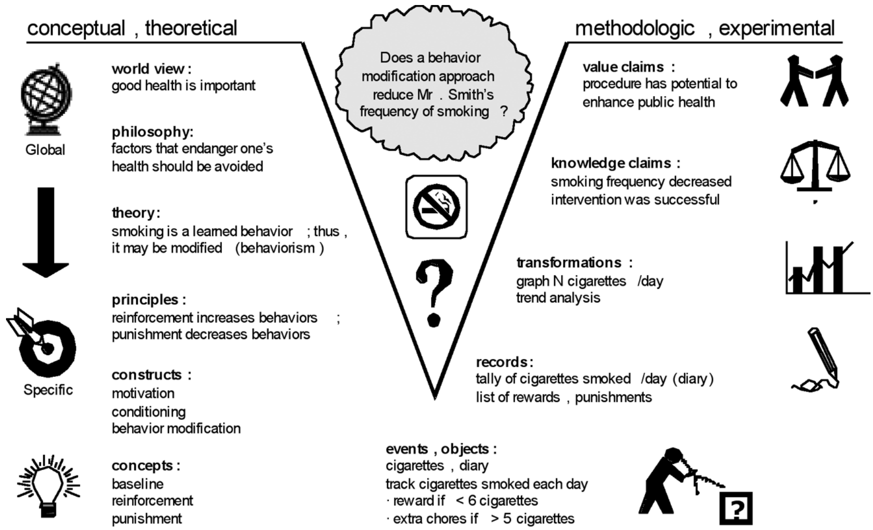
Transformations (10). Raw data must be organized and analyzed in order to answer the question posed in element 1. Analysis procedures may include tables, graphs, and diagrams, as well as statistical analyses or qualitative methods. These procedures will transform the data into a form that can be used to answer the original question.

Knowledge claims (11). Once the results of the study have been obtained, implications for the specific discipline (and for knowledge in general) should be explored. These implications are documented as knowledge claims on the V diagram.

Value claims (12). A well-designed project will have implications that extend beyond the specific conditions under study. In other words, findings are generalizable and their potential for addressing the goals of society should be considered and documented on the V diagram.

Figure 4

A V diagram for a hypothetical project designed to evaluate one type of behavior modification to reduce smoking.



An illustrative example

A completed V diagram is presented in figure 4. In this example, a hypothetical investigator seeks to evaluate the effectiveness of a behavior modification paradigm to reduce smoking. The research question is motivated by society's desire for good health and a related philosophy that one should avoid practices that may endanger one's health. The theoretical framework for this study is behaviorism, and the specified concepts, constructs, and principles are directly related to this theory. The proposed intervention entails rewards and punishment contingent upon a reduced level of smoking (operationally defined here as five or fewer cigarettes in a day). Mr. Smith will track smoking in a diary using tally marks, and the investigator will analyze these data by graphing the data and evaluating trends associated with the introduction of behavior modification[27]. If a successful outcome were obtained, then the procedure has implications for intervention with other individuals. Finally, if success is robust across individuals, then the procedure will be valued by society because its outcomes are consistent with the world view as specified in element 2.

Development of a V diagram is seldom a linear process. It may be easier for students to focus first on relatively concrete methodological details, identifying and defining concepts and constructs in the process. More abstract theoretical and philosophical elements may be difficult to discern in some cases. Accordingly, instructors may elect to modify or simplify the basic V diagram to accommodate students' needs and abilities.

The V diagram has heuristic value, providing a framework to enhance students' understanding of published research. Successful completion of a V diagram entails careful reading (comprehension in the sense of Bloom, Hastings, & Madaus, 1971), logical analysis, judgment, and attention to detail.[28] Technical writing may be complex and difficult for the reader to decipher. Accordingly, many students achieve only a superficial and partial understanding of such material. The V diagram framework encourages active reading and rewards the learner with a one-page distillation of the critical details of a study or project.

Conclusion

Clinical education entails the development of critical knowledge and skills. As the complexity and breadth of the discipline increases, instructors strive to maintain a balance between the coverage of facts and procedures and the development of critical thinking skills. In this paper, concept mapping and V diagramming are presented as two methods that provide a framework for logical thinking to promote meaningful learning. To borrow from Yeats, metacognitive tools may help us to shift our educational emphasis from the filling of buckets to the lighting of fires.

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Respiratory Care Education Annual
Volume 17, Fall 2008, 47-57

Factors Influencing Student Attrition in a Respiratory Therapy Program.

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Abstract

Student attrition in a respiratory therapy program can be attributed to various causes. Examples include academic rigor of the program, inefficient or ineffective study habits, conflicts between demands of college and personal life, and lack of financial backing. This five year study of a respiratory therapy education program in a single university in the Southeast U.S. evaluated the relationship between the two key reasons for attrition related to personal and academic issues and the demographic variables of race, gender, and age. Of the 81 students enrolled in the program between 2001 and 2006, 24 students withdrew from the program. The intent of this study was to determine why they chose to leave. Overall attrition was 31%, with 25% Caucasian students and 5% African American students. 100% of the male students (n=7) stated academic issues were the reason for withdrawing. Eight of the 17 female students held the same reason for withdrawing. The remaining nine female students sited personal reasons for leaving the program. The study results suggest that while there was no significant difference between the reasons for attrition based upon student's age or race, there was a significant difference when the reason for attrition between gender was evaluated.

