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Effectiveness of various innovative learning methods in health science classrooms: a meta-analysis

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Abstract This study reports the results of a meta-analysis of the available literature on the effectiveness of various forms of innovative small-group learning methods on student achievement in undergraduate college health science classrooms. The results of the analysis revealed that most of the primary studies supported the effectiveness of the small-group learning methods in improving students' academic achievement with an overall weighted average effect-size of 0.59 in standard deviation units favoring small-group learning methods. The subgroup analysis showed that the various forms of innovative and reform-based small-group learning interventions appeared to be significantly more effective for students in higher levels of college classes (sophomore, junior, and senior levels), students in other countries (non-U.S.) worldwide, students in groups of four or less, and students who choose their own group. The random-effects meta-regression results revealed that the effect sizes were influenced significantly by the instructional duration of the primary studies. This means that studies with longer hours of instruction yielded higher effect sizes and on average every 1 h increase in instruction, the predicted increase in effect size was 0.009 standard deviation units, which is considered as a small effect. These results may help health science and nursing educators by providing guidance in identifying the conditions under which various forms of innovative small-group learning pedagogies are collectively more effective than the traditional lecture-based teaching instruction.

Keywords Collaborative learning · Cooperative learning · Health science education · Metaanalysis · Meta-regression analysis · Nursing education · Problem-based learning · Small-group learning

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Introduction

Essential requirements of healthcare professional teams, who typically consist of physicians, nurses, and other healthcare professionals, are to be able to think critically, communicate effectively, and work collaboratively with other members of the multidisciplinary healthcare team. These requirements help healthcare professionals to effectively and efficiently deliver quality healthcare services to patients. The development of the skills to work collaboratively with other healthcare team members and effective interprofessional communication skills are few of the essential components of the health science and nursing education (American Association of Colleges of Nursing [AACN] 2008). Research in health and nursing education suggests that students in health science, including nursing classrooms need to be actively engaged in the process of inquiry and learning that is fostered in an environment that encourages active and collaborative classroom work and social interpersonal interactions. Therefore, in order to deliver high quality and safe patient care (AACN 2008), it is important that the design of the instructional environments in health science classrooms to include opportunities for college students to (a) learn from each other in educational settings that encourage collaborative and cooperative teamwork, (b) communicate effectively with other students in college classrooms that mirror future professional and team-oriented healthcare workplace, and (c) clearly present and explain medical and health related terminologies and concepts to non-scientists such as patients and family members and other healthcare professionals (Varma-Nelson et al. 2004).

For the last three decades, there has also been numerous and consistent calls for instructional reforms and innovations in health science and nursing education by the national agencies and organizations such as the General Medical Council (2002), National Research Council (2001), National Advisory Council on Nurse Education and Practice (2010), National Science Board (2003, 2012, 2016), and World Health Organization (1991, 2010). In their publications and recommendations, they have emphasized the need to examine and explore the teaching practices and student-learning processes that require active methods of small-group instruction (e.g., cooperative learning, collaborative learning, problem-based learning (PBL), peer-led team learning (PLTL), and team-based learning (TBL) in health science college classrooms. In addition, these calls have emphasized the requirement that the graduates from nursing and health science programs to have the ability to communicate effectively, think critically and creatively, learn independently, and function effectively in cooperative and collaborative multidisciplinary teams (AACN 2008). Therefore, today’s complex and dynamic nursing and health science educational and healthcare work environments emphasize the need for graduates from these programs to have effective and integrated teamwork and communication skills (National Advisory Council on Nurse Education and Practice 2010).

In response to these numerous calls and recommendations, many health science and nursing educators have been continuously experimenting and implementing various forms of innovative small-group learning methods that originally have been developed in disciplines other than health science and nursing disciplines. For example, problem-based learning method was developed in medical education (Barrows and Tamblyn 1980) and cooperative learning method was developed in the field of education (Johnson and Johnson 1989; Johnson et al. 1998). Accordingly, many primary (original) comparative research studies in health science and nursing have been conducted to examine the effectiveness of the various forms of innovative small-group learning methods in comparison to traditional lecture-based instruction.

Small-group learning method is the use of specific instructional strategies when students are physically placed in small learning groups to solve problems and complete learning tasks. Small-group learning is considered as an umbrella for the various forms of inductive and active student-centered instructional methods that empower the learners in the small groups to work collaboratively and cooperatively with the other members of the group in a team-based environment using effective communication and social skills (Cartney 2006; Kalaian and Kasim 2014; Springer et al. 1999). Cooperative learning, collaborative learning, problem-based learning, peer learning, inquiry-based learning, and team-based learning are examples of such small-group pedagogies.

