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Systematic Review

Team- and Problem-Based Learning in Health Services: A Systematic Literature Review of Recent Initiatives in the United States

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Abstract: The COVID-19 pandemic caused a sudden shift to virtual platforms. Physical distance and limited experience with both synchronous and asynchronous teamwork at work and school hampered problem-solving and the development of critical thinking skills. Under these circumstances, the implementation of team-based and problem-based learning (TBL, PBL, respectively) required a reevaluation of how teams collaborate and engage in problem-solving remotely. The research team conducted a systematic review to identify health services studies, themes, and attributes of learning initiatives associated with the success of TBL and PBL conducted during the COVID-19 pandemic. This systematic review was conducted using the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines. The review results identified three themes associated with TBL and PBL learning initiatives in health services: (1) TBL and PBL have transformed health services education with modified TBL (mTBL) and modified PBL (mPBL) as the new norms; (2) the amplification of age-appropriate principles for professional motivation in healthcare; and (3) active learning impacts practical abilities for professional success and future leadership roles. The pandemic underscored the importance of flexibility, resilience, and innovation in TBL and PBL approaches in health services education. Despite the superiority of mPBL and mTBL, the barriers to implementation and student acceptance of active learning include inadequate resource and space allocation, and student preferences for passive, traditional lecture. Further, online learning required increased facilitator training, administration time, and time to provide feedback.

Keywords: team-based learning; problem-based learning; health services; health care administration; health care leadership; active learning; online education; andragogy; barriers; critical thinking

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1. Introduction

1.1. Team-Based Learning

Teamwork has been identified as one of the primary skills required in the global workplace [1]. Further, the need for interdisciplinary teamwork in effective health services is well established [2]. Traditional team-based learning (TBL) includes consistent groups, student accountability, activities with immediate feedback, individual and team readiness assessments, and a team-based problem or project [3]. A qualitative study of TBL in a nursing student population validated themes similar to the traditional TBL approach, such as readiness for learning and collaboration, and identified students' difficulties navigating team roles and the high volume of content [4]. An experimental quantitative study of undergraduate nursing students demonstrated the superiority of TBL, compared to traditional lecture (TL), in the teaching of community understanding and assessment, and suggests a trend in overall higher scores for TBL vs. TL. Similar experimental quantitative

studies with a larger sample size are needed in health services education [5]. More broadly, graduate medical education (GME) was challenged during COVID-19. A quantitative study comparing TBL individual readiness assurance test (RAT) scores and group RAT scores of clinical decision-making before and during the pandemic found that the content delivery mode (in-person vs. online) was not significantly different amongst the teams. More research is needed in post-COVID-19 GME [6]. In engineering students, TBL enhanced the correlation of perceived writing skill and the instructors' assessment [7].

1.2. Combined Team-Based Learning and Problem-Based Learning

Problem-based learning (PBL) facilitates learning and critical thinking by applying problem-solving to relevant issues [8]. In health services, TBL and PBL emphasize collaborative and practical learning to tackle real-world issues in healthcare operations, management, and clinical problem-solving. Developed for medical education in the early 1960s, TBL involves forming small groups of students or professionals who work together to solve complex, multifaceted problems, like those typically encountered in healthcare settings [9].

The focus in PBL is on developing critical thinking [10], communication, and leadership skills, essential for effective health services, as well as required competencies for program accreditation. Participants engage in active learning by researching, discussing, and proposing solutions to these problems, guided by a facilitator rather than a traditional instructor. This approach not only enhances theoretical knowledge but also fosters teamwork, decision-making, and the ability to apply concepts in practical situations, crucial for successful management in the dynamic and challenging field of health services. Variations on traditionally defined TBL and PBL pedagogies have shown promise, and various combined approaches have been recommended [11]. A quantitative path analysis using hierarchical regression of PBL, TBL, and flipped classrooms in graduate and undergraduate business students found improved engagement and significant differences in learning with PBL and TBL. The flipped classroom was non-significant with negative effects. Similar quantitative studies of modified PBL and TBL are needed in health services education [12].

When PBL was applied to health services field studies via community service learning (CSL), the summative assessment of content knowledge improved by 19% relative to lectures ($p < 0.0001$, two-tailed) and the student perception of the value of both the course and the experience also improved significantly [13]. In a mixed-methods study, PBL and TBL combined with community-based research improved students' learning; however, students had difficulty working in teams and scheduling with community partners [14]. Interprofessional education (IPE) engages students from several health services disciplines to address a complex, real-world problem. A systematic review identified stakeholder perspectives (learner, teacher, researcher) and willingness to participate as factors for success using this learning approach [15]. However, to our knowledge, constructs associated with the success of combined TBL and PBL in health services have not been studied.

1.3. The Global Pandemic

During the COVID-19 pandemic, teacher stressors soared globally, including technical barriers, as well as the time required to manage an online classroom [16]. However, the implementation of innovative teaching practices during the COVID-19 pandemic resulted in improved student evaluations, compared to non-innovative methods [17]. Adaptations to PBL and TBL in the online milieu have been proposed in various student populations [18].

Health services education also faced challenges. Traditionally, health services education functions under a clinical model, i.e., learning and working on site. The swift move to online instruction presented both predictable and unique challenges. The implementation of online instruction was predictably hampered by an educational workforce with limited experience in online methodology. Problem-based learning (PBL) in health services was adapted using familiar case-study methods. However, a sudden shift to virtual platforms required a rethinking of how student and professional teams collaborate and engage remotely in problem-solving. Despite the physical distance, problem analysis continued to

play a crucial role, with teams tackling unprecedented real-world healthcare management issues brought on by the pandemic, such as resource allocation, emergency response, and public health strategies. The virtual environment posed challenges in maintaining effective communication and team dynamics. It also tested the co-adaptability and digital literacy of participants and facilitators. On the positive side, this shift expanded the scope of learning by incorporating global perspectives and enabling cross-border collaborations, as professionals worldwide grappled with similar healthcare challenges. The pandemic thus underscored the importance of flexibility, resilience, and innovation in team-based and PBL approaches in health services education.

To understand how learning in health services was impacted during the pandemic, this systematic review was conducted to identify constructs associated with the success of TBL and PBL in health services education.

2. Materials and Methods

This systematic review was guided using the preferred reporting items for systematic reviews and meta-analysis (PRISMA) process. The PRISMA process is a set of guidelines aimed at improving the reporting of systematic reviews and meta-analyses. It helps authors to provide a clear and transparent account of their review process, improving the quality and replicability of systematic reviews. PRISMA focuses on ways in which authors can ensure the clarity and transparency of their report, covering areas such as the title, abstract, methods, results, discussion, and funding.

Key, abbreviated steps in the PRISMA systematic review method are as follows:

- Define the inclusion and exclusion criteria.
- Describe all information sources in the search (e.g., databases, registries).
- Present the full search strategy for at least one database.
- State the process for selecting studies.
- Describe the method of data extraction and any processes for obtaining and confirming data from investigators.
- List and define all variables for which data were sought.
- Describe methods used to evaluate the risk of bias.
- Describe the methods of handling data and combining results of studies.
- Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions.
- For each study, present characteristics and collected data.
- Summarize the main findings.
- Discuss limitations at study and outcome level, and at the review level.
- Provide a general interpretation of the results and their implications for future research.

The articles identified for the review related to project or team-based learning for health services and used the Xavier University Library's EBSCOhost website, Advanced Search level. Peer-reviewed publications specific to project- or team-based learning and directly related to health services, but not clinical medicine or medical education, are limited.

2.1. Inclusion Process

The researchers focused on project- or team-based learning articles that were recently published to investigate potential underlying themes related to andragogy methods and/or practices implemented during the pandemic. Medical Subject Headings (MeSH) is the National Library of Medicine controlled vocabulary thesaurus utilized to index research articles for PubMed (MEDLINE) and was used to identify key words in the search. This website tool assisted in the research team's generation of the review's database search string and related key words to be included in the search. Boolean search operators were used to ensure proper words/phrases to capture all applicable literature for the sample as indicated by MeSH and other identified review terms. The database search conducted on 27 June 2023 using the finalized search string below:

[(problem based learning) OR (problem-based learning) OR (team-based learning) OR (team based learning) OR (project based learning or project-based learning) OR (pbl) AND (healthcare) OR (health care) OR (health services) AND (education) OR (learning) OR (teaching) OR (classroom) NOT (medical) NOT (international) NOT (community service learning)].

To be included in the review, publications had to be published between 1 January 2021 and 31 May 2023. This specific publication date range was utilized by the research team to identify health services andragogy and pedagogy methods related to the review topic, specifically related to and during the COVID-19 global pandemic, and beyond. Articles included in the review had to be classified by the EBSCOhost search database as scholarly (peer-reviewed) articles, published in the English language, and meet the publication date search parameter. To further identify publications specific to the review team's initiative, additional search parameters included: limiters of academic journals only, coded as United States geography only, not internationally classified, and not conference papers or other citations not qualifying as journal articles/publications.

This study's information came from secondary data sources (library research database). All of the literature included in this research is publicly available and any individual research subjects (if present) are unidentifiable. As a result, this systematic review qualifies under the "exempt" status in 45 Code of Federal Regulations (CFR) 46. An institutional review board review was not required, and no consent was necessary.

2.2. Exclusion Process

Figure 1 demonstrates the article exclusion process, beginning with the review team's initial research database search efforts and ending with a final literature sample (n = 70). Initially, 5180 articles focused on problem-based and team-based learning in health services (not medical) and not being international were identified by the research team. The EBSCOhost website assisted in the auto-detection and removal of 4984 ineligible articles and an additional 18 duplicate articles, leaving 178 manuscripts remaining for review.