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Factors Influencing Student Attrition in a Respiratory Therapy Program

Introduction

This study examined specific reasons for attrition of students in a Southeastern United States (U.S) respiratory therapy education program. Attrition, or its inverse, retention in allied healthcare programs, is and forever will be a concern among program and school officials along with the stakeholders in the program's host community. Stakeholders include (but are not limited to) the program's accrediting agency, the sponsor of the program, the student, the community's health system, and the allied health field at large.

The demand for allied healthcare practitioners is increasing as 'baby boomers' age and their increasing numbers challenge the capacity of the U.S. healthcare system.[1] To meet this increasing need for healthcare services, it is important that allied health programs retain and graduate a high percentage of their enrollees. These high retention rates should lead to an increase in the number of skilled professionals in the various allied health professions, thus meeting the needs of the aging in America.

Student attrition has been studied by other researchers in healthcare education. Andrews and coworkers evaluated disparity in several papers related to attrition in allied health education programs. They reported for physical therapy programs, attrition seldom exceeds 5%, while medical school attrition is documented at 17-19% and nursing school reaching levels of 20%.[2]

The results of this study, while limited to a specific region, may be transferable to other settings and might be useful in improving student retention in other respiratory therapy programs.

While a number of studies have been conducted on the retention of college students as a whole, there are limited studies on retention among students in allied healthcare fields. Shelledy, Dehm, and Padilla reported the average attrition rate for respiratory therapy programs ranges from 12.5% to 24%. [2]

It was estimated that approximately 85% of students leave college due to voluntary withdrawal. [3] Whether these students became disenfranchised and left due to personal reasons, or they are not prepared for the academic rigor of higher education, educators responsible for student success need information that explains attrition and facilitates improvement in student retention rates.

Respiratory therapy education programs strive to achieve an attrition rate below 30%, which would be considered an unacceptable attrition rate when compared to thresholds for most allied healthcare fields. The number of vacant respiratory therapy positions continues to increase. According to the U. S. Bureau of Labor and Statistics (2007), employment opportunity growth rate for respiratory therapy is much higher than the national average, with a proposed greater than 27% growth rate through the year 2014.[1]

To prepare for the increasing demand for respiratory therapy practitioners, respiratory therapy educators should be aware of the reasons why student choose to leave their program. In order to ensure the availability and quality of the respiratory therapy student graduate, an understanding of the problem and the development of plans to reduce attrition are needed within each respiratory therapy program. As program personnel become more aware of causes for attrition, innovative plans to reduce attrition and may contribute retention strategies to other respiratory therapy educational programs.

Purpose and Research Questions

The researchers set out to determine if student demographics were predictors of program completion for students entering this respiratory therapy education program, and were the reasons for attrition unique to this Southeastern respiratory therapy education program.

The study was guided by the primary research question:

1. Do student demographics (gender, type of student [traditional or nontraditional], and race) predict the student's likelihood of completing this Southeastern respiratory therapy education program?

Review of the Literature

The term 'allied health' describes a large cluster of health-related professionals that fulfill a variety of roles in the healthcare system. The Association of Schools of Allied Health Professions (ASAHP) defines allied health professional as an individual involved with the delivery of health or related services pertaining to the identification, evaluation and prevention of diseases and disorders."[4]

According to Arnson, attrition rates from allied health programs do not differ from attrition rates from other majors and programs. Rising attrition rates, for any given reason, appears to be consistent across all college majors and programs, including respiratory therapy students.[8]

The U.S. healthcare delivery system is relies on the availability of allied health professionals. Thus, various agencies accrediting for allied health programs have made student retention a priority. The Committee on Accreditation for Respiratory Care (CoARC) standards recommend respiratory therapy educational programs have less than 30% attrition when evaluated over a five to ten year period. Programs not meeting this standard may be at risk for losing their accreditation.[6] Respiratory therapy education programs nationwide appear to have attrition rates that are equal to or greater than other degree programs in allied health professions.[4-8, 11, 13-18] Respiratory therapy educators should monitor and determine any trends in the reasons why students do not complete their programs. Student retention and attrition studies suggest a number of reasons why students leave respiratory therapy education programs. [4,8,11,12, 13, 18]

These theories, some generalized to all college students, are useful when considering attrition and retention in allied health programs. The National Center for Education Statistics (NCES) found that first generation students, defined as students who were the first in their family to attend college, had family and background characteristics associated with attrition. First generation Black and Hispanic students were less likely to attend college within eight years of high school graduation.[9] This eight year gap is counterproductive when considering retention of the skills students learned in high school, and may explain in part why they attend college classes part-time or on an intermittent or less than part-time basis. Minority students also completed fewer higher-level mathematics courses in high school, had lower senior achievement test scores, and had lower college entrance examination scores.[9] Ishitani reported similar findings in a study of first generation college students. Ishitani found that, generally, first generation students had lower scholastic achievement tests (SAT) scores, lower grade point averages (GPA's), lower critical thinking abilities, less confidence in their abilities as a college student, and less supportive families.[10]