Small-group learning activities, which emphasize students' active and collaborative engagement in their classroom activities, is grounded in the Vygotsky's cognitive and social constructivism model of learning (Vygotsky 1978), which stresses and views the students as active learners engaged in constructing and restructuring their own newly learned course content based on their previous content knowledge and personal experiences through social interpersonal interactions with the other members of the group in team-oriented settings (Cooperstein and Kocevar-Weidinger 2004; Kalaian and Kasim 2014; Kalaian 2017; Vygotsky 1978). In other words, the constructivism learning theory explains the process of learning as actively constructing knowledge, which interacts with previously gained content knowledge, personal experiences, beliefs, and perceptions. In other words, the theory views and stresses that knowledge is actively and iteratively constructed and reconstructed by learners in groups working together in socially supported classrooms rather than being passively and individually transmitted (transferred) to learners by the instructor, which is the case in the traditional lecture-based classrooms.

In all forms of small-group learning methods, which are innovative student-centered pedagogies of learning, the role of the instructor changes from being a "sage on the stage" of information and knowledge dispenser (transmitter), which is the case in the traditional lecture-based classrooms, to a designer, supporter, guide, consultant, and facilitator of the learning processes in the classroom (Barrows and Tamblyn 1980; Dochy et al. 2003;American Association of Colleges of Nursing 2008; Kalaian and Kasim 2014). Therefore, in all forms of small-group methods, the instructor's ability and skills to create, support and facilitate social learning environments are essential factors to: (a) achieve the planned instructional goals such as engaging students in collaborative learning and encouraging creativity and critical thinking in the classrooms, (b) maintain the dynamics of group functioning to maximize learning the course content, and (c) successfully implement of innovative reform-based small-group instructional pedagogies.

There are many educational benefits for learning in active small-group environments (Albanese and Mitchell 1993; Vernon and Blake 1993; Kalaian 2017). For instance, small-group learning methods improve students': (a) ability to develop deep and meaningful learning of course content, (b) social and collaborative skills in team-based settings, (c) motivation to learn the course content, (d) problem-solving, critical-thinking, and meta-cognitive skills, (e) negotiation and conflict resolution skills, (f) ability to become self-directed and long-life learners, (g) retention of the course content, (h) self-confidence and self-esteem, (i) attitudes towards the subject matter, and (j) persistence in the classrooms.

In contrast to the various forms of small-group learning methods, the traditional lecture-based instruction, which is to date, the most commonly used method in most of educational levels across all disciplines, is a teacher-centered instructional method. In lecture-based classrooms, the whole class is taught as a single large group and instruction is typically delivered and guided by the instructor. The emphasis of lecturing is to orally present, demonstrate, and explain the course content to all students in class as a single group in a passive environment where the students passively listen and take notes (Kalaian and Kasim 2014; Springer et al. 1999).

In addition to the existing literature focusing on the effectiveness of the various forms of active small-group learning methods in comparison to traditional lecture-based instruction, several meta-analytic reviews of research evidence have been conducted in medical education to examine the effectiveness of problem-based learning (PBL), which is one of the forms of small-group pedagogies, compared to conventional teaching methods on medical students' achievement scores. Meta-analytic studies conducted by Albanese and Mitchell (1993), Vernon and Blake (1993), and Kalaian et al. (1999) are examples of such PBL effectiveness reviews in medical education. All of these reviews concluded that the problem-based learning (PBL) pedagogy is effective in maximizing achievement of medical students. But, as far as we know no meta-analytic review has been conducted to examine the impact of different forms of small-group learning pedagogies on students' achievement in health sciences and nursing undergraduate college classroom settings. It is of considerable importance to health science including nursing education to rigorously investigate questions regarding which forms of small-group learning methods produce better academic outcomes and under which classroom environments. Therefore, there is a need to survey, review, integrate, and synthesize the existing research on the effectiveness of the various types of small-group learning methods compared to lecture-based instruction in health science and nursing undergraduate college classrooms. The main objectives of the present meta-analysis were to:

(a) Determine which forms of various small-group learning pedagogies have been often implemented and evaluated in college health science disciplines, including nursing classrooms by conducting a comprehensive and extensive literature searches to locate the primary studies.
(b) Determine how effective is each form of the small-group methods in maximizing student achievement in health science and nursing college courses.
(c) Use the random-effects meta-regression methods to model the heterogeneity in these effect sizes by including the coded predictor variables as moderators (e.g., publication year, institution type, small-group size, and study duration) in the meta-regression model to explain some of the variability in the effect sizes.

In addition, the present meta-analytic research is needed not only to guide the utilization of the various forms of small-group learning methods in undergraduate college classrooms, but also to provide justification for the dissemination of the various small-group learning practices across nursing and health science higher education institutions.

Meta-analysis methodology

Meta-analysis is a quantitative method for integrating and synthesizing the reported descriptive summary statistics from the multiple related primary studies that address and test the same research question and hypothesis on a specific research topic (Hedges and Olkin 1985; Kalaian and Kasim 2014). In this meta-analytic study, the random-effects approach for meta-analysis and meta-regression methods (Hedges and Olkin 1985) were used to synthesize and integrate the accumulated literature on the effectiveness of various types of active small-group learning on undergraduate students' achievement in college health science classrooms and model the variability among the existing accumulated primary studies.

The five main steps that had been taken to conduct the present meta-analytic review were.

