A comparison of sonography and radiography student scores in a cadaver anatomy class before and after the implementation of synchronous distance education

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Abstract

Distance education is a solution to expand medical imaging education to students who might not otherwise be able to obtain the education. It can be a mechanism to reduce the health care worker shortage in underserved areas. In some cases, distance education may be a disruptive technology, and might lower student performance. This study compares student scores in a cadaver anatomy course in the four cohorts preceding the implementation of distance education to the first three cohorts that took the course using a multiple campus design. The means and medians of the lecture exam average, the laboratory component score, and the final course score of the nondistance education cohorts were compared with those of the distance education cohorts using nonparametric statistical analysis. Scores in an anatomy course were compared by campus placement among the distance education cohorts, and the independent effect of distance education on the laboratory component, lecture examination average, and final course scores, while controlling for cumulative grade point average and site (originating/distant), was assessed. Students receiving the course in a nondistance education environment scored higher in the anatomy course than the students who took the course in a distance education environment. Students on the distant campus scored lower than students on the originating site. Distance education technology creates new opportunities for learning, but can be a disruptive technology. Programs seeking to implement distance education into their curriculum should do so with knowledge of the advantages and disadvantages.

Keywords: Distance education, originating site, distant site, student performance, sonography, education

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Introduction

Technology in education has been viewed as a solution to the education crisis in the United States. US News and World Report stated that technology was capable of revolutionizing education in the United States by reducing costs both through online technology and by creatively finding new ways to learn with technology.¹ Wilson and Aagard suggest that sonography education can easily incorporate mobile learning through the use of technology such as applications on smart phones and tablet devices as well as through using social media and cloud computing.² They propose that technology should be explored as a means to promote learning.² Although, technology creates opportunities for students to learn in new ways, introducing it in the classroom without considering

potential disruptions could inhibit student learning rather than promote it.

Online and distance education (DE) are common ways that universities incorporate technology into education. Asynchronous DE occurs when the learner and the instructor do not interact at the same time or in the same place, such as an online class. Synchronous DE implies that the learners and the instructor are together at the same time, but are separated by geography. In the latter example, multiple campuses can be connected through the use of technology including computers, streaming video, and microphone/voice technology that allow all the connected classrooms to communicate in real time. The instructor resides at the originating campus and can instruct students who reside at the distant campus/campuses with the aid of

this technology. Colleges and universities implement DE programs because they are a mechanism to increase enrolment with minimal additions to faculty and staff, or when physical classroom or laboratory space is limited.³⁻¹⁰ Additionally, DE addresses the global health care workforce shortage in underserved areas by meeting the health care work force education needs, and technology provides an opportunity to reduce costs by pooling resources.^{3-8,10-13}

When DE is part of the learning environment, students should enter their training programs with the expectation that they can be successful while in the program, and after graduation. One concern with DE in health care professions is that students who complete the program should be able to pass board, licensing, or credentialing examinations regardless of the campus where they receive instruction. Grade point average (GPA) and preprofessional admission tests have been used as predictors of student success during their training programs and graduation rates.^{8,14,15} For students in professional health care training programs, the ability to pass basic sciences courses such as gross anatomy, pathology, or pharmacokinetics courses is also cited a predictor of passing board, licensing, and certification examinations.^{8,14,15} Ideally, for programs that have students on more than one campus, the cohorts should have similar entering admissions statistics for an equal chance at success, regardless of campus placement.

Student performance in a DE environment

The pharmacy, medical, dental, and nursing literature has robust documentation concerning student performance in a DE environment; there is less research in the field of medical imaging education. The available research is a predominantly retrospective analysis of dependent variables such as grades in a course, graduation rates, or pass rates on certification exams compared to the independent variable of campus location. Several researchers have looked at these student performance variables in a DE environment with mixed results. In some studies, the originating site has better program performance regardless of admissions characteristics.^{16,17} In other cases, the far site performs better.^{18,19} However, the majority of the research demonstrates no difference in classroom performance and student outcomes regardless of campus location.^{4-9,15,20-27}