The research team consisted of six members, working primarily on a remote/online basis. The 178 manuscripts were each reviewed by at least two team members for the first round of exclusions based upon manuscript title and abstract analysis to ensure that only articles germane to the study's initiatives were included. Table 1 shows the delineation of article/abstract review assignments, per PRISMA guidelines.

In addition to removing 5002 articles for not meeting the study criteria, the full text review of the remaining articles resulted in an additional 108 articles being excluded from the review. These additional articles were removed for the following reasons:

- Review articles (2 articles);
- International article (1 article);
- Not germane to the topic (105 articles):
    - International study (10 articles);
    - Not higher education (primary/secondary education only, 3 articles);
    - Specifically medical-related only (48 articles);
    - No problem-based or team-based learning (18 articles);
    - Other non-health services related studies (26 articles).

The research team's review focused on studies involving team- and problem-based learning activities and related projects in health profession programs at higher education institutions during the pandemic. This was part of their effort to identify potential constructs from the literature for future grant proposals. The team conducted a thorough examination of 70 articles, selected through a database search and an exclusion process as depicted in Figure 1. They used MS Teams to assign internal numbers to each article and then proceeded with in-depth reviews of the full texts. At least two researchers evaluated each article.

The research team held multiple collaborative meetings, both online via webinars and in-person, to discuss coding and identify constructs within the assigned articles. An initial data collection/synthesis spreadsheet was used for article analysis and review team

collaboration. For each theme, an occurrence was defined as the included articles in which the theme was identified. More than one theme could occur in any given article. For each theme, the percent instances of attribute was defined as the number of occurrences divided by the total reports of included studies (n = 70) and multiplied by 100.

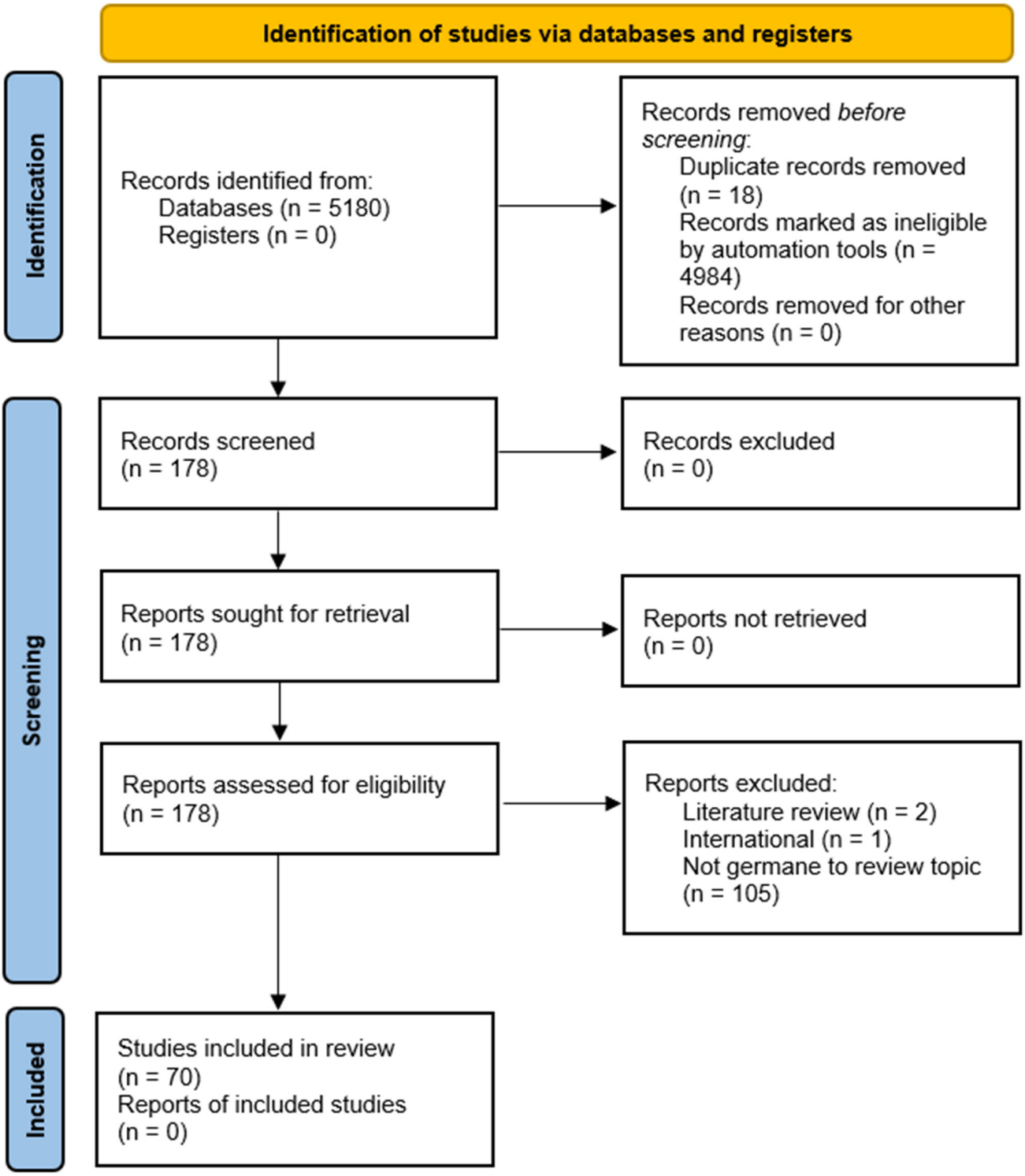

Figure 1. Preferred reporting items for systematic reviews and meta-analysis (PRISMA) figure that demonstrates the study selection process.

Table 1. Reviewer assignment of the initial database search findings (full article review).

Article Assignment	Reviewer 1	Reviewer 2	Reviewer 3	Reviewer 4	Reviewer 5	Reviewer 6
1–59	X	X				
60–118			X	X		
119–178					X	X

3. Results

Appendix A [19–88] provides the final review's included articles' (n = 70) information, to include the review team's perceived team-based and/or problem-based learning attributes identified in the review process. An analysis of Appendix A revealed eight constructs specific to PBL and TBL in health services education:

- High-impact learning methods for critical thinking;
- Modified problem-based learning, lessons learned/COVID-19 issues;
- Newer methods—simulation, games, puzzle/escape;
- Active learning methods in an online environment (time, effort, scalability);
- Meeting needs of age, cognitive styles, or developmental phase of students;
- PBL/TBL and improvement of instructor feedback or students' ability to self-assess;
- Cultural competencies and communication;
- Organizational leadership, team-based learning/collaboration.

From these eight constructs, three overarching themes emerged and are shown in Figure 2. Figure 2 provides a high-level lens of the three themes and eight constructs identified in the systematic literature review and the frequency of occurrence. These are as follows:

- TBL and PBL transform healthcare education; modified PBL is the new norm.
- TBL and PBL amplify age-appropriate principles for professional motivation in healthcare.
- Active learning impacts students' practical abilities for professional success and future leadership roles.

Theme 1 highlights the transformational importance of problem-based and team-based learning to healthcare education. Further, modified problem-based learning has emerged as the new norm in health services. Four constructs were clustered under Theme 1. High-impact learning methods for critical thinking had 14 occurrences across the included studies. As described in the Methods and required by the PRISMA guidelines for systematic literature reviews, the number of occurrences was divided by the total reports of included studies (n = 70), and the instances of this construct attribute was calculated at 20%. Modified problem-based learning and lessons learned from COVID-19 issues had 23 occurrences and 33% of the instances. Importantly, this was the highest percentage of instances of any construct. Newer methods, e.g., simulations, games, and puzzles with virtual escape rooms had 11 occurrences and 16% of the instances. Active learning methods in an online environment (time, effort, scalability) had 14 occurrences and 20% of the instances.

Theme 2 identified PBL and TBL as critical amplifiers of age-appropriate principles for professional motivation. Two constructs were clustered under Theme 2. Using TBL and PBL to meet the needs of students by age, cognitive styles, or developmental phase had 13 occurrences and 19% of the instances. The TBL and PBL improvement of instructor feedback or students' ability to self-assess had 15 occurrences and 21% of the instances.

Theme 3 identified specific ways in which active learning impacts students' practical abilities for professional success and future leadership roles. Two constructs were clustered under Theme 3. When TBL and PBL were applied, cultural competencies, communication, and performance measurement skills had 10 occurrences and 14% of the instances. Of note, TBL and PBL improved organizational leadership skills, teamwork, and collaboration with 18 occurrences and the penultimate percentage of instances at 26%.

More than one theme could occur in any given article, resulting in a broad range of reasons to incorporate TBL and modified PBL to improve learning in health services education. As we seek new means of preparing future healthcare professionals, these

themes and constructs should be considered when designing curricula and professional development experiences.

Figure 2. Occurrences of underlying themes and constructs identified in the literature surrounding team and problem-based learning in health services.

4. Discussion

The research team successfully identified specific constructs associated with team- and problem-based learning initiatives in health services. These constructs, grouped by the identified themes, encompass various attributes of learning initiatives conducted during the COVID-19 pandemic. Also, the identified constructs are interrelated rather than isolated phenomena within TBL and PBL initiatives. This interconnectedness signifies that

occurrences in one area often influence or overlap with others, highlighting the complexity and dynamic nature of the identified learning initiatives.