Literature search

This study used extensive search procedures to identify published (articles published in peer-reviewed journals) and unpublished (e.g., dissertations, and conference proceedings) primary (original) studies that have examined the effectiveness of small-group learning instruction in comparison to lecture-based instruction in healthcare (health science and nursing) college classrooms. Library searches were conducted to find and locate the primary studies that were published prior to December 2014 with no restrictions on the earliest publication years. The following library resources were searched: (1) the electronic databases, such as Education Resources Information Center (ERIC), ProQuest dissertations, CINAHL, JSTOR, and PubMed. Also, we searched the individual online journals such as the "Journal of Nursing Education"; and (2) manually searching the references of the retrieved primary studies and previously published meta-analytic reviews (e.g., Springer et al. 1999; Shin and Kim 2013) to look for and identify additional potential relevant health science and nursing primary studies, which may have been missed by the electronic database searches. Every effort was made to include both published and unpublished primary sources in this meta-analytic review to minimize the possibility of publication bias.

The keywords used for searching and locating the primary studies included "cooperative learning", "collaborative learning", "problem-based learning", "small-group learning", "Peer learning", "Inquiry-based learning", "Peer-led team learning", team-based learning" as the key learning pedagogies combined with "health" or "nursing" subject matters descriptors.

Inclusion criteria

Stringent inclusion criteria were established and used to determine whether a nursing or health science primary study was qualified to be included in the meta-analytic review. For a primary study to be included in the present meta-analytic review, it had to meet the following criteria:

1. Focused on comparing the achievement of a group of students in undergraduate college nursing or health science courses who were instructed using one of the forms of small-group learning methods to their counterparts who were instructed using traditional lecture-based instruction. Therefore, based on this criterion, a primary study was excluded from this review if the primary study (a) compared small-group learning to individualized learning methods and not to lecture-based instruction in nursing and health science courses (e.g., Iwasiw and Goldenburg 1993), (b) used self-reported achievement measures (e.g., Rideout et al. 2002), and (c) focused on graduate nursing and health science education (e.g., White et al. 2012).
2. Used one of the following three research designs: Two-group experimental research design; Two-group quasi-experimental (pre-post) research design; Or two-group comparative (post-only) research design. Therefore, based on this criterion, a primary study was excluded from this review if the primary study used one-group pre-post research design (e.g., Cheng et al. 2014).

3. Reported the necessary descriptive and sufficient statistics such as the means, variances, and sample sizes to be able to calculate the effect sizes. Therefore, the primary studies with missing one or more of the descriptive summary statistics were excluded.

With these preset criteria, we identified 19 primary health and nursing studies that were conducted in the United States and other countries in the world to be included in the present meta-analytic review. The focus of the courses included in the review were in nursing, medication giving skills, addiction, respiratory therapy, exercise and sport, biochemistry, CPR, and nutrition.

The total number of students across the 19 primary studies was 4050. A total of 1560 college students were in health science and nursing classrooms with small-group learning instruction and a total of 2490 students were in nursing and health science classrooms with lecture-based instruction.

Data extraction and coding of study features

Based on a careful review of the identified and selected primary studies that fit the inclusion criteria, a comprehensive coding instrument was developed and used to extract the methodological and substantive features (e.g., research design, publication year, small-group learning methods, field of study and discipline, academic subject area, assessment type, sample characteristics, contextual study features, instructional duration, and performance test type) of each of the 19 primary studies included in this meta-analytic review. The sample sizes and the descriptive statistics (e.g., means and standard deviations) of the achievement scores for each primary study were also coded.

The features of the 19 primary studies were coded independently by the two researchers to extract the methodological and substantive characteristics of the primary studies. The coding of the descriptive summary statistics and study features was based on the reported information in the primary studies. To reach consensus, the discrepancies between the assigned codes of the two researchers were reviewed, discussed, and resolved prior to data entry and analysis.

Effect-size calculations

For this meta-analytic review, we used the common quantitative metric, which is a standardized mean-difference index (effect-size) to represent the effectiveness of the specific form of the small-group learning method that is used in each of the 19 primary studies. For most of the primary studies, one effect-size was calculated to meet the assumption of the independence of the effect sizes based on independent samples of students. But, if a primary study reported the results of two or more different independent samples in the same study, then two or more independent effect sizes were extracted per primary study. For example, two effect sizes were calculated for the primary studies conducted by Bayart (1994) and Beachey (2004). On the other hand, if multiple effect sizes provided by the same subjects for different categories of the same outcome measure (e.g., assignment grades, mid-term exam score, and final exam score) for a primary study, the dependent effect sizes from such measures were averaged to yield a single effect size for that sample of students in a primary study.

Based on these preset criteria, 21 independent effect sizes from the 19 empirical primary studies were calculated to measure the effectiveness of small group learning instruction compared to the lecture-based instruction in evaluating college students' achievement in health science and nursing college courses. The effect-size index (effect size) for each primary study was calculated by taking the difference between the means of achievement scores of the students who were instructed by the small-groups methods and the lecture-based groups and dividing the difference by the two groups' pooled standard deviation, known as *Hedge's g* (Hedges and Olkin 1985; Kalaian and Kasim 2014). Each of the effect size indices was adjusted by the bias correction factor. To obtain the weighted average effect size, each of the adjusted effect sizes was weighted by its inverse of the sampling error in the fixed-effects models and by its inverse of the combined sampling and random errors in the random-effects models.