In studies that found differences between campuses, the researchers identified student traits that might contribute to their successes or their failures. Age and maturity are often associated with learners on the distant campus, and both have been implicated as reasons for success as well as failure.¹⁶⁻¹⁹ Students on a distant campus appear to be more likely to have employment in addition to university studies, and they may have more family demands.^{6,16,18,19} Learners at the distant site might also encounter challenges in establishing rapport with the instructor due to lack of face-to-face interactions.^{18,19,28} They may demonstrate a tendency to pay less attention because the instructor is not in the room or a reluctance to ask questions using video-conferencing equipment.^{24,29}

When technical issues arise, the inclination is to view them as disruptive to the distant site, with little attention

paid to their impact on the originating site. It is assumed, since the instructor is in the classroom with the students on the originating site that they are not in a truly DE environment. However, when technical difficulties occur, the originating site is subject to the same delays and interruptions while the instructor attempts to resolve the issues.³⁰ Students on the originating site experience DE, but do so differently from the students on the distant campus. Although many researchers examined academic performance in a DE environment by comparing the academic performance of students on an originating campus to a distant campus, no studies have looked at the academic performance of all students in a class before and after the implementation of DE without regard to campus placement. This type of comparison could show whether or not DE itself is a disruptive technology that can influence student performance regardless of proximity to the instructor.

Sonography education in the United States compared to the United Kingdom

The United States is similar to the United Kingdom in its lack of national education or credentialing standards for entry-level sonographers.³¹ Sonography education in the US differs in that the path to become a sonographer does not depend upon completion of radiography education first, nor does it require postgraduate training.³¹ Sonography education in the US can be achieved by attending any training program that may be academic based such as an associate's degree from a community college or bachelor's degree from a university. Career training may also occur through certificate programs offered by community colleges or vocational educational programs.³² The most important aspect of sonography education in the US is that the training program is accredited by The Commission on Accreditation of Allied Health Education Programs (CAAHEP), the accrediting body for programs of diagnostic medical sonography.³² There is not a minimum length of training time or a minimum degree standard, and all students completing accredited training programs have equal opportunity for employment. Students who come from CAAHEP accredited programs may take the American Registry of Diagnostic Medical Sonographers (ARDMS) credentialing examinations without a waiting period.³³ Individuals who do not graduate from CAAHEP-accredited programs may have to work supervised for a year under a credentialed sonographer before they can take the ARDMS-credentialing exams,³³ but they may have difficulty finding an employer who will allow them to work up to a year without a credential.

In medical imaging in the United States, the Joint Review Committee on Education in Radiologic Technology lists 35 accredited radiography programs that contain a DE component, but it does not specify whether the DE is synchronous or asynchronous.³⁴ The CAAHEP lists three accredited sonography programs as having online DE, and it does not include synchronous DE programs as part of the DE category.³² In the United Kingdom, the Consortium for the Accreditation of Sonographic Education³¹ identifies 16 institutions that can grant postgraduate sonography

education, and of those institutions, six offer DE, but it does not detail what kind of distance learning is offered.³¹ Therefore, it is difficult to know how many medical imaging programs in the United States or the United Kingdom use synchronous DE technology.

Global health care worker shortage

In the United States, the US Bureau of Labor Statistics reports that the field of diagnostic medical sonography will grow by approximately 42,700 jobs between 2012 and 2022.³⁵ This growth rate of 39% is above average, and exceeds the growth rate of radiography and MRI, nuclear medicine, and radiation therapy, which have expected growth rates of 21%, 20%, and 24%, respectively.^{36–38} The growth rate in all medical imaging and radiation sciences professions in the US is primarily attributed to an aging population and increased access to health insurance that will allow increased access to health care.^{35–38} The shortage of sonographers, however, extends beyond the United States, with The Australian Sonographers Association expressing that the growth in workforce has not kept pace with the demand in that country.³⁹ Finally, the Society and College of Radiographers in the United Kingdom also outlines efforts to increase the number of sonographers in order to meet the demand for services.⁴⁰

Program design and expansion

To address the health care workforce shortage of medical imaging professionals in all medical imaging modalities, a university in the southwest United States expanded its bachelor's degree program in medical imaging and radiation sciences to a satellite campus 90 miles from the main campus. The department is unique in that it offers bachelor's level education in four medical imaging and radiation sciences disciplines: radiography, sonography, nuclear medicine, and radiation therapy. Students apply to one of the four disciplines, and rarely do students complete education in more than one discipline. The sonography and radiography disciplines were selected to expand to the distant campus with sonography going the first year, and radiography joining one year later. These two programs were selected based on community demand and the availability of state funding.

