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Data Mining for Adverse Drug Events

Impact on Six Learning Styles

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Emerging technologies and big data influence the role of nurses, calling for new ways of thinking and teaching. Innovative educational methods are needed to prepare students for providing evidence-based care in today's complex healthcare environment. Active learning methods appeal to tech-savvy, self-directed learners who desire instant results during the learning process. The aim of this pretest/posttest study was to evaluate the impact of active learning methods on student attitudes and feelings, using the Grasha-Riechmann Student Learning Style Scale. Results were used to tailor active learning interventions using Twitter and Federal Adverse Event Reporting System data, for a research and evidence-based practice nursing course. Participants (N = 126) evaluated tweets describing adverse drug events and their concordance with federal reporting system data. Paired-samples *t* test results revealed significant differences ($P < .05$) between pretest/posttest for five of the six learning style preferences. Active learning methods resulted in high levels of student engagement and satisfaction. Data mining as an active learning intervention is popular with learners and offers a quick, valuable way to reveal real-world adverse drug event experiences while introducing basic research principles.

KEY WORDS: Active learning, Big data, Grasha-Riechmann Student Learning Style Survey, Informatics/information technology, Twitter

Scientific advances, new technologies, and volumes of big data are influencing the role of nurses, calling for new ways of thinking and teaching.[1–3] Innovative educational models are needed to prepare practitioners to provide safe, cost-effective, evidence-based care in today's complex, rapidly changing healthcare environment.[4] Meanwhile, students report that they get more actively involved in courses that use technology and that use of technology contributes to successful completion of courses.[5] Active learning methods (eg, exploration of attitudes and values; engagement in self-directed group activities involving discussion; data collection and analysis; emphasis on developing skills; involvement beyond listening) appeal to tech-savvy learners who desire instant results when applying information.[3,6,7] These "digital natives" expect to use a variety of technological approaches to enhance their learning, have grown up participating in group projects, and are accustomed to receiving group grades with immediate feedback.[3,6] Today's learners prefer working in teams; nursing faculty must be prepared to acknowledge and assist students as they encounter Tuckman's[8] four stages of group development (ie, form, storm, norm, and perform), which might affect group performance. A desire for instant gratification and preference to learn by observation and practice can be a barrier to critical thinking—which has significant implications for how faculty members deliver course content.[3,6] Mobile technology; interactive, group-focused learning methods; and use of social media offer ways to engage these learners.[3,6] Through active learning, students can apply basic research principles and learn about adverse drug events and common issues encountered when working with data. Active learning methods can help students connect key concepts, resulting in higher knowledge retention, enhanced critical thinking, and clinical judgment.[6,7]

Although nurses play a critically important role in ensuring patient safety by reporting adverse drug reactions, to our knowledge, no evidence exists to support the use of data mining as an active learning strategy to apply principles of research, evidence-based practice (EBP), and pharmacovigilance in nursing education. Learning style inventory results can be used for tailoring learning activities that will empower students to become active learners and successful participants in their education.[9–12] The Grasha-Riechmann Student Learning Style Scale (GRSLSS), originally developed in 1974, was designed to identify learner preferences for interacting with peers and instructors in the classroom setting.[13] The six learning styles in this model (ie, competitive, collaborative, avoidant, participant, dependent, and independent) describe a blend of characteristics, shaped by a

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learner's past experiences, and apply to all students.[13] These learning styles provide a conceptual rationale for designing group projects and activities and for balancing a variety of instructional approaches to meet learning needs. Although learners prefer certain styles, these preferences can be modified or changed, depending on how the instructor designs the course.[13] The history and evolution of the GRSLSS can be best understood by reviewing the work of the survey developers, Grasha[11] and Riechmann and Grasha.[13]

The aim of this study was to evaluate the impact of active learning methods on student attitudes and feelings, using the GRSLSS. To achieve this aim, we used the GRSLSS General Class Form as a pretest to assess attitudes and feelings toward courses that students had taken up to that point in college. We used the GRSLSS Specific Class Form as a posttest and outcome measure to assess the impact of active learning instructional practices on the learning styles of the students enrolled in a research and EBP nursing course.