Integrating and modeling effect sizes across the primary studies

Once an effect size had been calculated for each primary study or comparison, then these effects was averaged. For integrating (combining) the effect sizes and calculating the weighted average effect size across all the studies in the review, a weighted analyses using the fixed-effects models for categorical variables as well as the random-effects meta-regression model for continuous moderator (predictor) variables. In calculating the weighted average effect size, more weight was given to effect sizes from primary studies that had larger sample sizes based on the assumption that larger sample sizes yield closer approximation to the actual population average effect size (Hedges and Olkin 1985). Statistical significance of the weighted average effect sizes was then obtained by calculating the 95% confidence interval of the weighted average effect sizes using the fixed-effects for the subgroup analysis for the categorical variables and homogeneity test and the random-effects models for testing and modeling the continuous moderator variables.

In the present study, moderator analysis involving study and instructional characteristics of the primary studies was performed to investigate conditions under which various forms of small-group learning methods may have different effects. we used a fixed-effects model for the main effect and sub-group analysis for the categorical moderators as well as random-effects meta-regression analysis for the continuous moderators because (a) the test for the overall homogeneity of the effect sizes was statistically significant, and (b) the results of the random-effects model can be generalized to the population of possible primary studies based on the assumption that the primary studies are samples of a population of primary studies.

Results

The results of this study are organized into three main sections: The "overall meta-analysis results" section lists and describes the characteristics of the primary studies, the effect sizes; "Sub-group analysis of the categorical moderator variables" section reports the results of the subgroup analysis for the major subgroup characteristics of the primary studies (study design characteristics, instructional characteristics, and students' grouping characteristics) and includes the categories of the moderator variables; and the "random-effects regression analysis results of the continuous moderators" section reports the results of the meta-regression analysis to explain the variations among the 21 effect sizes using the coded continuous moderator (predictor) variables of the primary studies as moderators (predictors) in the regression model.

Overall meta-analysis results

Figure 1 shows the forest plot, which includes the variances, standard errors, and the lower and upper limits of the confidence intervals for each of the 21 effect sizes extracted from 19 primary studies. As is shown in Fig. 1, the primary studies that were included in this meta-analysis were published between 1987 and 2014. The 21 independent effect sizes, which were extracted from the 19 primary studies, ranged in value from −0.97 to +1.23. Out of the 21 effect sizes, 17 had positive effects and in favor of small-group learning, while the remaining four had negative effects and in favor of lecture-based instruction.

The results of the overall homogeneity test using the fixed-effects model indicate that the 21 effect sizes of the primary studies were heterogeneous (Q = 144.83, *d.f.* (Q) = 20, $p = 0.00$). The weighted average of the effect sizes using the fixed-effects model is 0.59 standard deviations with a 95% confidence interval between 0.52 and 0.66.

Subgroup analysis of the categorical moderator variables

Based on the homogeneity test results, which had indicated that the 21 effect sizes were heterogeneous, we conducted sub-group analyses across the coded categorical moderator variables, which are the categories of the coded categorical characteristics of the primary studies, using the fixed-effects model. The sub-group analysis was performed in order to identify both the source of variability among the effect sizes and the differences among the subgroups.

For reporting purposes, the study characteristics of the primary studies were further grouped into three major subgroup characteristics. The following are the results of the

Forest Plot of Health Sciences Effect Sizes

Study name	Statistics for each study						
	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Bayard a (1994)	-0.92	0.53	0.28	-1.95	0.11	-1.74	0.08
Bayard b (1994)	0.23	0.50	0.25	-0.75	1.22	0.47	0.64
Beachey a (2004)	0.21	0.15	0.02	-0.08	0.50	1.40	0.16
Beachey b (2004)	0.20	0.16	0.03	-0.11	0.51	1.27	0.20
Bosworth (2000)	0.56	0.26	0.07	0.05	1.06	2.17	0.03
Fernández-Santander (2008)	1.23	0.21	0.04	0.83	1.64	5.95	0.00
Sé, et al. (2008)	-0.16	0.13	0.02	-0.42	0.09	-1.24	0.21
Szogedi et al. (2009)	0.90	0.05	0.00	0.81	1.00	18.10	0.00
Beers (2005)	0.03	0.24	0.06	-0.43	0.49	0.12	0.91
Heather (2008)	0.13	0.46	0.21	-0.77	1.02	0.27	0.78
Hwang, et al. (2007)	0.47	0.24	0.06	-0.00	0.94	1.96	0.05
Lin, et al. (2010)	0.22	0.17	0.03	-0.11	0.55	1.29	0.20
Daodee, et al. (2006)	0.41	0.17	0.03	0.07	0.75	2.33	0.02
Lewis & Tamblyn (1987)	0.02	0.31	0.10	-0.59	0.62	0.05	0.96
Sevening & Baron (2003)	0.59	0.35	0.12	-0.10	1.28	1.68	0.09
Sangestani & Khatiban (2014)	1.04	0.25	0.06	0.54	1.54	4.08	0.00
Lyons (2008)	-0.02	0.27	0.07	-0.55	0.52	-0.06	0.95
Tiwari, et al. (2006)	0.06	0.23	0.05	-0.39	0.52	0.28	0.78
Choi, et al. (2014)	1.04	0.25	0.06	0.54	1.54	4.08	0.00
Penjvini & Shahsawari (2013)	0.17	0.37	0.14	-0.56	0.90	0.47	0.64
Basak & Yildiz (2014)	-0.07	0.24	0.06	-0.53	0.40	-0.28	0.78
	0.59	0.04	0.00	0.52	0.66	16.70	0.00