Synchronous DE through real-time video conferencing provides the didactic course work to the students on the distant campus. Typically, the originating campus broadcasts the didactic lectures to the students on the distant campus. There are instances in which the instructor on the distant campus broadcasts classes from the distant site to the main campus/originating site. Several health care professional programs from the main campus, including pharmacy, nursing, physical therapy and occupational therapy previously opened programs on the distant campus using the same DE technology about six years prior to this program's expansion.

Admission into any of the four medical imaging programs is a competitive process through the calculation of an admission score (ranging from 0 to 100) based on the

following criteria: cumulative GPA (based on a 4.0 scale) at application time, science prerequisite GPA, last 60 hours of coursework GPA, and a written interview (scored on a scale of 0–100). After the admission score is calculated, the number of available student positions is determined, and students are admitted based on their admission score and how many positions are available. Admission to the sonography program on the distant campus in the inaugural year was achieved by admitting students from the wait-list, meaning they had lower admissions scores than originally available slots. In the subsequent years, students on the distant campus were admitted based on their rankings.

Students who accept their admittance into the program are enrolled in the introductory five credit hour gross anatomy course with a cadaver laboratory that has been a part of the program curriculum since the 1970s. Students must pass anatomy with a 70% or higher final course score in order to continue enrolment in the department. Since success in basic sciences education courses has been cited as predictors of future success in an academic program,^{8,14,15} this course was chosen to analyze whether DE technology impacts student scores.

The instructor had taught the anatomy course for approximately 30 years, and had 7 years' experience teaching in a DE environment prior to implementing it into this course. The anatomy course score was comprised of the average of six semester examinations that were based on the lecture material and a laboratory component, which included weekly laboratory quizzes and a comprehensive laboratory final examination. The lecture examination average comprised 60% of the overall final course score, and the laboratory component made up the remaining 40% of the final course score.

Once DE was implemented, all lectures were conducted using video-conferencing technology with the instructor on the originating/main campus. The examinations were based on information presented during the DE lectures. However, the laboratory component was different for the two campuses. During the years that there was no DE, all students took the laboratory component from the instructor who also gave the lectures. Once DE was implemented, the laboratory component of the course was not conducted in a DE environment. The course instructor remained the laboratory instructor for students on the originating campus. The first two cohorts on the distant campus traveled to the originating site weekly and had laboratory with the course instructor, but they took laboratory quizzes separate from the students on the originating campus. In the third year, the distant site had its own onsite laboratory and instructor. Although in the third year of DE, the laboratories were separate by campus and had different instructors, the instructors communicated with each other, followed the same agenda and covered the same content each week.

Methods

To determine the influence of DE on student performance, scores from the anatomy course for the four student cohorts preceding the implementation of DE, were compared with

the scores from the first three student cohorts that used DE. The admission rosters from all the cohorts and the anatomy course grade spreadsheets were compiled. The admissions roster did not separate students by imaging discipline, and it is unknown as to which of the four imaging programs the students were enrolled. The admissions characteristics of overall GPA, last 60 hours GPA, science GPA, interview score, and total admissions score were entered into the spreadsheet for each student who was admitted into the program. Three of the anatomy grade components were entered into the spreadsheet: the average of the six semester anatomy lecture examinations, the laboratory component average, and the final course score (all on a scale from 0 to 100%). It was noted if the student experienced the anatomy course in a DE environment, and if the answer was yes, it was additionally noted if the student was on the originating or distant campus. In some cases, students may have been admitted into the department, but decided not to attend or withdrew from the anatomy course. The admissions characteristics were recorded and analyzed, but they were not included in the analysis of the anatomy grades. Identifying information was removed from the spreadsheet prior to data analysis and was not saved.