BACKGROUND

The Framework for Information Literacy for Higher Education was developed to guide faculty in the development of curricula that infuses information literacy concepts and skills that can be applied in today's dynamic healthcare environment.[14] This framework was chosen to guide the selection of active learning methods that could accommodate diverse learning style preferences and is based on a cluster of six flexible, interconnected concepts central to information literacy (Figure 1): *Research as inquiry* (iterative, depends upon asking complex questions); *information has value* (including as a commodity, reflects legal/socioeconomic interests); *authority is constructed and contextual* (reflecting creator's credibility); *information creation as a process* (iterative processes of creating, revising, disseminating); *searching as strategic exploration* (iterative searching, evaluating a range of information sources); and *scholarship as conversation* (engage in new insights, discoveries as a result of varied perspectives).[14] This framework offers a vision of information literacy as an overarching set of abilities in which students are consumers of information who learn to use information and information technologies ethically, legally, proficiently, and collaboratively.[14]

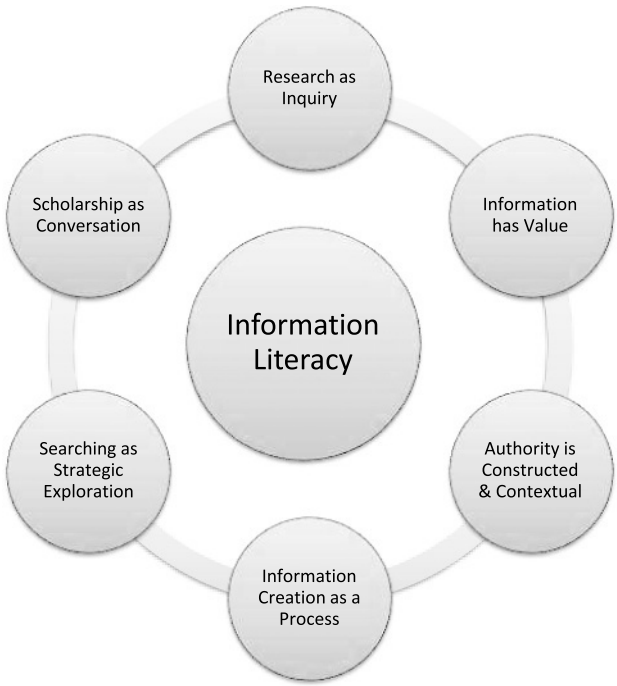

FIGURE 1. Schematic representation of Information Literacy conceptual framework based on Framework for Information Literacy for Higher Education described by the Association of College and Research Libraries, 2015, pp. 1–18.

We highlight active learning methods that appeal to each learning style and align with concepts from the Framework for Information Literacy for Higher Education, illustrating how students learn information literacy, basic principles of research, and EBP, while emphasizing the important role that nurses play in pharmacovigilance. Using active learning methods designed to appeal to all six learning style preferences, groups of students apply principles of the research process by comparing the concordance of adverse drug events between two sources of big data. In this course, nursing students with limited clinical and research experience develop higher-order thinking skills (eg, analysis, synthesis, evaluation)[1,6] while learning about adverse drug events from the US Food and Drug Administration Adverse Event Reporting System (FAERS) and Twitter data (Information Literacy concepts: *research as inquiry*, *information has value*, *searching as strategic exploration*). Through data mining adverse drug events, students quickly gain practical insights (eg, medication costs, off-label use), an appreciation of limitations surrounding self-reported data, and common pitfalls that may occur when interpreting findings extracted from big data (Information Literacy concepts: *scholarship as conversation*, *information creation as a process*).