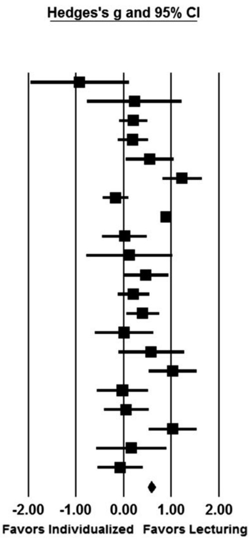

Fig. 1 Forest plot of the effect sizes in the review, the authors and publication years of the 21 effect sizes (Hedges's g) and their standard errors, variances, confidence intervals, Z-values, *p* values, as well as the weighted average effect using the fixed-effects model

subgroup analysis for these major subgroup characteristics (study design characteristics, instructional characteristics, and students' grouping characteristics).

Subgroup results of the study design characteristics

The subgroup results of the categorical analysis for the categories of the major coded study characteristics of the primary studies, such as publication year and research design, are shown in Table 1. As is shown in the table, eight effect sizes were extracted from the seven primary studies that had been published in 2000 or earlier with an average effect-size of 0.20. The remaining 13 effect sized were extracted from the 12 primary studies that had been published in 2001 or later with an average effect-size of 0.67, which is much larger than the average effect size of earlier published studies. The results also show that the differences between the average effect sizes of the two publication-year groupings are statistically significant ($Q_{Between} = 26.39$, *d.f.* $= 1$, $p = 0.00$).

Fourteen of the effect sizes were extracted from the 14 primary studies that were articles published in refereed (peer-reviewed) journals with a weighted average effect size 0.67. This weighted average effect size was much larger than the weighted average effect size of the remaining seven effect sizes extracted from four Ph.D. dissertations and one master's thesis (weighted average effect size = 0.18). The differences between the average effect

Table 1 Subgroup analysis of the study characteristics and the associated average effect sizes

Study characteristics	# studies (# ES)	Average ES	S.E.	−95% CI	+95% CI	*p* value
Publication year ($Q_{Between} = 26.39$, *d.f.* $= 1$, $p = 0.00$)						
2000 or earlier	7 (8)	0.20	0.08	0.04	0.36	0.02
2001 or later	12 (13)	0.67	0.04	0.60	0.75	0.00
Publication type ($Q_{Between} = 26.37$, *d.f.* $= 1$, $p = 0.00$)						
Published articles	14 (14)	0.67	0.04	0.59	0.74	0.00
Theses and dissertations	5 (7)	0.18	0.09	0.005	0.35	0.04
Research design ($Q_{Between} = 20.31$, *d.f.* $= 2$, $p = 0.00$)						
Experimental	4 (4)	0.13	0.12	−0.10	0.36	0.28
Quasi-experimental	7 (8)	0.47	0.09	0.29	0.66	0.00
Comparative post-only	8 (9)	0.66	0.04	0.49	0.74	0.00
Research setting ($Q_{Between} = 14.20$, *d.f.* $= 1$, $p = 0.00$)						
Regular classrooms	16 (18)	0.62	0.04	0.55	0.69	0.00
Clinical classrooms	3 (3)	−0.004	0.16	−0.32	0.31	0.98
Classroom level ($Q_{Between} = 23.81$, *d.f.* $= 1$, $p = 0.00$)						
First year	4 (6)	0.71	0.04	0.63	0.80	0.00
Not first year	15 (15)	0.35	0.06	0.23	0.47	0.00
Study location ($Q_{Between} = 50.84$, *d.f.* $= 1$, $p = 0.00$)						
U.S.	7 (9)	0.18	0.07	0.05	0.31	0.01
Other countries	12 (12)	0.74	0.04	0.66	0.82	0.00
Field of study ($Q_{Between} = 34.31$, *d.f.* $= 1$, $p = 0.00$)						
Health sciences	6 (8)	0.21	0.07	0.07	0.36	0.00
Nursing	13 (13)	0.70	0.04	0.62	0.78	0.00

ES represents effect sizes. *SE* and *CI* represent the "standard error" and the "confidence interval" of the weighted average effect size respectively sizes of the two publication types are statistically significant ($Q_{Between} = 26.37$, *d.f.* = 1, $p = 0.00$).