Family involvement or support structure is found to affect successful completion of programs. Lilly suggested that separation or disengagement was not the precondition for a successful adjustment to college. [11] She suggested that students who stay close to their lifelong basic support structure have a higher chance for success. Lilly, citing other workers, found inconsistencies in the influence of gender, student goals, developmental education, student grade point average (GPA), contact with family, or hours of study in regard to student retention. Lilly's small research study found several factors, to include older students, part-time students, minority students, and working adults with higher attrition rates than that of a traditional student.[11]

Watson's research offered evidence of older students having a higher attrition rate than traditional students enrolled in a respiratory therapy program. However, she found that when given a longer period of study or program time, the nontraditional students out performed traditional students. Watson explained that the adult learner is an individual whose major role in life was being someone other than a full-time student. This explanation is validated by the fact that the majority of these students had a household, a part-time or full-time job, and a family or children, thus making it extremely difficult for these students to excel in a program which generally required students to devote much of their time to school.[12]

Rye suggested that obligations such as family, employment, and social life took time and focus away from a student's engagement in their program and increased the risk of student attrition. Rye noted the program's willingness to involve themselves in the social and intellectual development of the students may decrease attrition.[13] This observation suggests that students are more likely to succeed if the educator individualizes the learning experience and becomes more attuned to each student's academic weakness and strengths.

Laudicina found three factors contributing to student attrition: the personal characteristics of the student, and both the academic and the social environments of the institution. Laudicina addressed retention concerns, noting that attrition could be influenced by the public sectors interest in improving retention, maximizing enrollment and graduation rates, and minimizing deleterious effects of attrition.[14]

A number of theories on attrition and retention are derived from Tinto's classic work on adequacy of intellectual and social student integration into college society. Tinto's ideas regarding attrition are limited to variables that are related to finance, gender, and college transfer issues in student life.[15]

Noel's work defined seven themes that emerge in attrition: academic boredom, academic uncertainty, and transition and adjustment problems, limited and/or unrealistic expectations of the college, academic under-preparedness, incompatibility, and irrelevancy. Academic boredom occurred when a student became uninterested in the subject matter. This was attributed to teaching style and poorly stimulating content. Academic uncertainty occurred when a student in an allied health program became uncertain about their goals and objectives for their future. Transition and adjustment problems can be encountered when a student transferred from secondary education to an allied health program. Students enrolled in two year allied health programs, such as respiratory therapy, often experience a steep learning curve, further challenging their academic preparation.

Students enrolled in a two year or four year program face similar transition and adjustment problems. A limited or unrealistic expectation of the demands of a respiratory therapy program may be one of the largest contributors to attrition in our profession. Not only does the student face the academic rigors of their program, they must commit time to community service, clinical internships, and attendance at seminars. Academic under-preparedness is found when students are not aware of the sacrifice that must be made in personal time and/or study time. Academic incompatibility occurred when the student and the program were mismatched in regards to program content, teaching styles of faculty, and clinical demands of the student's time. One example of a mismatch may be the increased emphasis on distance education in respiratory therapy, and an incoming student who prefers one-to-one, synchronous, highly kinesthetic classroom-based education. Irrelevancy would contributed to attrition when students project that their personal outcome in the program is irrelevant to their life expectations.[15]

If attrition is so important, than retention and the eventual graduation of students must become a center of excellence on the campus of the modern educational institution.

Habley and McClanahan surveyed 1,061 two-year colleges and found that 40.7% employed staff for coordinating retention strategies, 27.2% had established an improvement goal for retention between the first and second year, and 19.9% of institutions had a program planned to improve degree completion.[17]

Dyson clearly noted the regional impact of attrition in respiratory therapy education. Dyson surveyed all respiratory therapy educational programs in North Carolina and found that greater than 95% of all program directors reported adequate numbers of students enrolled in the respiratory therapy programs in North Carolina. However, based upon history, 30% of those applicants would not finish the respiratory therapy education program. Attrition, in this case, directly contributed to the scarcity of respiratory therapy practitioners in North Carolina, where 13 counties reported no respiratory therapy practitioners in practice, and an estimated statewide ratio of 10,000 people to every three licensed respiratory therapists in practice.[18]

Method

The retrospective study was conducted in a Southeastern U.S. respiratory therapy (RT) bachelor's degree program education program. Researchers gathered demographic data as well as the reason(s) why each student withdrew from the program.

The four-year RT program typically admits an average of 16 students each year. During the five year study period, 81 students were graduated from the program while the twenty-four students who had left the program prior to graduation were the focus of the study (Table 1).

Table 1

Demographics of 24 student participants who left the program prior to graduation.

Variable	**Gender**		**Ethnicity**		**Student Type**	
Variable Label	Males	Females	Caucasian	African-American	Traditional	Non-traditional
Count	7	17	20	4	16	8

This study was conducted in an effort to gain insight into our program using data from the entire population of respiratory therapy students enrolled in the program during the five years of the study, with the intent of developing strategies to address attrition. These student data was considered a convenience sample and may or may not be representative of students enrolled in other regional respiratory therapy programs or across the nation. The use of the entire population of students in the program between 2001 and 2006 negated the need for methods of randomization.

