Effectiveness of an Adaptive Quizzing System as an Institutional-Wide Strategy to Improve Student Learning and Retention

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**Exploring ways to help students achieve success in nursing programs is critical to increase retention and the number of nurse graduates. This study examined the impact of an adaptive quizzing system implemented as a strategy to support student persistence and performance measured by use, grades, and graduation. Results indicated that use of the system increased course content mastery and predicted final course grades. Retention and program completion rates were also positively influenced.**

**Keywords:** Adaptive Quizzing; NCLEX; Nursing Education; Retention; Remediation; Technology

The first-time National Council Licensure Examination (NCLEX) pass rate has emerged as one indicator of a successful and high-quality nursing program and as an indicator of quality for state boards of nursing and the nursing school’s community of interest. The focus on first-time pass rates is further supported by data showing higher failure rates for repeat NCLEX takers compared to first-time test takers. The National Council of State Boards of Nursing attributes the difference in failure rates to the extended time between graduation and retaking examinations for the repeat test-takers. Nursing schools also may risk the stigma of students with repeated failures, influencing the support of their community as well as continuing school accreditation. Moreover, if a student cannot pass the NCLEX, they are unable to pursue their chosen career.

The likelihood of a nursing student graduating and passing the NCLEX the first time is difficult to predict given the myriad interacting variables that influence success or failure. Despite this difficulty, many nursing programs use standardized assessment programs to try and predict student success on the NCLEX, with some schools implementing graduation policies based on standardized test scores. In Texas, for example, a survey of 74% of the state approved nursing programs found 98.8% of schools used standardized tests, and 47.9% of schools used scores on standardized tests to make progression or graduation decisions. Nationally, the percentage of nursing programs with progression policies that mandate students meet a benchmark on a standardized test to qualify for graduation is 20%. But as Spurlock has indicated, little or no guidance or validity evidence is available to faculty who wish to set cut, or decision, scores for their progression or graduation policies.

The process of using standardized tests (and achievement of a benchmark on those tests) to determine progression and graduation eligibility is also known as “high-stakes” testing. Two of the most commonly used programs used in high-stakes testing are the Health Educational Systems, Inc. (HESI) and Assessment Technologies Institute. Although both companies have a suite of examination offerings, many schools use the HESI Exit Exam (HESI E) as an NCLEX predictor test. Research indicates that although predictor tests may predict high-performing students who are likely to pass the NCLEX, they are much less precise in identifying the likelihood of failure. This distinction in describing the accuracy of a test is especially important when progression policies are in place and data may be used to preclude graduation.

There is, of course, another possible use for data from standardized tests; rather than only using the data to make progression decisions, information may also help students shape their remediation and studying efforts—before taking the NCLEX. Despite successful completion of nursing programs, some students may have difficulty achieving the benchmark on a standardized measure. If this is the case, standardized test results can provide students and faculty...
valuable information on areas of curricular weakness and strength, which can be used to focus remediation efforts. However, students are likely to need additional resources to help address their particular needs and master critical content required to pass the NCLEX and move on to the next phase in their chosen field.

Implementation of an Adaptive Quizzing System

The project reported here was a retrospective case study conducted at a baccalaureate school of nursing in the southeast United States. Nursing program enrollment at the study school consists of 85% to 90% African American students, with cohorts of around 100 students admitted twice a year. Since 2007, the on-time graduation rate for the nursing school has ranged from 55.8% to 71.13%. Multiple failures a year. Since 2007, the on-time graduation rate for the nurses, with cohorts of around 100 students admitted twice a year. Since 2007, the on-time graduation rate for the nursing school has ranged from 55.8% to 71.13%. Multiple failures and semester/course repetitions can lead to low student morale, frustration, and drop out. Consequently, retention of these at-risk students is instrumental in helping reduce the nursing shortage and increase the number of registered nurses.

In fall 2010, in response to the need for more academic student support and resources, the nursing program participated in a pilot program implementing an online adaptive quizzing system (AQS) to augment a second semester nursing course. The AQS used in this study was PrepU (Macmillan, New York, New York). The system is an online, computer-based platform with a large database of calibrated test questions in multiple formats (multiple choice, fill in the blank, hot-spot, graphics, etc).