4.1. High-Impact Learning Methods for Critical Thinking

Evidence-based decision support relies on critical thinking skills. Compared to traditional teaching methods, e.g., lectures, PBL and TBL have been shown to support knowledge acquisition, skill development, and critical thinking [23,30]. Definitions of critical thinking [30] overlap with the higher-order Bloom's taxonomy of cognitive development, i.e., apply, analyze, evaluate, create [89]. There are many excellent published descriptions of proposed projects with critical thinking skills for clinical health-related disciplines [78]. However, very little original research has been published in health services to support the effectiveness of PBL and TBL to improve critical thinking under real-world educational conditions [25,47].

Further, student satisfaction with high-impact methods varies [23,24,30]. It is unclear if students at the graduate and undergraduate levels will value improved professional skill acquisition from higher-effort PBL and TBL, compared to traditional teaching methods, such as lectures [23]. More research to study the knowledge, skills, and abilities associated with critical thinking and professional skills is needed, as well as student acceptance.

Although simple in concept, the increased classroom space and materials needed to support students' team-based projects present additional barriers [23,24]. In addition, smaller class sizes are required for success as the instructor moves into a facilitator role [23]. More research is needed to assess university resource allotment to high-impact courses.

4.2. Modified Problem-Based Learning, Lessons Learned/COVID-19 Issues

In the 1960s, PBL was developed in response to the poor performance of professional skills by medical students [9]. Since that time, many adaptations have been introduced. Reviewers found very few current studies utilizing traditionally defined PBL [24,30]. In addition, few studies addressed learning outcomes in undergraduate student populations [19,30], who may have limited readiness for the internal motivation to learn that is typical of adult learners. More studies are needed in undergraduate health services students.

During COVID-19, modified problem-based learning (mPBL) became the new norm, often in virtual formats [23,27,28]. The team identified both program-specific and interprofessional education methods, during and continuing after the COVID-19 global pandemic [32,34,67,77]. We suggest defining mPBL as PBL with elements of related active learning pedagogies. Most experimental curricula, courses, and studies utilize mPBL, such as project-based workshops [19], IPE [87], or a modification specific to the problem or course [27]. When PBL was paired with CSL in a graduate counseling student population, knowledge, attitudes, and self-efficacy assessment were all improved at statistically significant levels [25]. In addition, virtual mPBL modules may be used to address specific identified learning needs and gaps [28].

In health services, mPBL tailors the traditional problem-based learning method to better suit the specific needs and context of health services education. It involves presenting students and/or healthcare professionals with realistic scenarios, encouraging them to analyze and solve complex problems related to service delivery. This adaptation incorporates additional structure, guidance, and the integration of foundational knowledge, enhancing the effectiveness and relevance of problem-based learning within the health services domain. Modified PBL has replaced traditionally defined PBL in health services education.

Regardless of the improved content knowledge and professional skill development, however, students may prefer traditional lectures [23]. Traditional teaching is, out of necessity, less confusing, and requires relatively less effort to discern subtle differences in content knowledge and application to less-structured, real-world scenarios. A meta-analysis of combined PBL and TBL versus traditional teaching demonstrated a statistically significant improvement of knowledge and skills; however, student satisfaction was higher with traditional teaching [23].

TBL is an inherently "flipped" pedagogy. Traditionally defined TBL includes the use of individual and team readiness assessment tests, with immediate feedback, to test and document student accountability for work, and it has consistent team members throughout each project [65]. The four steps of traditional TBL are individual student preparation, individual readiness assurance testing (iRAT) and team readiness assurance testing (tRAT), application, and peer assessment [28]. A study of mTBL comparing graded and ungraded iRAT found no difference in scores [29]. The research team identified a subset of articles within this construct that utilize team-based learning with a focus on clinical processes [19,24,32,35,42]. When TBL was paired with Kearsley and Shneiderman's engagement components in graduate pharmacy students, team support and trust improved their ability to relate [35]. Modified TBL was combined with a technologically enhanced experience in a "flipped" virtual model to engage graduate nurse practitioner students learning teamwork and statistics [65]. Like mPBL, modified TBL (mTBL) has become the new norm. One best practice for this remote or online learning method was keeping consistent teams throughout the entire learning experience, versus switching team members during the initiative [65].

4.3. Newer Methods—Simulation, Games, Puzzle/Escape Rooms

The importance of active learning strategies to engage students in higher education and prepare students to collaborate effectively has been well documented broadly [90]. Since the 1960s, problem-based learning (PBL) and team-based learning (TBL) have been essential instructional approaches in medical school education to prepare students to effectively collaborate in the complex and evolving field of health services [11]. However, the COVID-19 pandemic was a catalyst for additional pedagogical adaptations and highlighted the need for innovative teaching methods that increase student engagement virtually as well as in person. While active learning strategies are commonly used with TBL and PBL among students training in clinical processes, few studies assess their impact in health services education. This lack of transdisciplinary knowledge may be a contributing factor to the confusion of roles within interprofessional learning experiences.

Articles that utilized simulation showed that they were beneficial for students by improving understanding and the clarification of roles. For example, a simulation video resulted in students shifting their focus to a cognitive leadership role through virtual discussions [20]. While in Article 93, the in-person simulation resulted in an appreciation for interprofessional team members and their roles within other health services disciplines, Article 21 utilized a simulation game in the context of an escape room online, in-person, and in hybrid settings utilizing teams and individuals. For each escape room scenario, a case was presented as a prompt that needed to be solved within an allotted time. This resulted in enjoyment and a high level of engagement that ranged from individual proficiency to group communication and collaboration.

Articles that utilized non-lecture-based teaching methods showed that most students favor a deep-learning approach that can be achieved with a flipped classroom [31], concept mapping [41], skill-based activities [42,77,87], or learning laboratories [26,57]. For example, in Articles 42, 47, and 77, students were able to self-direct their learning and improve performance skills by recognizing connections between unfamiliar concepts while practicing professional interactions. Article 57 uniquely implemented new design thinking methods inclusive of five phases: problem analysis, design, development, integration, and evaluation that resulted in deeper problem analysis.

Barriers to these innovative teaching methods to improve student engagement included students reporting awkward interactions with simulations, too many people grouped together, and the cost of time and/or money for planning and implementation. However, overall, these studies show that effective innovative teaching methods use immersive and experiential opportunities that require reflection, discussion, reasoning, and decision-making. The positive effects on student engagement occurred both virtually and in person. Therefore, these findings are generalizable to the diverse higher education

formats of multiple health services professions. This may result in a higher level of critical thinking and improved interprofessional collaboration within health services.

4.4. Active Learning Methods in an Online Environment (Time, Effort, Scalability)

Modalities for active learning include PBL and TBL. TBL exercises, such as debates, group work, and peer review prepare students to give and receive respect in a multidisciplinary, hierarchical environment. Analyses of best-practice reports and case studies, i.e., case series, single case reports, and practice scenarios, are examples of PBL. Students' abilities to communicate, verbally and non-verbally, and function in the delivery of health services has become an increasingly difficult transition post-COVID-19. By incorporating active PBL and practicing effective team processes and communication in an online milieu, students may be better prepared for their transition to multidisciplinary professional practice.

With a greater emphasis on active learning in the classroom, it is necessary to consider the adaptations needed to provide opportunities in an online environment, which is especially true post-COVID-19. Learning virtually serves as complementary to traditional education, but it also supports non-traditional students and students taking courses or training for continuing education or skill enhancement, and it reduces barriers between professionals working collaboratively. Active learning allows for introspection and reflection while professionals and students share experiences, assimilate into roles that enhance safety, and learn to routinely incorporate evidence-based practice before entering the workforce [20]. Students report feeling more engaged and having higher satisfaction when active learning is included in their education [33]. Further, students are more equipped to both educate others and delegate work, mimicking real-world workplaces that require working on teams and solving analytical problems with others [20,21].

Much has changed in higher education and there is greater understanding of the unique needs of learners when working virtually, including generational contexts and preferences [34]. Virtual active learning requires greater student responsibility [34] and an emphasis on the synthesis of complex information and critical thinking [34]. Virtual active learning gives students a chance to demonstrate and apply knowledge gained in coursework and prior experience [36]. There is a great opportunity to connect policy, procedure and guideline awareness [36] with evidence-based practice and safety across roles [19].

Online active learning often uses case-study review, but it also includes procedural reviews, escape rooms (for problem solving and use of constructivism), and self and group reflection [20,21,33,34,36,54]. Using a multi-modal discussion to brainstorm ahead of active learning and debrief after can help the online environment to feel more effective and connected, and it can be key to engagement [20]. Virtual active learning is impactful, with 360′ immersion using photo and video to understand settings and patient needs even when being in person is not feasible due to distance (national and international perspectives) or due to illness or related health concerns, e.g., COVID-19 [33].

The literature suggests that some components of working in an online environment can be cost effective, depending on the level of engagement between the faculty and the student [20,21,33]. A reduction in effort with each iteration of a project may occur if there are not significant changes as well as an inverse relationship with the ability to scale to larger groups over time [20,21,33]. The setup and organization of a project can positively or negatively impact engagement but requires proper planning upfront and purposeful goal setting to reduce costs and the need for a large number of staff to manage the project [21]. And, if the time is spent upfront, subsequent offerings of the same project have been noted to be at a reduced expense—both in time and resources [20]. Students benefit from having some freedom of choice [54] and having multiple methods for learning and interaction, which requires more staff and will not reduce the cost but instead provide flexible learning environments [20]. Recommendations include having options that work on a PC or laptop vs. on an iPhone [20,54], and having opportunities for pre-work that is asynchronous and offered in video or online discussion formats, giving the feel of individualization while still

being standardized [20,33,34,54]. User control features allow for concise, "bite-size" learning and create more frequent, consistent, and immediate opportunities for feedback [34].