Students who failed to complete the respiratory therapy program during the years of 2001-2006 participated in an exit interview with the program director. During the exit interview, demographic data and the student's reason(s) for exiting the program were discussed and recorded. A data file was developed and analyzed using SPSS Version 14.0. Due to the data being nominal, more conventional parametric procedures (e.g., t - testing, ANOVA) were not appropriate. In addition to descriptive statistics, the data were analyzed using a cross tabulation and its resulting Pearson's Chi-Square. Alpha = .05 was selected as the confidence level for all testing in this study.

Limitations to the study include:

1. The study was limited to students enrolled in a bachelor's degree program at a respiratory therapy program in a Southeastern academic institution.
2. The study was limited to five consecutive academic years.
3. Due to limited diversity of the program enrollees, the variable ethnicity was limited to Caucasian and African American.

Findings and Conclusion

Attrition and retention are concerns of program administration and faculty of respiratory therapy educational program across the nation. RT programs must graduate adequate numbers of therapists to meet local employer demands.

The average attrition rate for respiratory care students during this five year study period was 31%; slightly above the benchmark 30% recommended by the accrediting agency. The male attrition rate was 9% and the female rate 21%. The population contained only two self-reported racial groups, Caucasian and African American; the attrition rate among Caucasians was 25% while the rate for African Americans was 5%. Traditional students' attrition rates were higher than nontraditional students, 19% versus 11% respectfully.

While Lilly and Watson [11-12] found that nontraditional students had a higher attrition rate than traditional students, the findings of this study did not agree with their findings. We believe there is an important distinction that needs to be made between students who leave a program for personal issues and those who leave for academic failure; and this distinction was not reported by other authors. Within the program administration, the Program Director should document the distinction between a person who fails academically, and the attrition of a student who is making acceptable progress in the academic program but cites personal reasons for leaving.

Using collected data, a two-way contingency table analysis was conducted to determine whether gender, race, or the type of student was a predictor of whether students would leave their program for personal or for academic reasons.

Table 2

Demographic Data and Stated Reasons (at exit interview) for Leaving the Respiratory Therapy Program.

Variable	**Gender**		**Ethnicity**		**Student Type**		**Academic problem at time of quit/drop?**	**Reason for Leaving Program**
Variable Label	Males	Female	Caucasian	African-American	Traditional -	Non traditional	Academic Issues?	Reason for Leaving?
1	1		1		1		N	Removed
2	1		1			1	N	Medical
3	1		1		1		N	Removed
4	1		1		1		N	Removed
5	1			1		1	Y	Familial
6	1		1			1	N	Removed
7	1		1		1		N	Familial
8		1	1		1		N	Graves Dis
9		1	1			1	N	Pregnancy
10		1	1			1	N	Pregnancy
11		1		1		1	Y	Familial H
12		1		1		1	N	Sounds
13		1	1		1		N	Anorexia
14		1	1		1		N	Diabetes
15		1		1		1	Y	Traum/Death
16		1	1		1		N	Family/child
17		1	1		1		N	Unknown
18		1	1		1		N	Sleep
19		1	1		1		N	Finance
20		1	1		1		N	Finance
21		1	1		1		N	Finance
22		1	1		1		N	Finance
23		1	1		1		N	Finance
24		1	1		1		N	Anorexia
	7	17	20	4	16	8	3	

Student citation or stated rationale for leaving program:

8.	"Graves disease, medical necessity"
13, 24.	"Anorexia nervosa "
15.	"Did not like trauma/death of patient."
18.	"Sleep disorder."
2.	"Unknown medical disorder."
14.	"Diabetes, severe."
9-10.	"Difficulty due to pregnancy "
12.	"Could not tolerate 'sound' of dying patient and suctioning."
7,11.	"Familial, husband "
5,16.	"Familial children and childcare."
1,3,4,6.	"Removed for the good of program/community (not academic) (all males)."
19-23.	"Finance/financial aid x 4."
17.	"Unknown"

The study's three demographic variables were: gender, race, and classification (traditional or nontraditional). The value 'reason for attrition' was limited to leaving the program for personal reasons or academic failure (i.e., poor or failing grades). Gender differences were found to be statistically significant. The cross tabulation showed that seven of seven males cited academics (poor or failing grades) as their reason for withdrawing. Eight out of 17 females cited academics as their reason for withdrawing while the remaining nine females cited personal reasons for withdrawing. No males cited personal reasons for leaving the program. Similar analysis of ethnicity and type of student demonstrated no significant difference between academic and personal reasons for attrition in this program.