All data analysis was conducted using the SAS® (Carey, NC) 9.2 software package. Data were assessed for normality, and were deemed not normally distributed. Therefore, nonparametric tests were the most appropriate for analysis. Two-tailed tests with a significance level of 0.05 were used in the comparisons of the scores in the anatomy class. The mean and median scores for the lecture examination averages, laboratory component scores, and the final course scores were computed for the four non-DE cohorts (named non-DE 1-4) and for the three DE cohorts (named DE 1-3) and were compared using the Wilcoxon-Mann Whitney test. The DE classes were separated by originating site (instructor in the room) and the distant site (instructor seen on television), and the anatomy scores were compared using the Wilcoxon-Mann-Whitney test. The independent effect of DE on anatomy lab, lecture, and final scores while controlling for cumulative GPA and site (originating/distant) was assessed using iteratively reweighted least squares. Admissions characteristics for each class were compared using the Kruskal Wallis test. The University's

institutional review board approved this retrospective study.

Results

Seven cohorts with 462 students were included in the analysis of cumulative GPA, science GPA, last 60 hours GPA, interview score, and total admissions score. Of those students, 242 were in the non-DE cohorts, and 221 were in the DE cohorts. One student in the non-DE cohort did not have complete admissions records, and was not included in the analysis of the admissions characteristics. Therefore, there were 241 students in the non-DE cohorts with complete admissions records. There were 402 total students who, after admission, enrolled and completed the anatomy course. Two hundred and seven students were in the non-DE cohorts, and 196 students were in the DE cohorts. One student in the DE cohorts had incomplete anatomy records and was dropped from the analysis; leaving 195 student anatomy scores available for analysis. In the DE cohorts, 160 students were enrolled at the originating campus, and 35 were enrolled at the distant campus.

When the admissions data were compared for each of the cohorts, the comparisons showed that the cohorts admitted in the DE years had significantly higher entering cumulative GPA, science GPA, and last 60 hours GPA than the non-DE cohorts with the exception the non-DE Cohort 3, which had higher GPAs in all areas compared to DE cohorts 2 and 3, and had higher total admissions scores than DE cohort 3. The interview scores were not significantly different between the cohorts. Results of the comparison of admissions characteristics are displayed in Table 1. When admissions characteristics were compared by DE versus non-DE, the DE group had significantly higher cumulative GPA, last 60 hours GPA, and total admissions score. The science GPAs and interview scores were not significantly different between the non-DE and the DE groups. The comparisons of the non-DE admissions characteristics to those of the DE students are shown in Table 2.

When the anatomy scores of non-DE cohorts and the DE cohorts were compared, the non-DE group had significantly higher means and medians in all three areas: lecture examination average, laboratory component, and final course score (see Table 3). When only the DE cohorts were

Table 1 Admissions characteristics for students in the four non-DE cohorts and the three DE cohorts

Year	N	Cumulative GPA	Science GPA	Last 60 GPA	Interview score	Admission rank
Non-DE 1	53	3.33	3.09	3.31	83.9	81.45
Non-DE 2	64	3.42	3.23	3.45	81.6	82.66
Non-DE 3	61	3.45	3.19	3.48	83.71	84.81
Non-DE 4	63	3.58	3.41	3.58	81.59	85.89
DE 1	71	3.63	3.43	3.64	80.76	87.26
DE 2	76	3.55	3.33	3.55	81.51	86.57
DE 3	74	3.48	3.21	3.48	80.08	83.2
p Value		<.0001	0.0003	<.0001	0.24	<.0001

Note: DE, distance education; GPA, grade point average.

Table 2 Comparison of admissions statistics of the Non-DE cohorts to the DE cohorts

Admissions characteristics	Distance education class						
	No			Yes			
	<i>n</i>	Median (25th–75th%)	<i>M</i> (SD)	<i>n</i>	Median (25th–75th%)	<i>M</i> (SD)	<i>p</i> Value
Cumulative GPA	241	3.48 (3.24, 3.76)	3.45 (0.35)	221	3.58 (3.38, 3.76)	3.56 (0.29)	0.0024
Science GPA	241	3.32 (2.84, 3.64)	3.24 (0.51)	221	3.35 (3.00, 3.68)	3.33 (0.46)	0.0924
Last 60 hours GPA	241	3.54 (3.24, 3.76)	3.47 (0.38)	221	3.60 (3.40, 3.77)	3.56 (0.30)	0.0152
Interview score	241	82.5 (76.0, 88.0)	82.6 (8.67)	221	82.5 (75.0, 88.0)	80.8 (10.8)	0.2179
Total admission score	241	84.9 (80.7, 87.9)	83.8 (6.40)	221	86.0 (82.0, 89.9)	85.7 (6.53)	0.0043

Note: DE, distance education; GPA, grade point average.