Instructors can integrate the system into their courses in different ways to best align with current teaching practices and goals. For example, faculty can create class assignments using collections of questions chosen from the large AQS database or set a mastery-level target in a particular topic for students to achieve. Students can also use the system for their own independent studying and to practice test-taking skills. To do so, students select a nursing topic (or client need) and the desired number of quiz questions (between 5 and 20), and the system builds an adaptive practice quiz using those parameters. Quizzes are delivered to students based on an adaptive algorithm, which personalizes the experience for each student, optimizing learning potential by selecting quiz questions targeted at the current level of understanding. Students take the quiz and upon completion are shown a detailed answer key along with rationales and explanations of key concepts. Multiple versions of the AQS exist, each aligned to a particular nursing course or examination (eg, medical-surgical or NCLEX-RN).

Adaptive quizzing is efficient and helps focus each student’s learning on content tailored to their estimated ability level. Within the AQS, a student’s ability level is determined and continuously updated based on responses to calibrated questions with known difficulty parameters. As students answer more difficult questions correctly, they are given increasingly more challenging questions on subsequent quizzes. As they answer the more challenging questions correctly, the student moves up in mastery level (ML). Mastery level is reported on a scale of 1 to 8, and the levels provide students with a motivating measure of their progress and a clear indication of which topics or client needs they have mastered and which require more work. Practicing in a low-stakes, authentic environment can be invaluable to populations such as EL (English learner) or LEP (limited English proficient) students as well as those requiring extra support in content mastery and test-taking strategies. In both cases, evidence suggests that allowing students to engage in more independent, self-paced learning can help increase confidence as well support student learning.

The AQS also gives instructors a window into their students’ performance, with an assessment dashboard displaying individual and class-wide information on overall use and content mastery. Instructors can use these student use and mastery data to determine how students are using the system; identify where additional instruction, practice, or remediation is required; and focus instruction or assignments on key concepts with which students are struggling.

Some educators have suggested that nursing schools implement comprehensive testing systems to help students prepare for the NCLEX. A piece of predictive information is only useful, however, if it can be acted upon. If the information comes too late, or if there is no clear path to remediation and change, the “predictive” information loses its value and does not help students prepare. In contrast, the AQS can be used throughout the nursing program to help inform, guide, and support student learning. As students engage with the AQS, they get practice answering NCLEX-style questions in a low-stakes environment, gain feedback on strengths and weaknesses, and a better focus their studying, with the potential to increase content mastery and continue learning.

Purpose

The current study was designed to explore the use of the AQS and its efficacy as a learning tool for nursing students. The AQS was implemented with the study cohort in 1 nursing course to determine the potential impact on student success and retention. The purposes of the study were to explore the (1) degree of student use and engagement with the AQS, (2) relationship between use and content ML as measured by the AQS, (3) correlation between AQS use and mastery and HESI E2 and NCLEX-RN outcomes, (4) relationship between scores on the HESI and course grades in the first adult health course, and (5) impact of the AQS implementation on program completion patterns.

Methods

Design

The study used a retrospective descriptive and correlational design to explore the relationship between course use and mastery measured in the AQS, course outcome data, and standardized testing scores. Retrospective data were collected on AQS use, implementation, and subsequent student performance (including NCLEX outcome).

Participants

The participants were a convenience sample of undergraduate students enrolled in a second semester adult health
course in a BSN program. The ethnic distribution of the study population was 64% black (n = 64), 12% Hispanic (n = 12), 9% white (n = 9), and 15% Asian/Pacific Islander (n = 15). Approval for the study was obtained from the university’s institutional review board by the first author, and only data from consenting students (n = 100, or 65.8% of the eligible student group) are included in these analyses.

**AQS Implementation**

The AQS was first implemented in 2010 as a pilot program in the first adult health course. Typically, in this course, there are 7 to 10 failing students, but in the fall 2010 semester, only 2 students did not pass. In addition, before the introduction of the AQS, there was a history of persistent student challenges with critical thinking and test-taking skills, presence of test anxiety, and reduced retention of course content for subsequent courses. At the end of the pilot, students reported increased confidence in answering NCLEX-style questions and showed improved examination performance. After the success of the pilot, the AQS was adopted by faculty, with support of the dean, as an institutional-wide retention strategy for all nursing students in the undergraduate program (except Leadership and Management and Community Health Nursing).