Why did men participating in this study leave the respiratory care education program exclusively for academic reasons and women leave almost equally for academic and personal reasons? There are several speculations for this difference, but none are considered conclusive. Noel believed that women had more responsibilities in their personal lives. In the exit interview, female students placed a greater import on children and family related issues, and left the program for this reason (Table 2). At least one of the women in our study stated one of Noel's reasons for attrition at the exit interview, academic uncertainty, choosing to leave the program to 'experience personal change', that is, her experience with the reality of life and death in the intensive care setting awoke in her a desire to care for patients in a more administrative health career setting.[16]

Noel's conclusions were unique when compared to traditional theories of causes for attrition which seem focused on personal or academic attrition. Of Noel's seven themes, three that she identified emerged as important in the context of this analysis: academic uncertainty, transition and adjustment problems, and academic under-preparedness.[16] For the purpose of this study, academic uncertainty and academic under-preparedness resulted in attrition documented in the annual CoARC report as 'attrition due to academic reasons'; indeed, these issues were investigated by the program director as the starting point in an effort to decrease attrition.

Transition and adjustment problems were another key difficulty. When entering a respiratory therapy program, the student is asked to make sacrifices of their time in academic, work, and social life. In this transition there are both personal and academic boundaries standing in the way of their success. In this program, respiratory therapy students devoted much more time to the professional component of the program than they did to the general education curriculum experienced as underclassmen. Academically, with each passing semester, it became increasingly difficult for students to meet the demands of their course work, employment schedule, and family responsibilities. During the exit interview, it was difficult for the program Director to determine a primary cause for the attrition such as was the student working too many hours or was the student underprepared?

The primary reason for academic attrition, per Noel, was academic under-preparedness. This occurred when students were not able to fulfill the academic demands of the program. The student did not adequately learn information when taking the core prerequisite course; the student was not academically prepared for the program, or a combination of the two. Pre-admission measurement of under-preparedness is confounding and difficult for the program director, particularly when assessing academic preparedness based upon transcripts and transfer-credit.

While not evidenced by the findings of this study, a key cause of attrition can actually be diversity. A person's race, gender, and student classification (traditional or nontraditional) all play a part in the success or failure of a student. The effects of diversity factors are common to higher education and not exclusive to allied health or respiratory therapy programs. Future studies may demonstrate a relationship between diverse socio-demographic factors and their impact on reasons for attrition.

The differences between traditional and nontraditional students should be noted.[14] A traditional student exits high school and immediately enters college, starting college at 17-19 years of age and typically graduates before the age of 25. They seldom have dependents, spouses, or full-time jobs to distract them. It is common for traditional students to be involved in organizations within the university and attend university related functions. In comparison, nontraditional students are over the age of 25 and commonly have dependants, spouses and fulltime jobs. They are seldom involved in campus organizations, and are unable to attend or participate in university functions.[14]

Several studies concluded that the traditional student will perform better academically than the nontraditional student; however, this is not always assured. It is common for four year universities to enroll fewer nontraditional students, but many of the two year allied health programs (such as respiratory therapy) enroll a higher number of nontraditional students, many of whom do well academically in spite of the odds against their success. This is found to be typical for a number of reasons, including the length of their academic program, concentration of the program, flexibility of the program faculty, or other reasons of a more personal nature.[9-18]

Thus, all students need a comprehensive support system to succeed. For the traditional student this could be friends and parents to support them emotionally, and in some circumstances, financially. Likewise, the nontraditional student should actively seek support from spouses, parents, colleague students, or friends. Respiratory therapy program faculty may play a large, active role in developing support systems for their students.

Attrition from a respiratory therapy program has a personal impact on the lives of the unsuccessful student, and an impact on the public through a shortage of respiratory therapy practitioners. Striving to keep attrition at a minimum is a must in respiratory therapy education. Identifying identified risk factors in students is the key to keeping program attrition low and retention high. As the need for healthcare professionals grows, it is increasingly important to fill the demands of the community-of-need for well-qualified respiratory therapy professionals.

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Respiratory Care Education Annual
Volume 17, Fall 2008, 57-64

Influence of Problem-Based Learning Instruction on Decision-Making Skills in Respiratory Therapy Students

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Abstract

Background. The continuing evolution of the respiratory therapy profession require today's therapist to demonstrate advanced skills with patient assessment, problem solving, and decision-making skills. In 1998, the Respiratory Therapy Program at the University of South Alabama added a problem-based learning component to it's curriculum to improve students' decision-making (DM) and problem-solving skills. The rationale for focusing on teaching strategies to improve decision-making skills is based upon studies that demonstrate a positive relationship between decision-making and critical thinking. However, decision-making in respiratory therapy students has not been widely studied. The purpose of this study was to examine the effectiveness of problem-based learning teaching strategies on the decision-making skills of respiratory therapy students and determine if this strategy elicited changes in learning over time. **Methods.** Using a retrospective, correlation research design, DM scores from the NBRC Clinical Simulation Self-Assessment Examination (SAE) and the graduates' NBRC Clinical Simulation Exam DM scores were compared and correlated. These data were obtained from the traditional curriculum during the academic years 1996-1999 and the years 2000-2003 which represented the problem-based learning curriculum. **Results.** Statistically significant differences in exam scores by type of curriculum were found ($r = .58$, $p < .01$). DM scores on the Clinical Simulation Self-Assessment Exam and the graduates' NBRC Clinical Simulation Examination scores demonstrated an increase in mean scores for the students in the problem-based learning curriculum ($r = .34$, $p < .01$). **Discussion and Conclusion.** The findings of this study support the hypothesis that problem- based learning had a positive impact on decision-making skills in respiratory therapy students. The results of this study indicate that further investigation of problem-based learning approaches in respiratory therapy students is warranted.