In regards of research design that is used in each of the 19 primary studies (see Table 1), the eight non-experimental (comparative post-only) studies (weighted average effect size = 0.66) produced higher effect sizes than the seven quasi-experimental (two-group pre-post research design) studies (weighted average effect size = 0.47). The four experimental studies produced the lowest effect sizes (average effect size = 0.13) than the other two designs. The results also show that the differences between the average effect sizes of the three types research designs that were used to conduct the primary studies are statistically significant ($Q_{Between} = 20.31$, *d.f.* = 2, $p = 0.00$).

In terms of the settings of the primary studies, the 18 effect, which were extracted from the 16 primary studies had been conducted in regular college classroom settings and produced positive and much higher effect sizes (weighted average effect size = 0.62) than the three studies that had been conducted in clinical classroom settings (weighted average effect size = −0.004). The differences between the average effect sizes of the two types of classroom settings (regular classrooms and clinical classrooms) are statistically significant ($Q_{Between} = 14.20$, *d.f.* = 1, $p = 0.00$).

The first year (freshmen) college classrooms had higher effect sizes (weighted average effect size = 0.71) than the higher level college classrooms (sophomores, juniors, and seniors) with a weighted average effect size of 0.35). The results also show that the differences between the average effect sizes of the two classroom levels (first year and higher-level classes) are statistically significant ($Q_{Between} = 23.81$, *d.f.* = 1, $p = 0.00$).

Regarding the country where the primary study had been conducted, nine effect sizes were extracted from the seven primary studies that were conducted at U.S. universities and colleges (average effect size = 0.17). The remaining 12 effect sizes were extracted from 12 primary studies that had been conducted in other countries worldwide and had much larger effect sizes (average effect size = 0.74). One primary study had been conducted in each of the following countries: Brazil, Canada, China, Hungary, Spain, Taiwan, Thailand, and Turkey; and two primary studies had been conducted in each of Iran and South Korea. The differences between the average effect sizes of the two locations, where the primary studies were conducted (United States vs. other countries) are statistically significant ($Q_{Between} = 50.84$, *d.f.* = 1, $p = 0.00$).

As is shown in Table 1, the 13 nursing primary studies produced higher effect sizes with a weighted average effect size of 0.70) than the six health science studies with a weighted average effect size of 0.21. The results also show that the differences between the average effect sizes nursing and health science classrooms are statistically significant ($Q_{Between} = 34.31$, *d.f.* = 1, $p = 0.00$).

Subgroup results of the instructional characteristics

The results of the subgroup analysis, which is related to the instructional characteristics of the primary studies, are shown in Table 2. The results show that the primary studies had higher effect sizes (weighted average effect-size = 0.73) when the instructional intervention is delivered by the researcher (investigator) of the study than other instructor (weighted average effect-size = 0.21). The results in Table 2 also show that the differences between the average effect sizes of the two types of classroom instructors (investigator versus other instructors) are statistically significant ($Q_{Between} = 43.99$, *d.f.* = 1, $p = 0.00$).

Table 2 Subgroup analysis of the instructional characteristics of the studies and the associated average effect sizes

Instructional characteristics	# studies (# ES)	Average effect size	S.E.	−95% CI	+95% CI	*p* value
Learning method ($Q_{Between} = 112.36$, *d.f.* = 3, *p* = 0.00)						
Cooperative	3 (3)	−0.14	0.12	−0.37	0.10	0.26
Collaborative	1 (1)	1.23	0.21	0.83	1.64	0.00
Problem-based learning	14 (16)	0.29	0.06	0.18	0.41	0.00
Peer learning	1 (1)	0.90	0.05	0.81	1.00	0.00
Classroom instructor ($Q_{Between} = 43.99$, *d.f.* = 1, *p* = 0.00)						
Investigator	13 (15)	0.73	0.04	0.65	0.82	0.00
Other	6 (6)	0.21	0.07	0.08	0.34	0.00
Type of exam ($Q_{Between} = 19.07$, *d.f.* = 1, *p* = 0.00)						
Standardized test	9 (10)	0.33	0.07	0.19	0.46	0.00
Teacher made test	10 (11)	0.68	0.04	0.60	0.76	0.00

ES represents Effect Sizes. *SE* and *CI* represent the "standard error" and the "confidence interval" of the weighted average effect size respectively

In regards to the assessment method that was used in the college classrooms, teacher-made tests to assess students' achievement in health science classrooms (average effect size = 0.68) produced higher effect sizes than the classrooms that used standardized tests such as nursing or health science concept inventory tests with a weighted average effect size of 0.33. The results also show that the differences between the average effect sizes of the two types of assessments are statistically significant ($Q_{Between} = 19.07$, *d.f.* = 1, *p* = 0.00).

Regarding the learning pedagogies and methods that had been used in health science and nursing college classrooms, the majority of the effect sizes (16 effect sizes) was from the 14 primary studies that implemented and evaluated problem-based learning methods with a weighted average effect size of 0.29. Three effect sizes was from studies that implemented and evaluated cooperative learning methods with a negative and small weighted average effect size of −0.14. The remaining two studies; One primary study implemented collaborative learning methods and had a weighted effect size of 1.23; and the other primary study implemented peer learning grouping method and had a weighted effect size of 0.90. The results also show that the differences between the average effect sizes of the four types of pedagogies that had been used in the nursing and health science classrooms are statistically significant ($Q_{Between} = 112.36$, *d.f.* = 3, *p* = 0.00).