The US Food and Drug Administration (FDA) safety information and adverse event reporting program offers a publicly available database that contains information on adverse drug event and medication error reports submitted to the FDA since 1969.[14] The FDA receives adverse event reports directly from healthcare professionals (eg, physicians, pharmacists, nurses) and consumers (eg, patients, family members, lawyers). Healthcare professionals and consumers may also report adverse events and medication errors to product manufacturers, who are then required to report the event to FAERS.[15] Adverse drug events and medication errors are standardized according to terminology in the Medical Dictionary for Regulatory Activities to facilitate the sharing and comparison of regulatory information for medical products, including pharmaceuticals.[16]

However, data entered for drug names—which often include additional useful information such as dose, units, form, route, and generic/brand name—are stored in the database exactly as entered by users and therefore may be missing key information (Information Literacy concept: *authority is constructed and contextual*). This activity stimulates higher-order thinking skills necessary to question the validity and reliability of FAERS data, prompting just-in-time discussions on tolerating uncertainty.

The FAERS Public Dashboard offers an interactive Web-based tool that allows queries of FAERS data (eg, report year, report type, reporter, reporter region, report seriousness, product, demographics such as age, gender, year) in a user-friendly fashion.[17] The intent of this dashboard is to expand access to FAERS data to allow the public to search for adverse events reported to the FDA. Despite containing more than 14 million adverse event reports, the consensus is that FAERS captures approximately 10% of adverse events and suffers from underreporting and processing delays,[17–19] with implications for healthcare providers who rely on FAERS data to obtain current adverse drug event information.

Consumers are discussing adverse drug events in real time, on Twitter, and these data are immediately available. Twitter (San Francisco, CA) is a popular social network where users can share short messages (tweets). Hosting nearly 500 million tweets per day, Twitter represents a rich stream of data shared in real time.[20] Discussions of adverse drug events on Twitter have created a real-time method for pharmacovigilance, which even with its challenges and limitations can offer important information to healthcare providers that may not be reflected in traditional reporting systems.[17,21] Evidence of this trend is emerging in pharmaceutical and medical literature, and this evidence can also be applied in nursing.[18,21–24]

METHODS

Subject Characteristics

Participants included undergraduate students aged 18 years or older; no demographic information was collected. Exclusion criteria were any students under age 18 years and those not interested in participation. Most students were middle-class, Caucasian women who spoke English as their first language.

Sample Size and Sampling Procedure

Students were enrolled in a research and EBP course at a large Midwestern university as of spring 2017. For this convenience sample (N = 126), all students chose to participate. Students were advised that participation in the study was optional and that participation or nonparticipation would not affect their grade in any way. No incentives were offered for participation. Before the study began, university institutional review board approval was obtained (Protocol #1611018477).

Research Design

The pretest/posttest survey used in this study was administered by a doctorally prepared faculty member during a class period. The course was held in a computer laboratory to allow active participation in experiences that required Internet access. Using a "flipped classroom"[7] instructional strategy, participants were placed into groups of four to six members and were expected to come to class prepared to apply assigned readings in group activities.

Measures

Participants completed an electronic GRSLSS to identify their learning style preferences. Participants were provided information about the survey and advised that Internet protocol addresses would be deleted prior to analysis, to preserve anonymity. Survey data were downloaded, scored, and analyzed using IBM SPSS Statistics version 23.0 (IBM, Armonk, NY). Paired-samples *t* test results were used to evaluate the impact of the active learning interventions on student scores on the GRSLSS. Cohen's *d* was calculated to determine the magnitude of the intervention's effect (small effect = 0.2, medium effect = 0.5, and large effect = 0.8) on six learning styles. We planned to exclude any cases/responses with missing values, and the level of significance was set at $P < .05$, a priori.

The Grasha-Riechmann Student Learning Style Scale

Learning style inventory results can be used to empower students to become active learners and successful participants in their education.[9–13] The GRSLSS was developed to identify learning style preferences based on characteristics that apply to all students: *independent* (students who prefer to think for themselves); *dependent* (look to authority figures for guidelines; wants to be told what to do); *collaborative* (students who feel they learn the most by sharing ideas, talents; like to work with others); *competitive* (those who feel they must compete with others for the rewards of the classroom, such as grades and teacher's attention); *participant* (those who want to learn content and like going to class; take responsibility for learning and participates with others); and *avoidant* (those who are not interested in learning course content in the traditional classroom; disinterested and overwhelmed by what goes on in class).[11,13] See Figure 1 for descriptions of the six GRSLSS learning styles, preferences, and examples of active learning methods used in this study. Previous studies have noted that students representing different majors tend to have different learning style preferences. For example, Mahamod et al,[25] in a sample of native and nonnative Malay science students, found that they tend to prefer independent learning. Riechmann and Grasha[13] noted that for the participant-avoidant dimensions, opposite scores tend to be consistently observed and that most students show some degree of