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INTRODUCTION

Over the past 50 years, the respiratory therapy profession has undergone vast changes due to advancements in medical technology, the aging population, and a better informed consumer of health care. Respiratory therapists must now assume more responsibility for initiating, monitoring, and modifying the patient care plan. Recent changes in the respiratory therapy profession, such as the employment of therapist driven protocols, have empowered therapists to independently evaluate the patient's condition and make decisions regarding the need for treatment.[1]

The continuing evolution of the respiratory care profession requires that respiratory therapists demonstrate an advanced level of critical thinking, assessment, and problem solving skills.[1]

The National Board for Respiratory Care (NBRC) Clinical Simulation Examination (CSE) is one of three examinations administered as part of the credentialing process. This exam measures, in part, decision-making skills and the scores are often used as an outcome measurement for respiratory therapy programs. The CSE is considered, by experts in social sciences, to be one of the few domain-specific instruments for assessment of critical thinking skills.[2] To improve CSE scores, respiratory therapy educators have investigated alternative strategies to improve critical thinking and decision-making. One such strategy is problem-based learning (PBL).

Problem-based learning (PBL), a relatively new teaching strategies, has been adopted by a number of respiratory therapy programs throughout the nation as a response to meeting the educational needs of future practitioners. PBL is a student-centered method of teaching in which learning is fostered by active inquisition.[3] The basic premise is that students accept the major responsibility for their own learning. Classroom activities are transformed from the traditional passive-style lecture to an interactive classroom with active participation by students. Using small groups, questions are raised, hypotheses are proposed, data are presented by fellow classmates, and the teacher's role is more of a facilitator. The problem-based learning process consists of a clinical case problem which is presented to the students. The students then identify the learning objectives using clinical reasoning and decision-making in an interactive group process. Independent self-study and the application of newly attained knowledge as it relates to the problem are then followed by the students developing a summary of what has been learned.[4] This teaching method has been reported to improve the ability to think critically, to motivate self-directed learning, and to provide structure of knowledge into real-life contexts.[5]

Two similar studies involving respiratory therapy students reported a significant relationship between students' critical thinking abilities and decision-making skills as measured by the decision-making scores on the CSE.[2, 6] While it is difficult to determine cause and effect, both studies suggested additional research is needed to examine the effectiveness of various educational strategies. There are a limited number of studies which investigate respiratory therapy students' DM skills by comparing the effectiveness of diverse educational strategies.

The purpose of this study was to examine the effectiveness of PBL on the decision-making skills of respiratory therapy students. The rationale for this study was based upon previous studies in the field of respiratory therapy that demonstrated a positive relationship between critical thinking and decision-making.[1, 2]

METHODS

Research Design

This study was designed to describe the relationship between problem-based learning and decision-making skills of respiratory therapy students enrolled in the baccalaureate program at the University of South Alabama (USA) between the years 1996-2004 and utilized a retrospective correlation research design (ex post facto). The student's DM scores from the NBRC Self-Assessment Clinical Simulation Examination were used as an objective measure. The basic premise behind this study design was to describe and predict relationships among certain variables.

Subjects

The study group consisted of a convenience sample of all graduates (N = 100) enrolled in a four-year baccalaureate respiratory therapy program at the University of South Alabama between the years 1996-2004. Students were divided into two groups. One group consisted of all students enrolled in the respiratory program from 1996-1999. During this period, the program's curriculum was delivered using a traditional educational approach. The second group consisted of all students enrolled in the program from 2000-2003. During this period, the program's curriculum was delivered employing traditional classroom strategies and PBL. Regardless of the teaching strategy, the course content, evaluation, and clinical training were consistent across both groups, and adhered to Committee on Accreditation for Respiratory Care standards (CoARC).[7]

Procedures

The researcher identified the Respiratory Therapy Program at the University of South Alabama as a program that specifically maintained a consistent curriculum design, during their transition from traditional teaching with the addition of PBL. Permission to conduct the study was granted by the Program Director of the University of South Alabama Cardiorespiratory Care. An expedited approval from the Seton Hall Institutional Review Board was obtained. Students' DM scores from the NBRC Clinical Simulation Self-Assessment Examination and graduate exam scores from the NBRC Clinical Simulation Examination were obtained from program files during the years 1996-2003. Examination scores from the four year time frame of 1996-1999, which represented the traditional curriculum, were compared with the scores from 2000-2003, which represented the addition of PBL. The demographic data, such as students' GPA on admission and graduation from the program, sex, age, ethnicity, highest earned degree, and the area where they lived, were obtained. Student anonymity was maintained by coding students' initials with their year of graduation.

Instrumentation

Prior to graduation from the respiratory therapy program, all students were administered a self-assessment clinical simulation examination that was obtained from the NBRC. These examination scores are often used as outcome data for respiratory therapy programs. The self-assessment examination provides two scores for the student, information gathering and decision making for each of the ten clinical simulation problems. The program recommended that the student not prepare to take these examinations to provide a valid assessment of the knowledge base prior to exiting the program. Students then utilized examination results to help prepare for their NBRC credentialing examinations.