Table 3 Comparison of anatomy scores of the Non-DE cohorts to the DE cohorts

Anatomy course scores	Distance education						
	No			Yes			
	<i>n</i>	Median (25th–75th%)	<i>M</i> (SD)	<i>n</i>	Median (25th–75th%)	<i>M</i> (SD)	<i>p</i> Value
Anatomy final grade	207	83.1 (76.4, 87.3)	81.9 (7.86)	195	79.1 (73.0, 84.6)	78.0 (9.82)	<0.0001
Anatomy lab grade	207	86.1 (80.7, 90.4)	84.6 (8.01)	195	81.1 (74.8, 87.2)	80.1 (10.4)	<0.0001
Anatomy lecture grade	207	86.1 (80.7, 90.4)	84.6 (8.01)	195	81.1 (74.8, 87.2)	80.1 (10.4)	0.0012

Note: DE, distance education.

Table 4 Comparison of anatomy grades between the originating site and the distant site for the DE cohorts

Anatomy course scores	Campus						
	Originating			Distant			
	<i>n</i>	Median (25th–75th%)	<i>M</i> (SD)	<i>n</i>	Median (25th–75th%)	<i>M</i> (SD)	<i>p</i> Value
Anatomy final grade	160	79.4 (73.2, 85.6)	78.6 (9.9)	35	75.9 (67.0, 82.1)	75.0 (8.8)	0.02
Anatomy lab grade	160	80.7 (74.6, 87.0)	79.6 (10.9)	35	83.3 (77.4, 87.3)	81.9 (7.1)	0.44
Anatomy lecture grade	160	78.7 (71.9, 85.0)	78.0 (10.2)	35	73.3 (60.8, 80.1)	70.4 (11.8)	0.001

Note: DE, distance education.

analyzed and compared by originating or distant campus, the originating campus had significantly higher anatomy lecture exam averages and final course scores. The anatomy laboratory scores were not significantly different between the two sites (see Table 4).

Regression analysis was performed on the response variables, anatomy lab scores, anatomy lecture scores, and final course scores to explore whether a significant independent effect of DE on the response variables existed while controlling for site and cumulative GPA. The non-DE cohorts scored, on average, 4.5 points higher in the anatomy lab ($p < .0001$), 2.8 points higher in anatomy lecture ($p = .0009$), and 3.5 points higher on the final course score ($p < .0001$) compared to the classes that used a DE environment. The location of site (originating vs. distant) did have a significant independent effect on the anatomy lecture exam scores ($p < .0001$) and the final course scores ($p < .0087$) after

controlling for other covariates, with the students on the originating site performing better.

Discussion

This study appears to be one of the first of its kind to investigate the influence of synchronous DE on student performance regardless of campus location. Further, in all instances of the literature, the focus has been to compare student performance between the originating and distant sites and to identify student traits such as maturity or academic aptitude that might explain the differences. No researcher appears to have studied DE technology as the variable that impacts student performance.

The results suggest that the students who were in the DE cohorts had higher GPA and science GPAs as compared to the students in the non-DE cohorts, but they did not have

higher scores in the anatomy course. This trend was not expected since higher GPA is often a predictor of better student performance. In the DE cohorts, there was a tendency for the originating site to perform better than the distant site, except for in the anatomy laboratory component in which there were not significant grade differences. However, the laboratory was not conducted using DE technology, and the comparison of the laboratory component scores between the cohorts may not address the question, "Does DE affect student performance?" However, the anatomy lectures were conducted using DE technology, and there were differences between the cohorts as well as between the originating and distant sites. Therefore, the null laboratory component findings may strengthen the argument that the DE technology is disruptive to the classroom experience.