Subgroup results of the small groups characteristics

As is shown in Table 3, the six primary studies with small groups of size four or less had larger effect sizes (weighted average effect size = 0.75) than the 13 studies, which had small groups of size 5 or more (weighted average effect size = 0.30). The results also show that the differences between the average effect sizes of the two categories of the size of the groups are statistically significant ($Q_{Between} = 37.83$, *d.f.* = 1, *p* = 0.00).

Typically, grouping for small-group learning/teaching settings can be accomplished using three grouping methods. Students may be self-assigned into groups of their own choice, randomly assigned to groups by the instructor, or the instructor assign students to

Table 3 Subgroup analysis of the grouping characteristics of the studies

Grouping characteristics	# effect sizes	Average effect size	S.E.	−95% CI	+95% CI	*p* value
Placement of students into small groups ($Q_{Between} = 82.77$, *d.f.* = 2, $p = 0.00$)						
Random selection	12 (13)	0.32	0.07	0.19	0.44	0.00
Ability grouping	1 (2)	−0.02	0.10	−0.22	0.18	0.85
Self-selected groups	6 (6)	0.85	0.05	0.75	0.93	0.00
Group size ($Q_{Between} = 37.83$, *d.f.* = 1, $p = 0.00$)						
4 students or less	6 (6)	0.75	0.04	0.66	0.83	0.00
5 or more	13 (15)	0.30	0.06	0.18	0.41	0.00

ES represents Effect Sizes. *SE* and *CI* represent the "standard error" and the "confidence interval" of the random-effects weighed average effect size respectively

groups based on their abilities, for example, their Grand Point Averages (GPA) or Grand Point Averages (GPA). The results show that the 6 primary studies that placed the students into small groups by students' selecting their own groups (self-selection into the groups of their choice) produced much higher weighted average effect size of 0.85) than the 12 studies that placed students in the groups randomly (weighted average effect size = 0.32). Only one primary study had based the assignment of students into the small group on the abilities of the students and produced the lowest with negative and close to zero average effect size of −0.02. The results also show that the differences between the average effect sizes of the three methods of putting students into groups are statistically significant ($Q_{Between} = 82.77$, *d.f.* = 2, $p = 0.00$).

Random-effects regression analysis results of the continuous moderator variables

Based on the homogeneity test results, which indicated that the 21 effect sizes were heterogeneous, we conducted random-effects meta-regression analyses for each of the coded continuous moderator variables. The meta-regression analysis was performed to: (a) determine the ways in which the coded continuous predictor variables impacted the effect sizes and (b) explain the variability among the effect sizes. The coded continuous moderator variables were: Publication year, small-group size, and instructional duration in hours of each of the primary studies in this review. The results in Table 4 show that the slope of the instructional duration in hours was positive and statistically significant (slope = 0.009, $p = 0.00$). In other words, on average, for every increase in instructional hour, the predicted increase in effect size is 0.009 standard deviation units. The results also show that the slope of the year of publication was positive, but statistically not significant. In addition, the results show that the slope of the group size (# of students in the groups) was negative, indicating that small groups had larger effects on achievement than the larger groups, but statistically not significant.

Conclusion

This meta-analytic study aimed to survey the accumulated literature in undergraduate health science and nursing education that examined the effectiveness of the various forms of innovative small-group teaching/learning methods in comparison to the traditional

Table 4 Random-effects meta-regression analysis of the continuous moderator variables

Moderator variable	Regression coefficient	Standard error	−95% CI	+95% CI	*p* value
Publication year					
Intercept	−52.48	30.54	−112.33	7.37	0.09
Slope	0.03	0.02	−0.004	0.06	0.08
Group size					
Intercept	0.44	0.25	−0.051	0.92	0.08
Slope	−0.02	0.04	−0.095	0.06	0.69
Instructional duration in hours					
Intercept	−0.05	0.23	−0.50	0.39	0.82
Slope	0.009	0.005	0.000	0.02	0.05

CI represents the confidence interval of the random-effects regression coefficients

lecture-based instruction in maximizing college students' achievement scores in health science and nursing college classrooms worldwide. Therefore, the primary studies in the review, were all conducted within the specific context of one of the various forms of innovative small-group learning pedagogies and all studies used socio-constructivism framework of learning (e.g., cooperative learning, collaborative learning, pair-learning, peer learning, team-based learning, or problem-based learning).

The meta-analytic review revealed that 17 of the 19 primary studies included in the review produced positive effect sizes indicating that the various forms of innovative small-group learning pedagogies were effective in increasing achievement scores of college students in health science and nursing classrooms. Also, the results of the review revealed that the 21 effect sizes extracted from the 19 primary studies were heterogynous and some of the variability in the effect sizes of the primary studies could be explained by the differential characteristics of the primary studies.