Although the AQS was adopted across the institution, faculty implementation varied a great deal. Some faculty members were more engaged and began to use the AQS as an opportunity to assess student learning and comprehension. In other cases, faculty required the AQS as a course component but did not actively use it or view class data on a consistent basis.

Students included in this study had access to the AQS in their first Adult Health course and were given optional use of either 1 of 2 NCLEX preparation versions of the AQS (NCLEX-AQS 1 or 2). The latter was a newer version introduced in spring 2013 on a trial basis.

**Data Sources**

Data were gathered from course records and included predictor examination results along with use and ML data from the online AQS during the first Adult Health course and a later NCLEX preparation course (use in this latter course was optional). The predictor examination used in the study (HESI E²) was administered to students during their final semester in the nursing program. Three survey measures were sent to participating students: an introductory survey, a survey after the first Adult Health course, and a post-NCLEX survey. The introductory survey focused on students’ study habits, motivation, learning practices, and attitudes. On the second survey, students were asked questions about the AQS, its use, and perceived value and benefits. Students were given the opportunity to provide additional information for each question in an open-ended format. On the third survey, students were asked questions pertaining to the NCLEX and their experiences taking and preparing for it. Survey results are reported for the second survey, which focused on student use and response to the AQS.

**Results**

**AQS Use and Mastery**

All students enrolled in the BSN program took the first Adult Health course during their second semester and were required to use the AQS during the course. Despite this requirement, 8 students did not use the AQS. The AQS use and mastery for students who used the system are shown in Table 1. Student use of the AQS varied, with a mean (SD) of 109 (102.54) quizzes, 1062.51 (902.95) questions, and ML of 4.33 (1.78). Given the large standard deviation for questions answered, the median (842) is a more accurate measure of overall use. There were no significant differences between ethnic groups on AQS use (F3, 98 = 0.123, P > .05) or ML (F3, 96 = 0.814, P > .05). The NCLEX-AQS 1 and/or 2 were used by 62 students in the study sample (35 used the NCLEX-AQS 2, which allowed students to take longer practice examinations as well as quizzes).

**Adult Health Grade and AQS Use and Mastery**

Using a Pearson correlation analysis, we explored the relationship between final course grade points in Adult Health and AQS ML and use. The analysis revealed a significant positive correlation between the AQS ML and final grade points (r92 = 0.240, P < .05) but not between number of questions answered and final grade. Thus, the higher a student’s final number of grade points is (out of 100), the higher their AQS ML.

A linear regression analysis was conducted to explore the relationship between AQS ML and grade points in the course. The analysis established that AQS ML could statistically significantly predict final grade points (%) in the course (F1, 91 = 5.486, P < .05).

**Adult Health Course Grade and HESI Scores**

We also explored the relationship between final course grade points and the HESI E² score. The analysis revealed a significant positive correlation between the HESI E² score and final grade points in the course (r100 = 0.383, P < .01). Thus, the higher a student’s final number of grade points is (out of 100), the higher his/her HESI E² score when he/she took it in the final semester.

**HESI Outcome Groups**

Students who used the AQS (n = 92) were divided into 3 groups for subsequent analyses. These groups were created based on the number of attempts required by students to pass the HESI E². The goal was to explore similarities and differences on study outcomes, including AQS use among these 3 groups.

A 1-way Welch analysis of variance (ANOVA) revealed a statistically significant difference in overall ML across the 3 HESI groups (Welch F2, 32.13 = 7.77, P < .01). Mastery level decreased from group 1 (mean [SD], 4.68 [1.67]) to group 2 (mean [SD], 4.27 [1.95]) to group 3 (mean [SD], 2.97 [1.19]). A Games-Howell post hoc analysis revealed a significant difference between groups 1 and 3 (P < .005), as well as between groups 2 and 3 (P < .05). There was, however, no significant difference between groups 1 and 2.

A similar analysis was conducted comparing the number of questions answered within the AQS between groups. A 1-way ANOVA found a significant difference in number of questions answered based on HESI group (F2, 89 = 4.228, P < .05). There was a significant difference between the mean number of questions answered between group 1 (mean, 1274) and group 3 (mean, 622.64),
Retention and Persistence to Graduation

Program completion rates were analyzed for the year including the study cohort (academic year 2011) and the 4 previous years. Table 2 shows the percentage of students completing the program each year as well as time to graduation. On-time graduation is defined as graduating in 6 or fewer semesters.