Although higher education administrators commonly allow a higher capacity in courses that are offered virtually vs. in-person, this is not a well-supported decision. There is a notable increased time, effort, and difficult scalability of online courses, in general, and when active learning is included, there are additional barriers to appropriate project management in resource-limited universities. To provide timely feedback prior to graded exams, faculty challenges included ongoing quality improvement efforts, increased time for grading active learning assignments, and additional faculty members to coordinate and engage when the faculty: student ratio exceeded 1:27 [54]. In an online environment, PBL increased facilitators' time administering the active learning group work, as technical assistance for students was needed and facilitators were not able to do both simultaneously. Creating PBL in a virtual environment also required additional faculty training time [67]. PBL active learning via real-time teleconferencing was used to meet the interprofessional teamwork core competency. The faculty created case studies, guided questions, coordinated invited healthcare professionals to round out the multidisciplinary team, and created alternatives to a traditional exam. A "360 Workshop" with complex virtual interactive puzzles, documents, and content covered in the course and outside partners dramatically increases faculty time and effort [33].

In summary, in an online environment, active learning methods (PBL or TBL) affect time, effort, and scalability and require a reduced number of students per course instructor, compared to traditional teaching.

4.5. Meeting Needs of Age, Cognitive Styles, or Developmental Phase of Students

Age, developmental stage, cognitive style, and age-appropriate learning principles have high impacts on learning. Adult learners' engagement and achievement are improved by planned learning experiences targeted to their developmental stage and pragmatic needs. Andragogy, i.e., adult learning principles, gained attention in the 1970s, include self-direction, relevant material, problem-based learning, self-motivation, and application of life experiences [91]. Over time, the principles of adult learning have been expanded and applied by researchers, educators, trainers, and for-profit universities, e.g., interaction, small learning teams, and clear and timely feedback [92]. Yet, pedagogic principles for the traditional education of children prevail in higher education. Adult learning principles, as opposed to pedagogy, are rarely planned with intention. The implementation of TBL and PBL meets the needs of adult learners. Although programs and courses may utilize adult learning principles, few studies assess the impact in health services disciplines [11].

Andrienko et al. (2021) showed that team-based learning (TBL) has a positive effect on outcomes related to adult learning in undergraduate higher education, such as business communication, global employment, and intercultural competence [56]. Two-team simulations are efficient and effective [62]. One benefit of the two-team training approach is the motivation generated by the active observer role during simulation exercises. Further, motivation and self-direction were improved when the TBL case study was used in groups of graduate students at different levels [55]. White et al. modified traditional elements of TBL to create an online graduate statistics course, e.g., immediate student-to-student feedback and timely faculty feedback to support students in areas of difficulty. Computer-based testing is preferred by 79% of first-year doctoral students, due to its convenience and immediate feedback [60]. TBL as a tool is particularly useful for teaching complex subject matter to adult learners [66]. TBL enhances self-awareness of learning needs and thinking about thinking (metacognition) in graduate students [41]. When master's-level students engaged in the application of material in a real-world context, they were able to clearly connect didactic material to their discipline. PBL increased knowledge, attitudes, and self-assessment at large effect sizes, with statistically significant results [25]. A mock board presentation was used to simulate the real-world experience for graduate nursing students [78].

However, barriers to the implementation of PBL include faculty resistance due to inadequate facilitation skills, frustrated student learners unfamiliar with the process, and the complexity of cases being mismatched to with knowledge level and resources [24]. In addition, students expressed difficulty managing their own small groups [55]. Further, the "flipped" classroom approach did not support student motivation in undergraduate nursing students [45].

Collectively, these studies show that team-based learning (TBL) and PBL have a positive effect on outcomes related to adult learning in higher education. The findings can be applied to both undergraduate and graduate programs. Higher education in health-related fields, which require knowledge, skills, and the ability to apply business, clinical, change management, communication, and other strategies to everyday practice, would improve outcomes by implementing hybrid TBL and PBL projects based on the principles of adult learning.

4.6. PBL/TBL and Improvement of Instructor Feedback or Students' Ability to Self-Assess

Instructor feedback to students is expected and impacts student satisfaction. Formative assessments provide quick and informative feedback, while summative assessments evaluate knowledge and comprehension. Group work and peer-to-peer learning are examples of TBL and active learning. Case studies are used for PBL. The faculty provided timely feedback for active learning assignments prior to graded exams [54]. "Flipped" classroom interaction with instructor provides immediate feedback, and a TBL "escape room" provides immediate feedback and is viewed positively by participants [36]. To provide immediate feedback, the faculty created case studies, guided questions, invited healthcare professionals to round out the multidisciplinary team, and created an alternative to a traditional exam, via a "360 Workshop" with complex virtual interactive puzzles, documents, and content covered in the course [87].

Students' abilities to self-assess, and the results, are highly variable. Critical thinking skills contribute to accurate self-assessment [41]. Mid-level performing students (mean 84%) most accurately predicted their final score ($p < 0.02$) [41]. Although the results were not statistically significant, lower-performing students (<80% quiz score) overestimated their expected grade, whereas high-performing students underestimated their success [41]. When validated instruments for attitudes toward research and research self-efficacy scales were applied to study self-assessment, the results showed a statistically significant improvement in self-efficacy with a large mean increase of 18.4 (CI95 10.6–26.2). Students perceived themselves to be competent researchers, and their self-assessment was validated by the large effect size and statistically significantly improved scores in discipline knowledge and attitude toward research [25]. In addition to positive effects on critical thinking, reflective writing improved self-assessment [93]. Although TBL via group concept mapping significantly increased quiz scores ($p < 0.001$), it did not improve self-assessment ($p = 0.1$) on a summative assessment [41], nor was self-rated knowledge statistically significant after the TBL intervention ($p = 0.64$) [22].

4.7. Cultural Competencies and Communication

Value-based care requires health services professionals to collaborate and communicate in the continuous improvement of health outcomes [86]. Team- and problem-based learning is an effective tool for health services students to develop the communication and performance measurement skills needed to assess these improvements. The development of these skills was evidenced by an increase in confidence to perform technical skills and improved cultural competency to work in cross-cultural situations [43,86,94]. The importance of communication as a skill has been documented since the 1970s and current curricula often meet these expectations by incorporating PBL experiences [86,95]. PBL learning experiences build on prior knowledge and allow students to communicate their understanding of concepts with real-world practice [87]. The PBL approach blends theory and practice, and when used repeatedly with progressively increased complexity,

foundational knowledge and communication skills improve [88]. As a result, health services students exposed to PBL have an advantage with problem solving, incorporating basic concepts into professional application, and excelling during fellowships [87], and this starts in the classroom.

For example, in Article 19 using project-based learning, health services students were able to develop communication skills to address public health concerns regarding sexual health education within a specific population of older adults in a workshop setting. This workshop helped to expose biased views that would impact students' professional ability to disseminate and communicate information related to the topic of sex and aging as staff in long-term care settings. Additionally, it contributed to addressing the lack of professional skills when entering the workforce with necessary foundational gerontological knowledge [19]. As a result, students not only increased their awareness of late-life sexual health and behavior but demonstrated confidence and utilized creative strategies to discuss a sensitive topic. Moreover, students stated that they "appreciated the opportunity to develop transferable pre-professional skills" [19].

4.8. Organizational Leadership, Team-Based Learning/Collaboration

Team-based learning is a potent tool for organizations aiming to align their strategies and directives with collaborative and dynamic engagement. By fostering a culture of teamwork and collaboration, organizations can effectively implement strategies that capitalize on collective intelligence and varied perspectives. Teams provide a platform for integrating diverse skill sets, knowledge bases, and experiences, enhancing problem-solving and decision-making processes. Additionally, team-based learning cultivates a sense of ownership and shared responsibility among team members, aligning them with the organization's strategic goals. This approach encourages innovative thinking and promotes adaptability, critical components in responding to evolving market trends and disruptions. By employing team-based learning as a fundamental strategy, organizations can bolster their ability to navigate complexity, drive innovation, and achieve sustainable success in the fast-paced business landscape.

Articles that supported a construct surrounding the use of team-based learning in health services also furthered organizational leadership and/or an organizational strategy. Often conducted or tested in higher-education environments, such learning activities worked to further healthcare organizational outcomes or other performance indicators [22,26,27,37]. Additionally, several team-based learning initiatives also infused interprofessional learning and collaboration [37,40]. Often driven by difficult clinical situations, patient diagnoses, or other environmental factors, the use of team-based learning has demonstrated the ability to improve organizational metrics and support the organizational leadership's initiatives [42,47].

The research team identified several articles that not only focus on the training and implementation of team-based learning in a real-world environment to achieve better patient and/or organizational outcomes, but also aim to grow and support a safety culture [27,56,57]. Implementing team-based learning in the health services workplace can significantly enhance safety standards and practices. In a healthcare setting, collaboration and effective communication among team members are paramount to ensuring patient safety and optimal outcomes. Team-based learning facilitates interdisciplinary training and knowledge sharing, ensuring that healthcare professionals understand each other's roles, responsibilities, and expertise [57,78]. Through simulated scenarios and real-world case discussions, teams develop a deeper understanding of protocols, emergency procedures, and best practices for patient care [41]. This approach also cultivates a culture of accountability and shared responsibility for patient safety, encouraging individuals to speak up and voice concerns, ultimately minimizing errors and fostering a safer environment for both patients and health services professionals [26,27,43,86].