preference for each of the categories and do not adopt any one style exclusively. Studies by Novak et al[12] and by O'Faithaigh[26] found that females score higher in the collaborative learning styles than male students. Riechmann and Grasha[13] and Hamidah et al[27] found that students from urban areas score higher in the avoidant and competitive learning styles, as opposed to those from rural areas. Grasha[11] recommends varying classroom activities to encourage adaptability and lifelong learning and to expose students to familiar and unfamiliar ways of learning.[11,13]

The 60-item GRSLSS was selected to determine student learning styles as it has been used successfully with college students,[9–13] explores attitudes and values that appeal to learners, and can be quickly administered. Furthermore, the GRSLSS measures cognitive and affective behaviors at the undergraduate level and beyond and has been found to yield good/high validity and reliability (ranging from 0.58–0.89) across all scales.[13,25–31] Finally, we selected the GRSLSS for its ability to measure the impact of active learning methods used in our course.

Grasha-Riechmann Student Learning Style Scale Pretesting

During Week 1, the GRSLSS General Class Form[11] pretest was administered in class via Qualtrics survey (Qualtrics, Provo, UT), to assess attitudes and feelings toward courses taken previously. Participants were asked to rate attitudes and feelings using a 5-point Likert scale (eg, 1 = strongly disagree, 5 = strongly agree). Example statements are the following: (1) "I prefer to work by myself on assignments in my courses"; (2) "I often daydream during class"; (3) "Working with other students on class activities is something I enjoy doing."

Grasha-Riechmann Student Learning Style Scale Posttesting

During Week 4, participants were instructed to assess attitudes and feelings toward the current course after exposure to active learning exercises using the GRSLSS Specific Class Form[11] as a posttest. Example statements are the following: (1) "I preferred to work by myself on assignments in this class"; (2) "I often daydreamed during class sessions"; (3) "Working with other students on class activities was something I enjoyed doing." Ratings for each learning style preference were summed and scored as low, moderate, or high based on the norms for each learning style, as determined by the instrument author.[11]

The intervention consisted of a series of active learning exercises completed throughout the semester. These activities were intended to build upon one another, serving as steps toward completion of their final projects: a modified integrative literature review, professional poster, and professional presentation of findings (Information Literacy concepts: *searching as strategic exploration; information creation as a process, scholarship as conversation*). Figure 2 highlights selected active learning methods used in this course.

Interventions

The aim of this study was to evaluate the impact of active learning methods on student attitudes and feelings, using the GRSLSS.

Active Learning Method: Conducting a Literature Review

We followed the step-by-step process for writing reviews of academic literature, as described by Galvan.[32] To facilitate a successful literature search (Information Literacy concept: *research as inquiry*), students collaborated in groups to select a

Approximate Timeline of Group Activities

Task/Active Learning Method (ALM)	AUG		SEP				OCT				NOV				DEC
Week:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GRSLSS General Class Form Survey (pre-test)															
Tolerating Ambiguity Discussion															
Form groups															
ALM: Create PICOT question															
ALM: Conduct literature review															
ALM: Big data immersion using FAERs															
ALM: Basic data mining using Twitter															
ALM: Reflection #1															
ALM: Professional poster development															
GRSLSS Specific Class Form Survey (post-test)															
ALM: Reflection #2															
ALM: Final poster presentations															
Tuckman's Stages of Group Development (approximate timeline)	*Form*				*Storm*				*Norm*				*Perform*		

FIGURE 2. Approximate timeline of selected group activities and their relationship to Tuckman's Stages of Group Development.

topic of interest and created a clinical question (which included a drug) using PICOT format (ie, P = population of interest, I = intervention/issue, C = comparison, O = outcome expected, and T = timeframe for the intervention to achieve the outcome) as described by Melnyk and Fineout-Overholt.[33] A medical librarian guest presenter reviewed the Information Literacy Framework and conducted an interactive session demonstrating how to search databases, organize, cite, save, and share findings using Zotero, a free open-source research and education software provided by The Corporation for Digital Scholarship, Vienna, VA (available at https://www.zotero.org/). During this interactive session, participants were able to ask the librarian questions as they conducted a literature search. During class, participants worked together to document their research process in a flow diagram using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram generator available at http://prisma.thetacollaborative.ca/. These diagrams were later included on their final posters.