In addition, the results of the present meta-analysis have shed some light on the effectiveness of various forms of small-group learning methods in college health science and nursing classrooms. The results showed that small-group learning methods and activities were on average more effective than the traditional lecture-based instruction with a significant weighted average effect-size of 0.59 favoring small-group learning methods. This positive moderate weighted average effect-size means that using small-group learning in health science, including nursing classrooms could positively affect student achievement, moving the students' scores on a standardized and teacher-made exam from the 50th percentile (the percentile score of the students in the lecture-based classrooms) to the 73th percentile in the small-group classrooms. This average effect-size for health and nursing primary studies across the four small-group methods was much higher than the previously reported findings of the effectiveness of just using problem-based learning in medical education, which often ranged from 0.06 to 0.13 (e.g., Albanese and Mitchell 1993; Vernon and Blake 1993; Kalaian et al. 1999; Dochy et al. 2003). When compared with lecture-based instruction, four small-group learning methods (cooperative learning, collaborative learning, peer learning, and problem-based learning) had been implemented and used during the last four decades in nursing and health science college classrooms. Each of the four small-group learning pedagogies had positive impacts on student achievement in health science and nursing college courses.

Further, our results showed that the primary studies conducted in other countries (outside the U.S.) had much higher small-group effect-size indices than the primary studies that were conducted in the U.S. However, the number of published primary studies from each country, except the U.S., was limited (one or two studies) to form the basis for any meaningful comparisons.

Furthermore, the results showed that most of the primary studies were conducted and published in 2001 and later had much larger effect sizes than the studies that were published between 1987 and 2000. Possible explanation for this increase in the number of publications after 2000 is the increase in the number of nursing and health education researchers who are interested in the scholarship of teaching and learning (SOTL).

Moreover, the subgroup analysis results showed that the average effect size for first-year undergraduate health science and nursing students was much higher than undergraduate higher level (second-year to fourth-year) students. This result is in agreement with previous meta-analytic results of, for example, the differential effectiveness of PBL across grade levels of medical students such as studies by Dochy et al. (2003) and Kalaian et al. (1999).

Similarly, the rest of the subgroup analyses showed that the various small-group learning interventions appeared to be significantly more effective for (a) students in groups of two to four than groups of size 5 or more, (b) students who selected their own group members than the students who were assigned to the groups randomly or based on their abilities (e.g., Grand Point Average), (c) students who were assessed by using teacher-made tests than the students who were assessed by using standardized tests such as concept inventory tests, and (d) students who were taught by the investigators themselves rather than other instructors who are not the investigators. Finally, the results of fitting the random-effects meta-regression modeling, which included the exploratory continuous moderators (predictors), showed that the instructional duration (in hours) of the primary studies had a significant positive, but small effect on the effect sizes. This significant positive average effect-size indicates that the classrooms with longer hours of instruction had higher effect-size values favoring small-group learning methods than the studies with shorter instructional duration. In other words, on average, for every increase in instructional hour, the predicted increase in effect size is 0.009 standard deviation units, which is considered as a small effect. These findings are in agreement with previous meta-analytic results of, for example, the effectiveness of small-group learning in increasing achievement scores of computer science students and the positive effects of the instructional duration on achievement effect sizes (e.g., Kalaian and Kasim 2015).

However, the results of this quantitative meta-analytic study are based on only 19 primary studies that were conducted since 1987 and met the established inclusion criteria. Accordingly, we believe that the pedagogical research in health science and nursing is limited and there is a need to conduct more primary studies to examine the effectiveness of innovative reform-based small-group learning methods in health science and nursing college classrooms, especially the newly developed pedagogies such as Team-based Learning (TBL) methods, which is developed and introduced by Michaelsen et al. (2004). Also, there is a need for better reporting of the small-group instructional processes, activities, and the analytical results of the effects of the small-group learning research. For example, we had to exclude few of the primary studies that did not report some of the descriptive summary statistics (e.g., standard deviations and/or the sample sizes of the two intervention groups), which are necessary for calculating the effect sizes.

In conclusion, the results and findings of this meta-analytic review added to the already converging evidence that various innovative small-group learning pedagogies, which are active student-centered teaching/learning methods, appear to be a promising mechanism for promoting academic success. Also, based on the results, it is recommended that the roles of college health science and nursing students and instructors should be shifted and broadened to include the acquisition of both cognitive and social skills such as critical thinking, meta-cognition, creativity, collaborative and cooperative team-work, and life-long independent learning. These findings might help health science and nursing educators, administrators, and policy makers to support who wants to utilize the most effective way to deliver instruction in college classrooms. In addition, the results could contribute significantly to the current knowledge concerning nursing and health science education to use and implement active small-group learning methods and improve undergraduate health science and nursing educational policy and practice. Further, the findings might help higher education institutions to make institutional decisions to develop educational programs that focus on faculty development workshops and seminars that enhance the health science and nursing faculty's ability to effectively implement various forms of small-group such as cooperative, collaborative, team-based learning, or problem-based learning instruction. Consequently, it is important to note that effective implementation of these small-group pedagogical methods leads to increase undergraduate students' interests, success, motivation, and persistence in health science and nursing fields of study throughout the nation and worldwide.

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