Data Analysis

The DM scores from the self-assessment examination and the DM scores from the NBRC Clinical Simulation Examination were compared.

The data were analyzed using the Pearson product-moment correlation coefficient to describe the relationship between the DM scores and problem-based learning from students in the traditional curriculum versus after the intervention of the problem-based learning curriculum. This statistical test was chosen due to its ability to measure the strength of association between two variables that are on the interval or ratio scales.[8] Furthermore, this measure was chosen because it can be used for paired observations for the same set of individuals, and the size of the sample does not affect the size of the correlation coefficient.

The t-test for independent samples was also used to determine the strength of the means between the independent variable, the type of curriculum, and the dependent variable, the decision-making scores. This study was a correlation design; therefore causation cannot be concluded due to the lack of a true experimental design.[8] Levene's test for equality of variances was also conducted due to the low sample number (n =14) for the actual graduate exam scores who participated in the problem-based learning curriculum. The percentages of students passing the exams for both the self-assessment and the actual decision-making scores were also calculated and reported.

RESULTS

Demographics

There were 60 participants in the traditional curriculum group and 40 in the PBL curriculum. The number of students who took the NBRC Clinical Simulation examination after graduation from the program was 58. Of those 58, 44 were from the traditional curriculum and 14 were from the PBL curriculum. Of the total 100 students in this study, 37% were male and 63% were female. The average age of the participants was 22.76 years. 91% of the participants were from the Southeast area of the country (which included Alabama, Florida, and Mississippi). 71% of the participants were White, 17% were Black, 7% were Asian, and 5% were of other ethnicities. The mean admitting GPA was 2.96 and the mean GPA at graduation was 3.04. Both means (GPA on admission/graduation) were analyzed with the self-assessment exam and the actual exam scores, however, there were no significant differences between the two so they were excluded from further analysis.

Pearson-product moment correlations were calculated for the DM scores for the NBRC Clinical Simulation Examination and NBRC Self-Assessment Examination, and type of curriculum, traditional or including problem-based. In addition, the NBRC Clinical Simulation Self-Assessment Examination scores were correlated with the NBRC Clinical Simulation Examination DM scores. The NBRC Clinical Simulation Self-Assessment Examination

DM scores and the NBRC Clinical Simulation Examination DM scores had a positive correlation ($r = .342$, $p < .01$). Thus, students who scored higher on the NBRC Clinical Simulation Self-Assessment Examination generally scored higher on the NBRC Clinical Simulation Examination as well. The NBRC Clinical Simulation Self Assessment DM scores and the type of curriculum had a moderate positive correlation ($r = .216$, $p < .05$) with the traditional curriculum coded as 1 and the problem-based learning curriculum coded as 2. Coding was due to the nominal nature of the variables. This finding demonstrated examination scores for the PBL curriculum were statistically significant. The NBRC Clinical Simulation Examination DM scores and the PBL curriculum had a high positive correlation of ($r = .583$, $p < .01$). This finding demonstrated that students from the PBL curriculum scored higher on the NBRC Clinical Simulation Examination than students in the traditional curriculum. The Pearson product-moment correlation coefficients for the three correlations and the decision-making scores and the type of curriculum are shown in Table 1.

Table 1

Pearson-Product Moment Correlation Coefficients for DM Scores and the Type of Curriculum

Variables	**Correlation Coefficient**
NBRC SAE DM Scores and PBL Curriculum	.216*
NBRC CSE DM Scores/SAE DM Score and PBL Curriculum	.342**
NBRC Exam DM scores and PBL Curriculum	.583**

*** significant at the 0.01 level (2 tailed)*

** significant at the 0.05 level (2 tailed)*

Note: Independent variable is the type of curriculum and the dependent variable is the DM scores

The t-test for independent samples was also performed to compare the means of the PBL included curriculum with the traditional curriculum decision-making scores for both the NBRC Clinical Simulation Examination and the NBRC Clinical Simulation Self-Assessment Examination. The minimal passing decision-making score for the NBRC Clinical Simulation Self-Assessment Examination was 79. For the NBRC Clinical Simulation Examination, the range was from 63-67, depending on the year taken. There was a significant difference in NBRC Clinical Simulation Self-Assessment Examination scores by type of curriculum. Students in the PBL included curriculum ($M = 87.23$) scored 10 points higher on the NBRC Clinical Simulation Self-Assessment Examination DM scores than students in the traditional curriculum ($M = 77.18$). There was a significant difference in the NBRC Clinical Simulation Examination DM scores by type of curriculum. Students in the PBL included curriculum ($M = 108.71$) scored 27 points higher on the NBRC Clinical Simulation Examination DM scores than students in the traditional curriculum ($M = 81.07$).

Therefore, the curriculum with PBL was associated with higher scores. The mean scores and standard deviations are presented in Figure 1. The independent t-test results are presented in Table 2.