Active Learning Method: Big Data Immersion Using the US Food and Drug Administration Adverse Event Reporting System

An interactive discussion was held to explain the content and meaning of FAERS data and to identify potential validity and reliability issues (eg, incomplete/missing data, reports from varied sources such as consumers, physicians, nurses, lawyers, manufacturers). To obtain optimal results, participants were required to include variations in the name of their drug (ie, generic and trade names) to ensure that their query correctly considered the maximum collection of events corresponding to their drug (Information Literacy concept: *research as inquiry*). Because FAERS drug names are entered and stored as "free text," issues such as alternative spellings, abbreviations, data entry errors, and brand-name versus generic are common (Information Literacy concepts: *authority is contextual*; *searching as strategic exploration)*. Participants interactively viewed, explored, and generated reports/graphs identifying top reactions associated with their chosen drug.

Active Learning Method: Basic Data Mining Using Twitter

Participants created a free Twitter account and reviewed the instructions for Using Twitter Search, located in the Twitter Help Center. Drug names (generic and trade names) were extracted from PICOT questions and then entered into the Search Twitter bar. From there, participants applied advanced search filters (eg, by location, language, and date range) and were assigned to locate 300 tweets that mentioned their chosen drug. Participants evaluated each tweet (Information Literacy concept: *searching as strategic exploration*) to determine if it contained the four components of an adverse drug event as defined by the FDA (ie, person reporting the event, person experiencing the event, the name of the drug/product, a description of the event/reaction/fatal outcome suspected to be due to the drug).[34] Findings were discussed and recorded in spreadsheets (Information Literacy concept: *scholarship as conversation*). Participants later evaluated the level of concordance between Twitter posts mentioning adverse events and reports collected by FAERS, determined rates for comparison, and generated a visual display of their data (eg, bar charts). This activity created an opportunity for participants with previous spreadsheet skills to help their peers learn how to sort data and prepare/label basic bar charts, which were also later included on their posters.

Active Learning Method: Course Reflections

Week 8 corresponded approximately with the "storm" phase of the group process.[8] At this point, some participants were beginning to face inevitable challenges associated with delegation of responsibility, and time management issues. At Week 8, participants completed a reflection, which asked: "The thing I like most about our group is…," "The thing I like least about our group is…," "One thing I'd really like to see us accomplish in our final project is…," and "Which group member deserves a 'thank you'?" Participants were asked to handwrite this reflection and to leave it in a designated box, allowing an opportunity to privately share any thoughts about their group's progress, without divulging names. At Week 14, participants completed an additional reflection, which asked: "What I learned, what I most enjoyed in this class, and what I would do differently if I took this course again" (Information Literacy concept: *scholarship as conversation*). Results were aggregated and shared with the participants. Brief strategies and tips for successful team development were subsequently offered, to assist participants with tackling problems, finding solutions, and to accomplish remaining work.

Active Learning Method: Professional Posters and Presentations

Participants created a professional poster (Information Literacy concept: *information creation as a process*) using their modified integrative review of literature, following tips for better visual elements in posters as described by Zerwic et al.[35] Posters were displayed at the school of nursing, and faculty members were invited to vote on best posters, using assignment instructions as criteria for evaluation. Three groups were awarded ribbons, and all were encouraged to present their posters at an upcoming student research event. Costs for poster printing and award ribbons were covered by the school (Table 1).