4.9. Limitations

Systematic reviews typically strive to eliminate bias, but we would be remiss not to include the limitations of our study. Although we attempted to reduce bias in our study by justifying our choice to use PRISMA guidelines, it can never be fully eliminated. With small sample sizes, several of the studies included in the review could overestimate the intervention effects. Further, publication bias is also more likely to occur in small studies (due to not being statistically significant), of which we reviewed many [19,20,24–26,28,34,42,45,51,52]. Another limitation may include bias in our conclusions. As we attempted to categorize 70 studies into three underlying themes, our conclusions may have been broad [36,43,48–50,52–54,59,61,69,82].

5. Conclusions

To understand how learning in health services was impacted during the pandemic, this systematic review uniquely found eight constructs associated with the combined success of problem-based learning (PBL) and team-based learning (TBL) in health services education. PBL and TBL are integral to the preparation of students in health services and mimic the roles and responsibilities that exist as they enter their respective occupations. Notably, active learning impacts practical abilities for professional success and future leadership roles. However, modified PBL and TBL are the new norm in health services education because they amplify age-appropriate principles for professional motivation in healthcare. Importantly, the principles of adult learning are met by mPBL and mTBL, including choice, flexibility, and the unique learning needs of each individual.

While the benefits of implementing mTBL and mPBL contribute to the critical thinking, motivation, and practical abilities necessary for success in healthcare, it comes with challenges that need to be considered. A key takeaway is the necessity to creatively work through implementation barriers. To assist with the implications of results and summarize this review's efforts and initiatives for future research, the research team completed a force field analysis of perceived positive and negative influences on the use of mTBL and mPBL in higher education. The force field analysis (Figure 3) compares the benefits and barriers of implementing modified team-based learning (mTBL) and modified problem-based learning (mPBL) in health services education.

Based on our results, there are significant forces making implementation difficult. Important barriers include the lack of university resources and space allocation, a counterproductively large class size, lower student satisfaction scores, and limited faculty engagement, or the lack thereof. When implementation barriers are not recognized or mitigated, the ramifications are experienced by the students and amongst the faculty. Burnout amongst faculty may occur along with lower student satisfaction scores affecting faculty attainment of desirable annual evaluation scores, promotion, and tenure.

Considering these barriers, a practical suggestion for an educational intervention with mTBL and mPBL is the use of quick real-time assessments with the delivery of course content. Several ways this can be easily accomplished include using various student engagement platforms such as Socrative, EdPuzzle, Kialo Edu, and Padlet. These student engagement platforms differ from gamification apps because their assessments are not based on competitive performance against other students. Engagement platforms provide students an individualized opportunity to actively participate with course content while enabling instructors to collectively gauge their understanding with real-time assessment and data collection. These and other engagement platforms can assist students with the increased responsibility for synthesis of complex information by simplifying the delivery of course content. They can be used within traditional lectures or with large class and group sizes and remove awkward interactions. Many engagement platforms offer a free basic account to educators with autogenerated content and online storage of data results to reduce or mitigate the barriers of administrative time, money, and the lack of university resources. As a result, the use of engagement platforms could streamline the benefits of implementing mPBL and mTBL and address many implementation barriers.

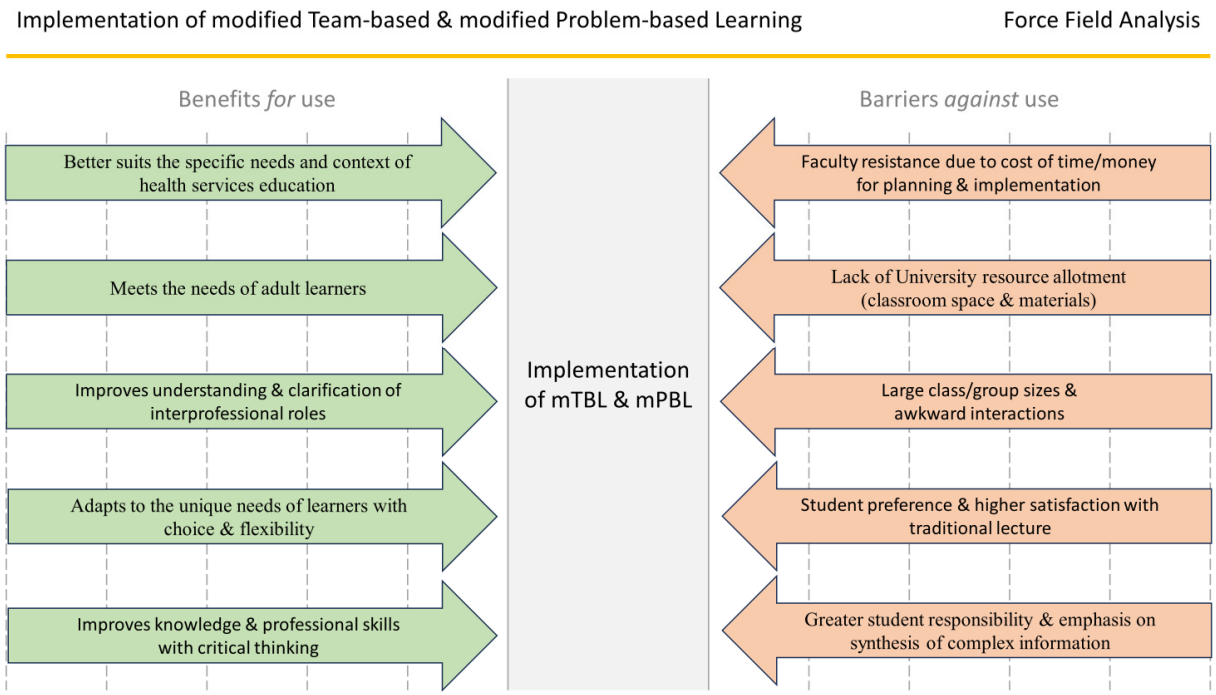

Figure 3. Force-field analysis of influential factors surrounding modified team-based and problem-based learning in health services.

As faculty members continue to strive to better understand the unique developmental needs of undergraduate student populations, future studies are needed to identify effective mPBL and mTBL strategies in health services education to help them to progress as internally motivated learners. Most studies in this systematic review were based on qualitative data and student perception. Specifically, experimental studies are needed to collect quantitative data to test the association of knowledge, skills, and abilities needed for professional practice compared to students' perceived level of knowledge, skills, and abilities. Time and effort studies are needed to determine the time, effort, faculty, support staff, and resource allocation needed to implement and scale up effective active and experiential learning methods, including mPBL and mTBL, while avoiding burnout. In doing so, given the positive and negative aspects of remote study and work during the COVID-19 pandemic, the implementation of effective mPBL and mTBL strategies can help prospective students to adjust to higher-education expectations and prepare them to function in a complex, multidisciplinary workplace.

Author Contributions: All authors contributed to this review in accordance with ICMJE standards. E.S.A. and C.L. primarily led the research, team initiatives and provided guidance throughout the research process. E.S.A., C.L., A.A.W., K.A. and A.V. contributed to investigation into the research topic, participation in the method of the review, and original drafting of the manuscript. Discussion and analyses of review and topic modeling results were conducted by all authors. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Summary of findings (n = 70).