Previous researchers have found that the GPA upon admission is an overall predictor of student success in a professional health care training program.⁸⁻¹⁰ Although this study did not intend to look for that type of association, the cohorts with higher GPAs did not score higher in the anatomy course, further suggesting the DE could be the reason for the poorer performance. This finding was demonstrated even after controlling for campus location and cumulative GPA. Other studies investigating student performance in DE curricula suggest that remote site learners are more passive²⁹ and stress the importance of teacher-student connectivity to achieve successful outcomes.²⁸ Interestingly, asynchronous distance technology such as bulletin boards that promote conversations among teachers and students may be superior at achieving this connection than synchronous video interactions.⁴¹ However, students who are involved in a DE curriculum report that attending synchronous video lectures help them stay focused on the material being presented,¹² which may foster greater success.

This study focused on students earning bachelor's degrees in medical imaging and radiation sciences at one university in the southwestern United States. Therefore, the results may not be generalizable to medical imaging programs that offer certificates, vocational training, or associates degrees, and it may not be applicable to the United Kingdom where sonography education tends to be offered as a postgraduate course. The results will not apply to universities or training programs that use asynchronous DE in their courses. Further, this analysis included students from four medical imaging disciplines, and since the researchers were blinded as to which scores were associated with students in each of the disciplines, it is not possible to relate these findings only to sonography students.

When this department incorporated DE into the curriculum, all courses converted to DE at one time, and it could be that the implementation of several courses in a DE environment at once caused further upheaval in student performance. This course was chosen for analysis because it is a large course, every student has to take the course, there was a level of consistency of instruction over several years and it had an instructor experienced in DE course delivery. Therefore, the findings were not likely affected by the instructor or factors related to his use of the technology.

The first cohort on the distant site was admitted from the bottom of the applicant pool, and overall anatomy scores in the first DE cohort could have been lower because of their lower admissions rankings. Additional factors such as student age, outside employment, grade inflation, or other unexplained and undetected factors in the prerequisite work could have artificially influenced the higher GPAs and/or lower anatomy scores for the DE cohorts and those students on the distant campus.

This study did not compare graduation rates, pass rates on credentialing examinations, or employment rates for the DE cohorts versus the non-DE cohorts, nor were these comparisons made between the students enrolled on the originating or distant campus. It is unknown if lower anatomy scores had any impact on the students' careers. Although not analyzed for significance in this study, this department's postgraduation analysis does not detect changes in graduation rates, pass rates on credentialing examinations, or employment rates after the implementation of DE. Further, no differences are observed between the graduates from the originating versus the distant campus. These observations are similar to the conclusions of a longitudinal study by Olmsted who compared pass rates of students in DE programs and found no significant difference.²⁶

Although this study found lower anatomy scores in a DE environment, one cannot draw conclusions about overall student success. Further research should be conducted to determine if student outcomes for graduation, credentialing, and employment are affected by the lower scores in the anatomy course. If the benchmarks for success are something other than scores in one course, and students are successful at meeting those goals, then it may not matter that the students scored lower in this environment. The students may find additional benefits from learning through DE technology, such as staying in their communities in order to train for a medical imaging career. Further, the community may benefit because there are more health care employees available to serve those areas.

Although further research beyond the first three cohorts following the implementation of DE into the department would help determine if these findings are sustained, the department performed a complete curriculum revision, and the consistency, which was the most attractive feature in the decision to analyze the scores of the anatomy course, is no longer present. The program could look at other large courses, but could not entirely replicate this research study internally if cohorts beyond the ones studied here were evaluated. The department could compare demographic data from students on both campuses to determine if age or family demands impact student performance on either campus. Finally, it would be interesting to learn if the lower scores in anatomy during the DE years were sustained and seen in other courses, or if student performance returned to previous levels as a result of the department adapting to the technology.

Conclusion

At a time when education is testing the limits on what can be accomplished with technology in the classroom, this

study serves as a cautionary consideration that the use of technology does not automatically equate to better learning. The introduction of technology into the medical imaging curriculum should occur when it is incorporated with a clear understanding of its limitations and benefits. Further, the impact of technology on the classroom should be continually evaluated. This department will continue to use DE as a means to deliver courses to sonography and radiography students at a distant location, but does so with awareness of both the positive and negative influences that technology has on student performance. The addition of technology to enhance learning should be used when it serves a purpose and with full recognition of its limitations.