RESULTS

A total of 126 participants (100%) completed the GRSLSS pretest/posttest in a class period; average time for completion

Table 1. Student Learning Style Descriptions, Preferences, and Active Learning Examples

Style	Description	Preferences	Active Learning Methods Used
Competitive	Learn material in order to perform better than others; feel they must compete with other students. Like attention and to receive rewards.	To be group discussion leader; like to dominate discussions. Recognition for doing good job. Prefer activities where they can do better than others.	Poster contest-faculty vote. Reflection: Who deserves a thank you? Names announced in class.
Collaborative	Learn by sharing ideas, talents. Cooperate with teachers, peers; like to work with others.	Lectures with class discussions in small groups; small seminars. Group, rather than individual projects.	Group projects, discussions.
Avoidant	Lack enthusiasm for learning content, attendance. Little participation with peers, teachers. Disinterested; overwhelmed by what goes on in class.	Generally turned off by most classroom activities. Prefer everyone gets a passing grade; no tests. Dislike enthusiastic teachers.	Few tests, lectures. Individual assignments.
Participant	Good citizens in class. Enjoy attending class; take responsibility for getting the most out of a course. Participate as much as possible.	Lectures with discussion; opportunities to discuss material. Prefer reading assignments; teachers who analyze and synthesize information well.	Delegation; group process, assigned readings; time management tips.
Dependent	Show little intellectual curiosity; learn only what is required. View teacher, peers as sources of structure, support. Look to authority figures for specific guidelines.	Outlines/notes on the board. Clear deadlines and instructions for assignments. Teacher-centered classroom methods. Prefer little ambiguity.	Used Blackboard learning platform as repository. Leadership traits emphasized; toleration of ambiguity discussion.
Independent	Students who like to think for themselves. Prefer to work alone, but will listen to ideas of others. Learn content they feel is important and are confident in their learning abilities.	Independent study; prefer to work alone. Self-paced instruction. Student-centered rather than teacher-centered course designs.	Interactive demonstration of GroupMe text app, Google Docs for group document editing.

Adapted from Grasha.[11(p128)] Copyright 2002 by Alliance Publishers.

was 5.8 minutes. The mean age of participants was 19 years, and the majority (94%) were female. Table 2 displays a comparison of learning style scores before and after a semester of using the active learning methods described. There were statistically significant decreases ($P < .05$) on the *Independent*, *Dependent*, *Competitive*, and *Participant Style* scores and a statistically significant increase in the *Avoidant* style score. No significant differences were noted for the *Collaborative Style* of learning. Cohen's *d* was calculated for each score, indicating a low to moderate effect for all significant scores.

Approximately 32% of the participants on the Week 8 reflection reported feeling that participation in their groups was not equal, whereas 25% reported their group experienced communication issues and inefficient use of time working on projects during class. Approximately 42% of participants reported that they hoped to get an "A" on the final project, and approximately 20% hoped to produce a high-quality final poster that they could be proud of, to finish ahead of time, to be better organized, and that participation would be equal.

Week 14 reflections revealed the following responses: *What I learned*: drug adverse events on Twitter are not always the same as those reported in the FAERS data, the importance of clear communication and professionalism in teamwork, time management, and new skills (eg, applying formatting guidelines, working with spreadsheets, using Zotero to organize the literature review, free GroupMe mobile group messaging app to facilitate communications, conducting literature searches, mining databases). *What I most enjoyed*: learning the importance of EBP in nursing and how it will help me in my role as a professional nurse, working in small groups using active learning methods as opposed to lectures; the FAERS: Twitter project, using Zotero to organize literature, creating a professional poster. *What I would do differently*: change or revise my PICOT question, proofread and follow instructions more closely, use class time more efficiently, delegate work to peers, complete more of the assigned readings, start sooner to create the poster and literature tables.