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[19] Naar, J. et al.	Experiential education through project-based learning: Sex and aging Gerontology and Geriatrics Education	• Undergraduate students.	• Two-day project-based workshop on sex and aging. • Content analysis of open-ended responses. • The authors sought to identify the benefits of project-based learning when encouraging undergraduate students to be comfortable and confident with disseminating information about a sensitive topic such as sex in the aging population. • Feedback from a 2-day workshop was analyzed.	• Development of transferable pre-professional skills. • Comfort and utilization of creative strategies to discuss a sensitive topic. • Greater awareness of late-life sexual health and behavior. • Closing the knowledge gap about issues of late-life sexual health and behaviors. • Skills for translating knowledge into practical resources. • Students found they were able to benefit from project-based learning on the topic of sex and aging as it provided them with transferrable pre-professional skills, gave them creative freedom to work on a topic of choice alongside peers and increase their awareness of a topic while identifying evidence-based resources. • Themes and implications: Project-based learning, confidence, knowledge gap, skills development, experiential, intervention, cultural competency, inclusive. In future, consider preexisting comfort/bias and access to resources.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[20] Littleton, C. et al.	What Would You Do? Engaging Remote Learners Through Stop-Action Videos Nurse Educator	• Nurse educators and their students in virtual classes.	• Use of stop-action video vignettes as unfolding case studies. • The study design seems to be an evaluative approach or possibly a descriptive study based on the provided text, but specific design details (e.g., randomized control trial, observational, etc.) are not mentioned in the information provided.	• Enhanced student engagement. • Improved critical thinking. • Effective knowledge application through case studies. • This article argues that stop-action videos using case studies can be an effective means for engaging remote learners when in-person opportunities are limited and experiencing problem solving related to the field is warranted. • Stop-action video vignettes were used alongside video-based discussion, text-based discussion and branching matrices (stated at a Nursing Practitioner program in Southeastern US—no mention of the size of the student body or the educators providing the program). • Both students and educators found the use of stop-action videos to be beneficial, with the decision-making process feeling similar to being in person, with a focus on cognitive learning occurring. • Themes and implications: Scalable option for students of all levels, allowing frequent exposure/opportunities to practice, competencies, multimodal, ability to assess skill deficits and allow time for correction, great option to use before a clinical experience, virtual learning, immersive, experiential.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[21] Helbing, R. et al.	In-person and online escape rooms for individual and team- basedlearning in health professions library instruction Journal of the Medical Library Association	• Health professions students from various disciplines (optometry, pharmacy, medicine) participating in health sciences library instruction.	• Incorporation of escape rooms into library instruction in a variety of settings (in-person, hybrid, online) and formats (team, individual). • This article utilized an escape room/game-based learning approach to help pharmacy, optometry, and medical students enhance their library use and resource allocation skills in an active format. • In-person team-based, on-site virtual individual and fully remote virtual individual escape room formats were tested between 2020 and 2021 (details of number of students was not provided; learning objectives were shared as they varied year to year).	• Improved learning experience through active learning. • Promotion of teamwork. • Encouragement of analytical thinking. • Enhanced problem solving. • Students found the escape rooms to be enjoyable and were able to complete all tasks, with benefits from both in-person and virtual options. • Themes and implications: Can be cost effective and scalable to a large audience once created, though there is a significant initial cost to implement due to planning time, active learning, and game-based learning.
[22] Whillier, S. et al.	Team-based learning in neuroanatomy Journal of Chiropractic Education	• Students who are enrolled in an undergraduate neuroanatomy course.	• Introduction of TBL in the tutorials of the course. • The researchers sought to find out if team-based learning improved the knowledge and sense of satisfaction from students taking a neuroanatomy course when compared to traditional learning methods. • Questionnaire was completed by students in a neuroanatomy course and compared from 2018 (183 students; team-based learning) to 2011 (90; traditional teaching methods).	• The outcomes the researchers were interested in include the grades of the students (to assess their knowledge) and their subjective satisfaction with the teaching method. • Team-based learning was not shown to be effective, with no improvement in grades or satisfaction being reported; however, they provide elements that could be altered including assigning groups, assessing readiness and teaching more in advance, better use of time and connection to the material, incentivization, and peer review. • Themes and implications: active learning, team-based learning NOT for classes where knowledge acquisition is the focus, teachers must identify issues and prepare students accordingly.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[23] Luke, A. et al.	Effectiveness of Problem-Based Learning versus Traditional Teaching Methods in Improving Acquisition of Radiographic Interpretation Skills among Dental Students—A Systematic Review and Meta-Analysis		• This systematic review and meta-analysis sought to find the effectiveness between problem-based learning and traditional teaching methods related to the skills of dental students learning radiographic interpretation. • Using the PRISMA and PICO (patient, intervention, comparison, and outcome) format, 13 total studies were reviewed with 835 total participants accounted for (411 PBL/424 TT). • Teaching methods and problem-based learning methods were varied, but across the studies using PBL facilitated skill enhancement and critical thinking ability over TT, with motivation to learn also being seen. A negative effect was present for the satisfaction of students using PBL, which was attributed to a learning curve using the format and the amount of additional time spent to accomplish a similar outcome.	• Themes and implications: active learning, team-based learning, satisfaction of students, interpretation, types of knowledge.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[24] Henderson, K. et al.	Addressing Barriers to Implementing Problem-Based Learning AANA Journal	• Nurse anesthesia educators and students. • The setting of interest is nurse anesthesia education where they are contemplating the use or integration of PBL.	• The outcomes the researchers were interested in including identifying barriers to implementing PBL and finding interventions that can address these barriers. • The authors sought to understand the barriers for the implementation of PBL into the nurse anesthesia curriculum. • An "evidence-based review" was completed in which a total of 23 students were examined from a variety of disciplines and interventions.	• Barriers that exist include faculty resistance to implementation due to inadequate facilitation skills, frustrated student learners who are unfamiliar with the process, complexity of cases that are a mismatch to knowledge level, resource allocation and availability. • This review revealed several barriers to the successful implementation of PBL, including faculty, resources, and students. Nurse anesthesia students and educators benefit from employing PBL. Increased student engagement, improved performance, and a rapid improvement in development of critical thinking skills are observed. PBL use in nurse anesthesia education is novel. There are opportunities for future research in PBL in CRNA education.
[25] Hurt-Avila, K. et al.	Teaching Counseling Research and Program Evaluation through Problem-Based Service Learning Journal of Creativity in Mental Health	• 20 master's-level counseling students.	• Problem-based service learning was used to impact research learning outcomes for counseling students in a blended-learning format (in-person and online) with a 5-week project. • A quantitative action research study with 20 counseling students—formative and summative data collected and analyzed with a repeated measures design.	• Research knowledge, attitudes, and self-efficacy had significant increases with the implementation of problem-based service learning; however, the small sample size warrants further investigation. • Research was undertaken on the self-efficacy and knowledge acquisition of master's-level counselors in training. Problem-based service learning (PBSL) was used to research educational content in a real-world environment. This study applied research learning outcomes using PBSL to impact the counseling student's development of principles supporting the researcher practitioner identity. The PBSL components of the research and program evaluation course were blended. The high-impact learning method of the PBSL program evaluation project consisted of the student-led/instructor-supported development and implementation of a program evaluation. To complete the project, students engaged with the on-campus counseling clinic managed by the counseling program. • Themes and implications: experiential learning, service learning, problem-based learning, client outcomes, transition to telehealth services due to COVID-19.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[26] Shorten, A. et al.	Development and implementation of a virtual collaborator to foster interprofessional team-based learning using a novel faculty-student partnership Journal of Professional Nursing	• Students of professions including dentistry, nursing, occupational therapy, social work, and public health. • 37 students (dentistry, nursing, social work, public health, occupational therapy) used a faculty–student partnership to create a comprehensive care plan; qualitative self-assessment used for feedback specific to interprofessional interaction and interprofessional value (only 16 granted permission for the data to be analyzed.	• A case-based online interprofessional collaboratory course designed using a faculty–student partnership model. • Develop an online, collaborative tool for interprofessional work, based in the IPEC core competencies.	• Increase in IPEC competency assessment interaction domain mean scores. • Retention of high scores in the values domain. • Qualitative feedback highlighting core themes for success. • The faculty–student partnership model was successful with the primary indicators including active team engagement, case reality, clear expectations, shared team commitment, and enjoyment. • Themes and implications: team-based learning, interprofessional, IPEC, online/virtual, curriculum gaps, COVID-19, decision making, diverse.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[27] Manske, J. et al.	The New to Public Health Residency Program Supports Transition to Public Health Practice		• Discussed the development, content, and structure of a new public health workforce development program for employees from various health related backgrounds. • The residency program was adapted from Southeastern Wisconsin Public Health Nurse Residency Program and program evaluation was based on the Kirkpatrick model, the modified version of the core competency for public health professionals, and the adapted Casey Fink nurse retention survey. • No quantitative, qualitative findings or lessons learned were presented.	• Public health employees are inexperienced. Many new PHEs have primarily carried out COVID-related work. Public health workforce challenges can be addressed with professional development, beyond training. Instead of individual competency-building, the focus needs to be on cross-cutting competencies and collective community action. The N2PH residency program aims to increase the confidence and competence of new public health professionals while supporting their professional socialization and identity formation through interactions with peers and mentors. The N2PH residency program fills gap in public health training resources. Assessments, program content, evaluations, and ongoing participation are evidence-based components of the nurse residency programs, matching residents with trained mentors, based on professional interests, experiences, culture, and gender identity preferences and the completion of a quality improvement or evidence-based practice project.