Figure 1

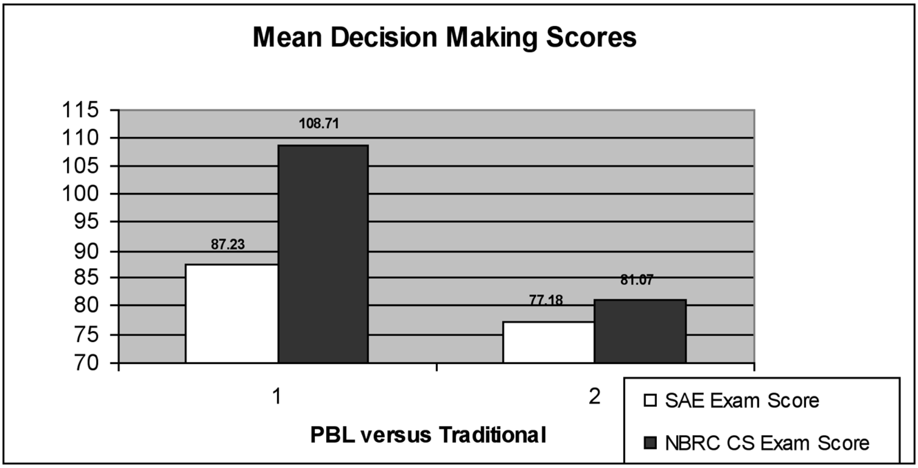

Table 2

Independent Samples t Test Results

	t	df	Sig.	Mean Difference	P
SAE Exam DM Score	2.186	98	.031	10.04	< .05
NBRC CS Exam DM Score	7.928	52.11	.000	27.65	< .01

Note: Correlation between independent variable which is type of curriculum and the dependent variable which is DM scores

The Levene's test for equality of variances was performed as a standard procedure for independent samples t-test. Despite a significant finding for inequality of variance, there is still a significant mean difference in exam decision-making scores by type of curriculum.

The percent of students passing the self-assessment exam in the traditional curriculum was 53% as compared to 68% for the students in the PBL included curriculum. This was a significant finding as well and is reported in Table 3.

Table 3

Percent of Students Passing NBRC Self-Assessment Examination by Type of Curriculum

Program	n	%
Traditional	60	53%
Problem-based Learning	40	68%

DISCUSSION

The purpose of this study was to examine the effectiveness of PBL teaching strategies on the decision-making skills among baccalaureate respiratory therapy students. This study looked at students who were exposed to a traditional learning curriculum and a PBL curriculum between the years 1996-2003. Students' examination DM scores from the NBRC Clinical Simulation Self-Assessment Examination and the NBRC Clinical Simulation Examination scores following graduation were analyzed. Analysis of the data revealed statistically a significant difference between examination scores by type of curriculum. Examination DM scores on the NBRC Clinical Simulation Self-Assessment Examination and the graduates' NBRC Clinical Simulation Examination scores demonstrated a steady increase in mean scores for the students in the problem-based learning curriculum. The percentage of students passing the NBRC Clinical Simulation Self-Assessment Examination was 68% for the problem-based learning curriculum compared to 53% for the traditional curriculum. Interestingly, GPAs on both admission and exit shared no relationship with the scores of NBRC Clinical Simulation Self-Assessment Examination or the NBRC Clinical Simulation Examination and therefore, was excluded from further analysis. Gender, ethnicity, and age were not related to the examination scores and were also excluded from further analysis.

The problem addressed in the present study represents current challenges faced by respiratory therapy educators nationwide. Hill stated that the continuing evolution of the respiratory care profession requires that respiratory therapists demonstrate an advanced level of critical thinking, assessment, and problem solving skills.[1] Therefore, if respiratory therapy educators utilize new andragogies that are designed to improve students' decision-making skills, then their graduates can be better prepared to meet the future demands of the profession. Statistically significant differences in NBRC Clinical Simulation Examination DM scores by type of curriculum were demonstrated by the students in this study and support the use of PBL in respiratory care.[2,9] The outcomes in this study also support findings in other studies in both the medical and dental programs.[10-12] This study reveals that PBL improves decision-making skills in respiratory therapy students. Finally, the outcomes raise implications for respiratory therapy education in general.

The findings in this study support the hypothesis that there is a statistically significant change in students' DM scores on the NBRC Clinical Simulation Examination after completion of a baccalaureate respiratory therapy program, which utilizes a PBL curriculum, as compared to students' decision-making scores from the traditional curriculum

While these results are in contrast to the findings of the studies by Mishoe and Hill, this outcome may be due to the nature of the NBRC Clinical Simulation Examination which requires a strong background in discipline-specific content and therapeutic processes.[1,2]

CONCLUSION

Despite the small number of participants in this study, the findings support that PBL curriculum had a significant positive impact on decision-making skills in respiratory therapy students. Further research should be conducted to increase the literature available to guide educators in utilizing the PBL method in respiratory therapy programs.

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Respiratory Care Education Annual

American Association for Respiratory Care
9425 N. MacArthur Blvd., Ste 100
Irving, TX 75063-4706

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Dallas, TX

Respiratory Care Education Annual is a publication
of the American Association for Respiratory Care