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REFERENCES

- Reynolds GH. *How Technology Can Save Education*. US News and World Report. 6 March 2014. See <http://www.usnews.com/opinion/articles/2014/03/03/how-technology-can-save-american-education> (last checked 4 October 2014)
- Wilson M, Aagard SD. Exposing the gap between what is possible and what is acceptable: how M-learning can make a contribution to sonography education. *J Diag Med Sonogr* 2012;**28**:202–06. DOI: 10.1177/8756479312444349
- Parrott S. *Future Learning: Distance Education in Community Colleges*. Office of Educational Research and Improvement. (ED) No. ED 385-311. Washington DC: ERIC Document Reproduction Service, 1993
- Knapp DA, Roffman DS, Cooper WJ. Growth of a pharmacy school through planning, cooperation and establishment of a satellite campus. *Am J Pharm Educ* 2009;**73**:Article 102
- Steinberg M, Morin AK. Academic performance in a pharmacotherapeutics course sequence taught synchronously on two campuses using distance education technology. *Am J Pharm Educ* 2011;**75**:Article 150
- Congdon HB, Nutter DA, Charneski L, et al. Impact of hybrid delivery of education on student academic performance and the student experience. *Am J Pharm Educ* 2009;**73**:Article 121
- Sadoski M. The Texas A&M experience with class size and campus expansion: evaluation of first year using distance learning and on-site curriculum delivery. *Teach Learn Med* 2010;**22**:247–62
- Olmstead JL. Longitudinal analysis of student performance in a dental hygiene distance education program. *J Dent Educ* 2002;**66**:1012–20
- Gadbury-Amyott CC, Ding AH, Overman PR. Teaching with technology: learning outcomes for a combined dental and dental hygiene online hybrid oral histology course. *J Dent Educ* 2013;**77**:732–43
- Iwasiw C, Andrusyszyn MA, Moen A, et al. Graduate education in nursing leadership through distance education technologies: the Canada-Norway nursing connection. *J Nurs Educ* 2000;**39**:81–6
- Davies H, Hall DMB, Pullan C. The role of distance learning in specialist medical training. *Arch Dis Child* 2005;**90**:279–83. DOI: 10.1136/ad.2003.048835
- Groenwald RH, Knowl MJ. Learning styles and preferences for live and distance education: an example of specialisation course in epidemiology. *BMC Med Educ* 2013;**13**:93. DOI: 10.1186/1472-6920-13-93
- Szeto E. Bridging the students' and instructor's experiences: exploring instructional potential of videoconference in multi-campus universities. *Turkish Online J Educ Technol* 2014;**13**:64–72
- Alzahrani MJ, Thomson EM, Bauman DB. Predictors of student success in an entry-level baccalaureate dental hygiene program. *J Dent Hyg* 2007;**81**:51. PMID: 17570175
- Hayes SH, Fiebert IM, Carroll SR, et al. Predictors of academic success in a physical therapy program: is there a difference between traditional and non-traditional students. *J Phys Ther Educ* 1997;**11**:1–16
- Reid LD, McKenzie. A preliminary report on the academic performance of pharmacy students in a distance education program. *Am J Pharm Educ* 2004;**68**:Article 65
- Kidd RS, Stamatakis MK. Comparison of students' performance in and satisfaction with a clinical pharmacokinetics course delivered live and by interactive videoconferencing. *Am J Pharm Educ* 2006;**70**:Article 10
- Reid LD, Motycka C, Mobley C, et al. Comparing self-reported burnout of pharmacy students on the founding campus with those at distance campuses. *Am J Pharm Educ* 2006;**70**:Article 114
- Lentz TL, Monaghan MS, Wilson AF, et al. Using performance-based assessments to evaluate parity between a campus and distance education pathway. *Am J Pharm Educ* 2006;**70**:Article 90
- MacLaughlin EJ, Supernaw RB, Howard KA. Impact of distance learning using videoconferencing technology on student performance. *Am J of Pharm Educ* 2004;**68**:Article 58
- Fox BI, McDonough SL, McConatha BJ, et al. Establishing and maintaining a satellite campus connected by synchronous video conferencing. *Am J Pharm Educ* 2011;**75**:Article 91
- Cook CE, Merrifield HH. Distance learning outcomes for Texas Tech University's physical therapy program. *J Phys Ther Educ* 2003;**17**:74–7
- Bertsch TF, Callas PW, Rubin A, et al. Effectiveness of lectures attended via interactive video conferencing versus in-person in preparing third-year internal medicine clerkship students for clinical practice examinations. *Teach Learn Med* 2007;**19**:4–8. DOI: org/10.1080/10401330709336616
- Dubose TJ, Bittengle J, Donaldson R. Diagnostic medical sonography, interactive video, and distance learning. *J Diag Med Sonogr* 1997;**13**:146–52. DOI: 10.1177/875647939701300307
- Corum KA, Gadbury-Amyot CC, Johnson K, et al. US dental hygiene faculty perceptions of learner outcomes in distance education courses. *J Dent Educ* 2014;**78**:530–40
- Olmstead J. Application of a conceptual framework for distance learning in dental hygiene education and allied health disciplines. *J Dent Hyg* 2010;**84**:81–6
- Russel BL, Tekeselassie A, Turnbull D, et al. A comparison in academic performance between distance and on-campus students in allied healthcare education. *J Allied Health* 2008;**37**:e1–321
- Wong RY, Chen L, Dhadwal G, et al. Twelve tips for teaching in a provincially distributed medical education program. *Med Teach* 2012;**34**:116–22
- Ogrinc G, Splaine ME, Foster T, et al. Exploring and embracing complexity in a distance-learning curriculum for physicians. *Acad Med* 2003;**78**:280–5
- Harrison LC, Congdon HB, DiPiro JT. The status of US multi-campus colleges and schools of pharmacy. *Am J Pharm Educ* 2010;**74**:Article 124
- Consortium for the Accreditation of Sonographic Education. *Directory of Courses Accredited by the Consortium for the Accreditation of Sonographic Education*. 2014–2015. See <http://www.case-uk.org/index.html> (last checked 21 November 2014)
- Commission on Accreditation of Allied Health Education Programs. CAAHEP accredited program search. See <http://www.caahep.org/Find-An-Accredited-Program/> (last checked 3 October 2014)
- Prerequisite and SPI Requirement Information. American Registry of Diagnostic Medical Sonography website. See http://www.ardms.org/apply/prerequisite_spi_requirement_information/ (last checked 21 November 2014)
- Joint Review Committee on Education in Radiologic Technology. *Find a JRCERT accredited program*. See <http://www.jrcert.org/find-a-program/> (last checked 3 October 2014)