[28] Veneri, D. et al.	Flop to Flip: Integrating Technology and Team-Based Learning to Improve Student Engagement Internet Journal of Allied Health Sciences and Practice	• Students enrolled in the evidence-based practice course in a physical therapy curriculum.	• Revising the traditionally taught course using a combination of flipping the classroom, team-based learning, and technology. Online preparatory modules with multimedia content, in-class vocabulary quizzes, summary lectures, in-class assignments in pairs or small groups, and discussions. • Discussed the revision of a course using various technologies and a team-based learning activities for doctoral students of Physical Therapy. • The methodology for the new course design was a flipped classroom, a team-based learning model and Malcom Knowles' adult learning theory.	• Students' preparation for class as evidenced by quiz performance. • Student perceptions of the helpfulness of various online preparatory module components. • Quality and depth of in-class discussions and interactions about content. • Based on student perceptions/self-reflection PowerPoint with voiceover, quizlets, concept checks, and weekly lists of vocab terms were the most helpful with learning content. • This article consists of lessons learned due to no quantitative or qualitative analyses being performed.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[29] Eudaley, S. et al.	Student Performance on Graded Versus Ungraded Readiness Assurance Tests in a Team-Based Learning Elective American Journal of Pharmaceutical Education	• Third-year student pharmacists enrolled in an ambulatory care elective course.	• Use of ungraded readiness assurance tests (RATs) as part of the team-based learning framework. • Evaluated the impact of graded vs. ungraded pre-class preparation on exam performance with doctoral pharmacy students in one elective course. • Used a standard framework for team-based learning and peer evaluation.	• Overall mean percentage score on individual RATs. • Overall mean percentage score on individual examinations. • Student responses on pre-class preparation, perceived team accountability, and the impact of RATs on learning. • There were no statistically significant differences between graded and ungraded pre-class preparation on the impact of course assessments. • This article provides good insight on lessons learned with peer-to-peer learning and student motivation.
[30] Seibert, S.	Problem-based learning: A strategy to foster generation Z's critical thinking and perseverance Teaching and Learning in Nursing	• Third-year student pharmacists enrolled in an ambulatory care elective course.	• Use of ungraded readiness assurance tests (RATs) in the context of team-based learning. • Reviewed attributes of the Gen Z student cohort and discussed problem-based learning as a strategy to enhance critical thinking and perseverance.	• The outcomes researchers were interested in are the overall mean scores on RATs and examinations, as well as student feedback regarding pre-class preparation and perceived benefits of RATs on learning. • Noted Gen Z's inexperience with higher-order critical thinking and tendencies to give up, specifically in the field of nursing/nursing students. • Critical thinking, perseverance, and problem-based learning are all defined. • The article recommends PBL for Gen Z and higher-order critical thinking initiatives, to include the use of their open-minded inclusiveness and also technology-savvy traits. • Unique use of ill-structured case studies.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[31] Walker, J. et al.	A deep learning approach to student registered nurse anesthetist (SRNA) education International Journal of Nursing Education Scholarship	• Generation Z students.	• Implementation of problem-based learning as a teaching strategy. • The article summarizes the benefits of deep learning in the physiology education of student nurse anesthetists. • Study involved a flipped classroom method, deep learning, PBL, and a post-survey about the learning experience.	• Enhancement of critical thinking and perseverance in Generation Z students. • Results: most students (the majority) favored the deep-learning approach.
[32] Bavarian, R. et al.	Implementing Virtual Case-Based Learning in Dental Interprofessional Education Pain Medicine	• Dental students training in oral/facial pain management procedures were prohibited from rotations due to the pandemic.	• A virtual objective structural clinical examination was used by the institution. • Students utilized telemedicine to interact with patients and conduct self-exams. • Case-based learning methods were also incorporated.	• Student feedback included comments stating they were confident in their virtual training, as compared to in-person. • Claimed to be an effective in diagnosis and management of oral pain, etc. • B, E, I (add A for collaboration component)
[33] Woodworth, J.	Nursing Students' Home Care Learning Delivered in an Innovative 360-Degree Immersion Experience Nurse Educator	• Nursing students enrolled in the third semester of an associate degree program.	• An in-home immersive nursing training program was started using 360-degree footage and zoom-in pictures presented via a web platform. • Cross-sectional design with 81 convenience sample.	• Student satisfaction with the immersion experience. • Engagement and positive responses to the new pedagogy. • Perceived learning impact and overall feedback through written comments. • Positive learning feedback from students after the training. The immersive experience claimed to provide PBL experience.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[34] Tomesko, J. et al.	Using a virtual flipped classroom model to promote critical thinking in online graduate classes in the United States: a case presentation Journal of Educational Evaluation for Health Professions	• Health professions faculty and students in online graduate nutrition courses at the School of Health Professions, Rutgers, The State University of New Jersey.	• The intervention being studied is the implementation of a flipped classroom model design in a virtual learning environment, using a combination of pre-class, live virtual face-to-face, and post-class activities. • Flipped classrooms can be beneficial in health science education, including a virtual face-to-face setting. • The authors provided examples of how a flipped classroom can be used in a nutrition graduate-level curriculum.	• The outcomes the authors/researchers are aiming for include the enhancement of student engagement, a thorough synthesis of information, and an increase in students' critical thinking skills. • Material should be provided ahead of time to students to build knowledge, and in-class activities should connect this information to real-world scenarios.
[35] Carpenter, R. et al.	The Student Engagement Effect of Team-Based Learning on Student Pharmacists American Journal of Pharmaceutical Education	• Student pharmacists.	• Application of team-based learning (TBL) pedagogy. • Identify the parts of the student experience when educated in a team-based learning environment. • This was a qualitative case study using student interviews.	• Psychological state of student engagement experienced by student pharmacists. • Themes and components of engagement (relate, create, donate) as perceived by student pharmacists. • The researchers did find evidence of the relate, create, and donate aspects of student engagement from Kearsley and Shneiderman. • The authors claim the study also describes how students relate psychologically to team-based learning.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[36] Diaz, D. et al.	Using Experiential Learning in Escape Rooms to Deliver Policies and Procedures in Academic and Acute Care Settings Nursing Education Perspectives	• Registered nurses, nursing students, and community members.	• Participation in puzzle room or escape room for experiential learning. • The objective was to transfer knowledge from policy and procedure to practice. • Methods: use of escape, or puzzle, room simulation with nursing residents (n = 60) and students (n = 40) in both acute care and academic settings, with 2 scenarios.	• Teamwork and collaboration skills. • Critical thinking and communication skills. • Reinforcement of standard nursing policies and procedures. • Positive acceptance and affirmative learning engagement. • Results: SLOs were met; participants liked the active learning simulation; high program evaluation. • Themes and implications include simulation design standards INACSL; cooperative learning; collaboration; critical thinking; communication; debriefing; leadership; quality outcomes; active learning.
[37] Hopkins, K. & Afkinich, J.	Diversifying the Pipeline of Social Work Students Prepared to Implement Performance Measurement Journal of Social Work Education	• Social work graduate students, primarily of color (50%) and women (80%).	• Implementation of a results-based accountability (RBA) designed course involving team-based application of learning in real-time projects with partner organizations. • The objective was to assess the learning progress of social work students using a result-based accountability approach, to include diversity and inclusion initiatives. • Methods: mixed methods data collection and post-assessment • Students of color. • Other initiatives surrounding the training and transition of human services professionals are necessary.	• Successful performance in graded content learning and project application of performance measurement (90% of students performed successfully). • Empowerment to apply RBA in current and future work. • Acquisition of skills enabling data-driven decisions and a results-oriented, learning-focused culture in professional settings. • Results: future workforce application surrounding team-based learning activities and using performance measures to guide practices in the field. • This article discusses the external environment and how the use of TBL in the education of human services like social work assist with future job performance and performance improvement metrics. • Themes and implications: the article cites and discusses how the use of performance measurement, evaluation, and QI are related, yet are different, and often QI efforts occur without performance measurement.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[38] Muirhead, L. et al.	Role Reversal: In-Situ Simulation to Enhance the Value of Interprofessional Team-Based Care Journal of Nursing Education	• Interprofessional education trainees.	• Implementation of an in situ simulation learning experience using role reversal to enhance team-based care coordination. • The objective was to assess effective interprofessional team-based care and value the role of each team member involved. A strong effort to have knowledge and awareness of others' roles in team-based environments was evaluated to allow for a collaborative knowledge and understanding to prevent role confusion. A VA simulation lab (in situ) was used for the training experience. • Methods: mixed methods examined readiness, perceived value, and attitude towards interprofessional learning in the context of role-reversal.	• Participants' readiness for interprofessional learning. • Perceived value of the in situ simulation and role reversal. • Attitudes toward interprofessional learning and collaboration in solving complex clinical cases. • Appreciation of interdisciplinary roles and the value of team-based care. • Results: experiences related to thoroughly understanding the entire process of care delivery, and others' roles in the initiative. • Some negatives including awkward interactions with the simulator were reported. The IPE experience using this team-based care with role valuing was affirmed in the study. • Themes and implications: role-reversal and role valuing demonstrate a higher level of IPE experience and knowledge of process/delivery of care, enhancing team-based learning efforts.
[39] Yang, S. et al.	The impact of dental curriculum format on student performance on the national board dental examination Journal of Dental Education	• Dental students in hybrid PBL cohort and traditional cohort.	• Hybrid problem-based learning (PBL) curriculum. • The objective was to assess a hybrid problem-based learning method for a dental school curriculum and on the National Dental Board Exam pass rates. • Methods: retrospective study on control and sample cohorts.	• Results: No significant differences were observed between examination methods and cohorts. This information as then used to further the evaluation of the use of PBL in future dental school assessments. • Themes and implications include the following: could be deleted from the review, as it does not directly assess PBL in the workforce of application of the hybrid exam to the "real world" well.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[40] Avery, M. et al.	Improved Self-Assessed Collaboration Through Interprofessional Education: Midwifery Students and Obstetrics and Gynecology Residents Learning Together Journal of Midwifery and Women's Health	• Midwifery students and obstetrics and gynecology residents.	• Interprofessional learning activities and education. • The objective was to assess the use and benefits of IPE among both OB/GYN and midwifery students in higher education. • Methods: observational, pre-post assessment of collaborative competencies and an IPE formal survey/results were used.	• Self-assessed interprofessional and collaborative competencies. • Improvement in overall ability to collaborate. • Positive feedback and recommendations regarding team-based experiences, communication, understanding each other's education and scope of practice, and recommended skills development. • Results: IPE initiatives were positive among both groups, and team-based learning was cited as valued among both groups of students. • Themes and implications include: the article does loosely focus on the benefits of IPE and collaboration competency required for use in the field; future examination of healthcare industry practitioners and their related teams is suggested as a future study initiative.