Discussion and Limitations

Given the precedence of new technologies and use of big data for tracking health trends, emphasis has been placed on updating nursing curricula in recognition of the importance of critical thinking, problem solving, and self-direction in learning as necessary skills required to address patient safety issues arising in today's complex healthcare environment.[6,12,18,21,22] Active learning methods can complement these changes through their emphasis on problem solving, data collection and analysis, and synthesis of findings.[3,6,7]

Table 2. Comparison of Learning Style Scores Before and After Active Learning Experiences

Learning Style	Time 1, Mean (SD)	Time 2, Mean (SD)	*t*	Cohen's *d*
Independent	3.38 (0.36)	3.21 (0.41)	2.22[a]	0.42
Dependent	3.81 (0.35)	3.61 (0.34)	3.46[b]	0.57
Collaborative	3.79 (0.34)	3.82 (0.32)	1.52	0.01
Competitive	2.66 (0.50)	2.43 (0.53)	2.34[a]	0.43
Participative	3.96 (0.38)	3.75 (0.44)	2.63[a]	0.50
Avoidant	2.56 (0.54)	2.87 (0.58)	−3.17[a]	−0.56

Interpretation of magnitude of effect: Cohen's *d* small effect = 0.2, medium effect = 0.5, and large effect = 0.8.
[a]$P < .05$.
[b]$P < .001$.

Findings from this study were encouraging for the use of active learning in this group of primarily female, sophomore-level undergraduate students who had little prior exposure to these methods, and little prior clinical experience. Like the study conducted by Novak et al,[12] the scores for learning style preferences in a group of primarily female pharmacy students fell in the moderate range for all constructs except for the *Collaborative* learning style preference. The high scores found for the *Collaborative* learning preference suggest that active learning methods involving collaboration are appropriate for this course in the nursing curriculum, as active learning methods encourage collaborative, student-focused learning processes.[11] The high collaboration scores found in this study may be correlated to the high proportion of females enrolled in the course, similar to previous study findings.[11,12]

Results showed a significant pretest to posttest increase in the mean *Avoidant* score and significant pretest to posttest decreases in the *Independent*, *Dependent*, *Competitive*, and *Participant* scores. Similar to findings from previous studies,[12,13,25] this group of nursing science students indicated a preference for independent learning. Although we did not collect demographic information for this study, it is possible that students scored higher in avoidant and competitive learning styles, similar to findings from previous studies,[13,27] because they were from urban areas, attending a large Midwestern university. The increase in avoidant scores may also be attributed to the negative wording of several questions and how those questions were scored (ie, ratings of 1–3 indicate the student strongly/moderately disagree or was undecided). Examples of avoidant questions were as follows: "I typically cram for exams"; "During class I tend to socialize with people sitting next to me"; and "Paying attention is difficult for me to do." For questions pertaining to avoidance, lower scores noted on the pretest would be desirable. Since the posttest was administered near the time of student final examinations, it is possible that students were experiencing higher stress levels in anticipation of upcoming examinations and end-of-semester deadlines, possibly contributing to the higher ratings on questions such as "I cram for exams," and so on. No significant differences were noted for the *Collaborative Style* of learning, which was expected for college students and for this group composed largely of female participants.[13,29]

We incorporated classroom activities to address all six learning style preferences. Course reflections revealed participant expressions of enthusiasm and interest in these active learning activities, which enhanced their understanding of research, EBP, and pharmacology. As was found in studies involving pharmacy and medical students,[11,12,18] active learning exercises involving group work, self-direction, and higher-order thinking appealed to this group of participants. Through course activities and peer role modeling, participants developed delegation, time management, and organizational skills and took responsibility for their learning, similar to previous findings.[3,10] The GRSLSS pretest results revealed learning preferences, which guided the selection of Twitter and FAERS data mining as challenging activities for the application of principles of research and EBP. These activities appealed to the participants' desire for instant gratification when seeking answers to their queries, similar to previous findings.[3,12,18] Today's learners may have little patience with traditional research processes as results take much longer, yet these methods were appealing and may inspire students to continue to pursue research as a career. Aggregated reflection comments were summarized and presented in class, and we plan to share this information with future students as ways to anticipate and overcome identified issues.