Results of a $\chi^2$ analysis revealed a significant trend in on-time graduation rates between 2007 and 2011 ($\chi^2_1 = 8.06, P = .0045$). On-time graduation rates increased between 2007 and 2011 and were the highest for the 2011 group. In the study cohort (a subset of academic year 2011), there was an on-time graduation rate of 71.13% and an overall program completion rate of 72.16%. These data represent the highest on-time graduation rate since 2007. The 2011 year also had the smallest number of students ($n = 7$) remaining in the program 7 or more semesters (Table 2).

Student Surveys

Completion rates for the survey measures were 75% for survey 1, 59% for survey 2, and 17% for survey 3. Survey 2 focused on student self-reported use of the AQS and opinions about features and need for improvement. The Table, Supplemental Digital Content 1, http://links.lww.com/NE/A261, summarizes findings from survey 2 relating to use of the AQS and rating of the features.

Students also were asked to indicate how much they valued certain features of the AQS. More than 80% of the respondents indicated that the large number of practice questions, the adaptive functionality, the ability to track progress throughout the year, and Web-based convenience were “extremely important.” Mastery levels were seen as “extremely important” by 67.8%, and close connection of the tool to the textbook, by 74.14% of respondents. Only 1 student rated the features of the AQS as not important at all. When asked if using the AQS improved course performance, 21 students provided additional information in an open-response format. Of these students, 7 indicated that the AQS helped them better master course content, and 3 indicated the AQS helped them identify weak areas and remediate, among others.

NCLEX Outcomes

The purpose of this study was first and foremost to explore the use of the AQS within a nursing course, but we also were interested in how use of the AQS could impact student completion of the program and progression to the next phase of their career. Eighty-nine students in the study group passed the NCLEX on the first or second attempt, and 4 students failed. Looking only at students who used any version of the AQS ($n = 95$), 84 students passed the examination, and 4 did not pass. Of this group, 3 used only the NCLEX AQS, 59 students used both, 33 students used the AQS only during the first Adult Health course, and 5 students had no use. We did not have NCLEX information for 7 of the participants.

Discussion

Overall, findings from this retrospective study support the use of an AQS to augment student learning and engagement within nursing programs. Our primary objectives

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Enrollment</th>
<th>On-Time Graduation, n (%)</th>
<th>7, n</th>
<th>8, n</th>
<th>9, n</th>
<th>10, n</th>
<th>Overall Completion Rate, %</th>
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</thead>
<tbody>
<tr>
<td>2007</td>
<td>191</td>
<td>109 (57.1)</td>
<td>15</td>
<td>3</td>
<td>9</td>
<td>2</td>
<td>66.5</td>
</tr>
<tr>
<td>2008</td>
<td>181</td>
<td>101 (55.8)</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>68.2</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>195</td>
<td>123 (63.1)</td>
<td>15</td>
<td>3</td>
<td>1</td>
<td>74.2</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>221</td>
<td>142 (64.3)</td>
<td>5</td>
<td>2</td>
<td>72.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>200</td>
<td>137 (68.5)</td>
<td>15</td>
<td>3</td>
<td>2</td>
<td>72.0</td>
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</tr>
</tbody>
</table>
were to explore use of the AQS and the relationship to student performance in the accompanying course and program completion.

In the Adult Health course, most students took practice quizzes within the AQS, and some continued using the program after the course was over. Students who engaged with the AQS, and more importantly achieved higher MLs by answering more difficult questions, had greater success in the course.

The AQS ML was a significant predictor of the final grade points in the course, whereas number of questions answered was not. In an adaptive quizzing environment, the most important factor is not the number of questions a student answers, but rather the ML attained. A higher-ability student may progress to a higher ML in a shorter time (with fewer questions) than a lower-ability student will—and this illustrates the efficiency of an adaptive system. Number of questions, therefore, can provide information on engagement with the system but is not necessarily associated with overall mastery.