35. United States Department of Labor. Bureau of Labor Statistics. *Occupational Outlook Handbook. Diagnostic Medical Sonographers and Cardiovascular Technologists and Technicians, Including Vascular Technologists*. See <http://www.bls.gov/ooh/healthcare/diagnostic-medical-sonographers.htm> (last checked 21 November 2014)
36. United States Department of Labor. Bureau of Labor Statistics. *Occupational Outlook Handbook Radiologic and MRI Technologists*. See <http://www.bls.gov/ooh/healthcare/radiologic-technologists.htm> (last checked 21 November 2014)
37. United States Department of Labor. Bureau of Labor Statistics. *Occupational Outlook Handbook Nuclear Medicine Technologists*. See <http://www.bls.gov/ooh/healthcare/nuclear-medicine-technologists.htm> (last checked 21 November 2014)
38. United States Department of Labor. Bureau of Labor Statistics. *Occupational Outlook Handbook Radiation Therapists*. See <http://www.bls.gov/ooh/healthcare/radiation-therapists.htm> (last checked 21 November 2014)
39. The Australian Sonographer Association. *The Future of Sonographer Education in Australia*. 15 April 2011. See http://www.a-s-a.com.au/file_rep/ceo-discussionpaper-sonographereducationfinal-110420.pdf (last checked 21 November 2014)
40. Thomson, N. *Developing and Growing the Sonographer Workforce: Education and Training Needs*. Professional document. 13 November 2009. The Society and College of Radiographers. See <http://www.sor.org/learning/document-library/developing-and-growing-sonographer-workforce-education-and-training-needs> (last checked 21 November 2014)
41. Mash RJ, Marais D, Van Der Walt S, et al. Assessment of the quality of interaction in distance learning programming utilizing the internet (WebCT) or interactive television (ITV). *Med Educ* 2005;**39**:1093–100