The Information Literacy Framework was useful as a guide for planning active learning strategies used in this course. Participants found the guest presenter librarian's interactive lecture to be valuable as an opportunity to ask questions and obtain answers when they were actively immersed in the literature review process. All six Information Literacy Framework concepts were interwoven throughout the semester in activities involving teamwork, delegation, time management, data mining, and conducting reviews of literature and developing professional posters. Participants filtered their

mined data to ensure that results adhered to the established FDA[29] criteria, creating a useful experience in managing big data variation and veracity issues. Data completeness is an issue that has become critically important in the collection and analysis of medical data, and this exercise gave participants firsthand experience in understanding how these issues are managed with big (and sometimes sparse) data. Participants were responsible for thoroughly investigating events and identifying alternative drug names to include in queries.

Participants learned that Twitter findings were not always in concordance with FAERS, underscoring the importance of considering a variety of adverse event reporting methods. Participants were surprised to discover differences where a drug was prescribed versus taken recreationally. Some hypothesized that Twitter reporting might be less common when adverse events were embarrassing, as tweets were not anonymous. Some inadvertently used different date ranges to compare data and learned the implications of attempting to compare data from different timeframes. During the norm and perform stages[8] of the group process, participants drew upon their aggregate reflection comments (gathered approximately during the storm stage) and learned to capitalize upon the strengths in their groups to complete work (eg, some group members were more familiar with spreadsheets, creating posters). Final posters were displayed in the school of nursing, and faculty members critiqued and voted for the best posters. One Grand Champion and two Poster of Distinction ribbons were awarded to posters voted as best by faculty members. Photos were taken of awardees with their posters, and this information was published in the school of nursing newsletter. Participants enjoyed positive feedback and praise that they received on the quality of their posters. Twitter mining revealed some surprising discoveries: participants were alerted to drug costs, learned that some may not be covered by insurance, and were surprised by reports of illicit use of some drugs. Participants were cautioned that although Twitter and other forms of social media can enhance real-time pharmacovigilance, these are considered self-reported data, which could be subject to bias, therefore lowering validity and reliability. Participants believed that FAERS reports were more likely to contain more reactions deemed as "personal," since reports were anonymous. Some participants expressed surprise at reports of drugs being ineffective and questioned why healthcare providers prescribe those drugs. The active learning methods used in this course were cost-effective and popular and are reasonable ideas for faculty to consider when working with college students.

Limitations

Limitations of this study included a small sample size, most participants were female, and faculty teaching style was not measured or factored into the study design. Although studies using the GRSLSS have been conducted in online courses and various geographic locations around the world, a similar comparison study was not found using nursing students in a face-to-face "flipped classroom" setting. No demographic data were collected; nor was a control group used for this study. Future study designs should factor in the inclusion of additional male participants and a control group, possibly comparing differences between online and traditional learning environments, and urban versus rural learning style preferences. Detailed descriptions of FAERS data limitations may be found on the FDA Web site.[15] The GRSLSS faculty teaching style was not factored into this study design/intervention. The FDA[15] discloses several limitations to consider when working with FAERS data, including the following: information in FAERS reports has not been verified; therefore, there is no certainty that the reported adverse event was due to the actual drug. Existence of a report does not establish causation. The FDA does not receive reports for every adverse event that occurs, and many factors influence whether an event will be reported (eg, marketing, publicity, litigation). Quality of the FAERS data may be suspect, as duplicate reports may be submitted; some reports are missing information. Twitter data are a potentially invaluable source of information that could be considered for pharmacovigilance, yet some technical, regulatory, and ethical challenges (eg, reporting bias) are acknowledged.

CONCLUSION

Broad-based skill sets are needed as advances in science and technology continue to emerge. Nursing faculty must proactively design courses to ensure that students have the competencies needed to work with emerging technologies and should consider using learning style preferences to facilitate course preparation. Nursing faculty must be willing to adopt diverse approaches to best meet the learning needs of today's students. Findings from this study have clear implications for faculty who desire to use active learning techniques for teaching EBP courses. The active learning techniques used in this course had a favorable impact on learning style preferences and helped participants become savvy consumers of research, resulting in high levels of student engagement and satisfaction. Students found active learning projects to be meaningful, interesting, and of importance for their future careers. Using technology, big data, and working in group projects were popular ways to reinforce knowledge needed by nurses around the world. Twitter mining offers a valuable way to explore adverse drug reactions and possible patient safety issues when compared to adverse reactions reported in FAERS alone.

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