The study cohort had an on-time graduation rate of 71.13% and an overall program completion rate of 72.16%. These data represent the highest on-time graduation rate in the past 5 years (considering data available since 2007). Previous years had on-time graduation rates of between 57.06% and 64.25%. The 2011 year also had the lowest number of students remaining in the program 7 or more semesters. This latter finding is important given the previous years’ pattern in which a larger percentage of students remained in the program for more than 6 semesters, repeating courses in which they had been unsuccessful. Indeed, the 2010 graduating cohort had 22 students in the program for 7 or more semesters. This pattern of course failure and repetition is likely to result in higher student dropout and low morale.

At the study school, the HESI E² is used to help evaluate student readiness for passing the NCLEX-RN. Given the high-stakes nature of the HESI E², we were interested in how data on student mastery in the AQS was associated with HESI E² outcomes. Our results indicated that higher AQS ML and use were associated with success on the HESI E². This relationship is significant as the HESI E² plays a high-stakes role at the study school. If use of the AQS during the nursing program can help students achieve the passing standard, students will be required to retake courses and delay graduation.

Students provided feedback in the survey on their use and opinions on the AQS. Of the 59 of 100 students who responded, most indicated that use of the AQS improved their performance in the course and that they would use it in another course if given the option. Most of the students also indicated that the AQS was helpful in preparing for examinations, getting feedback on strengths and weaknesses, and increasing their knowledge of course concepts. Students who provided additional information on perceived benefits of the AQS indicated factors such as decreased test anxiety, identifying areas for remediation, and the opportunity for ongoing practice as beneficial features.

Conclusion

This study reflects early efforts to examine ways to help students remain engaged and achieve success in nursing programs. Although there are various measures and indicators of student achievement and progress, all provide different types of data at different times during the nursing program. Early, ongoing feedback can be used proactively to help students strengthen areas of weakness before they move too far along in a course or program. Information indicating a student did not meet a particular benchmark (eg, HESI E²) can be useful—but only if there is time for the information to be used to shape remediation in a formative way.

The results of this study support implementation of a low-stakes, proactive learning strategy, such as the AQS, and suggest that it can pay off significantly with respect to high-stakes educational outcomes and reduce the likelihood of course failure and repetition. In this study, students who engaged with the AQS, and more importantly who achieved higher MLs, had greater success in the Adult Health course. We studied AQS implementation in only 1 course, and thus, the cumulative effects of use might be greater or might plateau. Regardless, this is a promising finding and suggests that implementing an AQS is a strategy to help students complete and pass nursing courses and remain engaged in their learning outside of class time. One student noted that using the AQS daily over the summer helped to keep track of strengths and weaknesses and formulate a study plan, which helped the student pass the HESI E².

Determining how to best implement the AQS is another consideration. To ensure that all students use the tool, faculty could consider creating regular, required assignments or associate a participation grade with quiz answering activity. A clear policy stating standardized use of the AQS can be beneficial to both faculty and students in improving critical thinking, test-taking skills, course and program outcomes, and NCLEX success. We hope that the results of this study will add to the knowledge base on the implementation of online adaptive study tools to help support teaching and learning and improve student outcomes and retention.

References

Writing Prompts

Writing prompts heighten students' interest in writing and kick-start creativity. Nurse educators can (1) use metaphors to generate a deeper level of thinking and ask students to (2) make connections, (3) support with evidence, (4) question assumptions, (5) compare, (6) take a stance and develop an argument, (7) dismantle the argument, and (8) analyze the opposing view. The following prompts provide a practical illustration of how they may be applied using the subject of hand hygiene. (1) “Hand hygiene is germ warfare: explain this metaphor.” (2) “Make the connection between noncompliance with hand hygiene practices and the spread of infection.” (3) “In most health care settings, adherence to recommended handwashing practices is low: support this claim with evidence.” (4) “Question the assumption that, if properly implemented, hand hygiene can significantly reduce the risk of cross-transmission of infection.” (5) “Compare hand hygiene protocols: soap and water versus alcohol-based hand sanitizer.” (6) “Make an argument to teach patients to observe if health care providers wash their hands or use an alcohol sanitizer before care.” (7) “Break down the argument by answering ‘why.’” (8) “Provide an opposing view to that statement with a rationale.” Providing nursing students with these writing prompts will not only help them gain confidence and improve their writing but also will make writing fun.

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