[41] Martirosoy, A. & Moser, L.	Team-based Learning to Promote the Development of Metacognitive Awareness and Monitoring in Pharmacy Students American Journal of Pharmaceutical Education	• Pharmacy students (n = 100).	• Introduction of the metacognitive concept along with team-based learning (TBL). • The objective was to determine if team-based learning initiatives support/enhance metacognition for pharmacy students. • Methods: a pre/post test using the MAI inventory was conducted on pharmacy students before and after the use of TBL.	• Metacognitive abilities of students as measured by the metacognitive awareness inventory (MAI). • Improvement in metacognitive skills from the beginning to the end of the course. • Differences in declarative and conditional knowledge based on performance groups. • Students' ability to predict their performance on the final examination. • Impact of baseline grade point average on the final examination score and final course grade. • Themes and implications: a self-awareness of learning needs, and thinking about thinking (metacognition) assists in the team-based learning approach for this group of students. • The middle-level performers were best able to predict their learning results/outcomes among the entire sample of students ($p < 0.02$). • A knowledge of one's strengths and abilities in a team learning environment demonstrates optimal outcomes for all students, with selected learning groups performing better than others.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[42] Powers, K. et al.	Interprofessional student hotspotting: preparing future health professionals to deliver team-based care for complex patients Journal of Professional Nursing	• Health professions students from medicine, social work, pharmacy, nursing, and health psychology who participated in a six-month interprofessional student hotspotting program.	• Participation in a six-month interprofessional student hotspotting program. • The objective was to assess a student "hotspotting" learning initiative that involves IPE and team-based learning initiatives. • Methods: descriptive qualitative study, 42 students from 6 different institutions.	• Student experiences and perspectives on the program. • Appreciation for interprofessional team-based care. • Skills gained for collaborative care. • Management of group dynamics. • Approaches learned to care for complex patients. • Four themes were identified: observed benefits of interprofessional collaboration; gained skills for collaborative care; experienced difficulty managing group dynamics; and learned approaches to caring for complex patients. • Themes and implications: the hotspotting technique seems interesting, voluntary, and not for credit. The optional program demonstrated the advantages of IPE for the students and an ability to assist (or better assist) patients in the real world.
[43] Elaimy C. et al.	Availability of Didactic and Experiential Learning Opportunities in Veterinary Practice at US Pharmacy Programs American Journal of Pharmaceutical Education	• US pharmacy programs.	• Offering veterinary pharmacy didactic and experiential learning opportunities. • Study involved a questionnaire/survey (23 questions) to members of the AACPCPP listserv. • The possibility of using a didactic course and accepting credit from an outside program for veterinary pharmacy course was investigated.	• Availability of a didactic veterinary pharmacy course in pharmacy programs. • Availability of experiential rotation opportunities in veterinary pharmacy. • Likelihood of programs accepting outside credit for didactic knowledge. • Association between pharmacy programs geographically linked with a veterinary school and the offering of didactic and experiential opportunities. • The survey identified the need for more programs to offer a learning experience for pharmacy programs to expose students to veterinary medicine in either format due to the ongoing expansion of the industry segment/demand.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[44] Duck, A. et al.	A pedagogical redesign for online pathophysiology Teaching and Learning in Nursing	• Undergraduate nursing students in a large academic health sciences center.	• Implementing active learning strategies in an online pathophysiology course (including case studies, tables of abnormal conditions, short reports on evidence-based practice, group work, and peer learning).	• Enhanced student engagement, understanding, and performance in the pathophysiology course due to the implemented active learning strategies. • More engagement of learning activities was used in an online pathophysiology course, to include case studies, table of abnormal conditions, short reports on evidence-based practice, group work, and peer learning. • Increased demands for optimal virtual learning drove the purpose of the study. • The effectiveness of this course redesign requires ongoing monitoring to assure relevance and quality improvement was noted as very important.
[45] Pence, P. et al.	Flipping to Motivate: Perceptions Among Prelicensure Nursing Students Nurse Educator	• Prelicensure BSN students at a Midwestern university.	• Study investigated the use of a flipped learning environment and students' motivation to learn. • Descriptive, comparative design method: 25 undergrad nursing students.	• Improvement in student motivation to learn. • Changes in learning strategies used by students. • Mean scores for task value, control of learning beliefs, and help-seeking subscales. • In the end, the study did not find a flipped learning environment suggestive of improving students' motivation to learn.
[46] Lybarger, K. et al.	Annotating social determinants of health using active learning, and characterizing determinants using neural event extraction Journal of Biomedical Informatics	• Clinical text with data related to social determinants of health (SDOH).	• Introduction of the Social History Annotation Corpus (SHAC) with SDOH annotations. • Application of a novel active learning framework for annotation. • A novel active learning framework that selects samples for annotation using a surrogate text classification task as a proxy for a more complex event extraction task.	• Increased frequency of health risk factor annotations. • Improved automatic extraction of these events using the active learning framework. • Performance metrics (F1 scores) for the extraction model trained on SHAC for various SDOH aspects.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[47] Powell, B. et al.	A Concept Mapping Activity to Enhance Pharmacy Students' Metacognition and Comprehension of Fundamental Disease State Knowledge American Journal of Pharmaceutical Education	• Second-year pharmacy students in a problem-based learning course.	• Engaging in pre-class concept mapping activities with or without feedback. • The objective was to see if concept mapping (CM) predicts students' ability to accurately self-assess their knowledge and quiz performance. • Methods: case-based course; pseudo-randomization to 14 topics and 3 conditions (CM with feedback; CM without feedback; no CM).	• Ability to accurately self-assess foundational disease state knowledge. • Ability to predict pre-class quiz performance. • Actual quiz performance. • Results: self-assessment does not equal quiz scores; concept mapping increased quiz scores. • Themes and implications: improved performance; active learning; high-impact methods; newer concept mapping; collaborative learning; self-assessment; feedback.
[48] Flores-Sandoval, C. et al.	Interprofessional team-based geriatric education and training: A review of interventions in Canada Gerontology and Geriatrics Education	• Health care professionals and students in Canada.	• Interprofessional team-based education and training interventions focused on geriatric competencies.	• Enhanced knowledge of geriatric competencies. • Improved ability to work in interprofessional geriatric teams. • Improved team functioning.
[49] Blaine, K. et al.	Training Anesthesiology Residents to Care for the Traumatically Injured in the United States Anesthesia and Analgesia	• Anesthesiology residents.	• A tier-based approach to teaching the ABA outline that includes lectures, simulation, problem-based learning discussions, and case-based discussions.	• Improved and standardized trauma-focused education and training for anesthesiology residents.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[50] Acker, L. et al.	Perioperative Management of Flecainide: A Problem-Based Learning Discussion A&A Practice	• Patients on flecainide, particularly during the perioperative period.	• Use of flecainide for treatment of atrial arrhythmias and/or supraventricular tachycardia.	• Assessment of potential predisposition to rapid atrial flutter and resultant hemodynamic compromise during the perioperative period while on flecainide.
[51] McCaffery, J. et al.	An Interprofessional Education (IPE) Experience with a Scaffolded Teaching Design Journal of Allied Health	• Graduate occupational and physical therapy students at one institution.	• Use of an intentional scaffolded IPE (interprofessional education) design which progresses from observation to application, analysis, and evaluation. This design incorporated both virtual and in-person experiences.	• Enhanced interprofessional collaboration, effective real-time clinical decisions, improved understanding and application of patient-centered care, and positive student reflections and surveys.
[52] Prince, A. et al.	The Clarion Call of the COVID-19 Pandemic: How Medical Education Can Mitigate Racial and Ethnic Disparities Academic Medicine	• Medical students and the diverse communities (African Americans, Native Americans, Latinx Americans) impacted by health care disparities.	• Salient learning experiences in diverse communities built on a 3-pillar framework consisting of trust building, structural competency, and cultural humility.	• Enhanced understanding and passion for addressing structural inequities and championing social justice, leading to improvements in social determinants of health.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[53] Mattingly, J.	Fostering Cultural Safety in Nursing Education: Experiential Learning on an American Indian Reservation Contemporary Nurse: A Journal for the Australian Nursing Profession	• Baccalaureate nursing students; American Indian/Alaska Native peoples, especially those in the Pine Ridge Reservation.	• A clinical immersion experience on an American Indian Reservation with health promotion events focusing on prevention of heart disease, diabetes, and unintentional injury. This is combined with student reflections via blogging and a transformative learning framework.	• Improved cultural safety among nursing students, transformative learning experiences, better understanding of biases and power imbalances, increased awareness of historical trauma, and positive feedback from Lakota screening participants.
[54] Williams, C. et al.	Adapting to the Educational Challenges of a Pandemic: Development of a Novel Virtual Urology Subinternship During the Time of COVID-19 Urology	• Senior medical students at the Perelman School of Medicine at the University of Pennsylvania.	• A 2-week virtual urologic surgery clinical rotation curriculum, combining asynchronous (e.g., prerecorded lectures, self-paced modules, directed reading and video content, online discussion board) and synchronous (e.g., real-time videoconferences for case discussions, simulated patient presentations, critical literature reviews) content.	• Improved self-perceived urologic knowledge, increased confidence in identifying and understanding urologic conditions, enhanced comfort with performing urologic evaluations, and boosted confidence in placing consults for urologic issues, as measured by post-course surveys.
[55] Tomeh, H. et al.	Self-motivation and self-direction in team-based and case-based learning Journal of Dental Education	• Dental students.	• The objective was to improve self-direction and motivation. • Methods: Survey of dental students (n = 349); teams include students from all 4 years.	• Students' favorite aspects were collaboration, clinical relevance, passing the course, and faculty involvement. Students did not like the difficulty associated with managing their own work and group dynamics. • Themes and implications: self-directed learning and motivation; "real-world" case-based learning; TBL, collaboration, leadership in Year 3 students improved, faculty mentorship valued.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[56] Andrienko,T, et al.	Developing Intercultural Business Competence via Team Learning in Post-Pandemic Era Advanced Education	• Engineering students in the USA and Ukraine.	• Team learning in virtual teams based on andragogical principles and methodology tailored for Ukrainian engineering students, emphasizing project work. • The objective was to assess the effect of team-based learning (TBL) on competencies required for business communication. • Methods: USA and Ukraine engineering students in a mixed methods observational and experimental study of TBL. No statistical significance testing.	• Improved development of intercultural business competencies and skills such as team building, teamwork, critical thinking, decision making, conflict prevention, and resolution. Additionally, enhanced motivation towards learning English for specific purposes (ESP), increased engagement, persistence towards graduation and employment, and overall positive learning experiences. • Results: improved communication competencies, motivation, engagement, and persistence to graduation and employment. • Themes and implications: an excellent discussion/review of the 4 traditional adult (andragogy) learning principles vs. child (pedagogy) learning methods, and learning management for self-directed learners (heutagogy). For the study, the focus is on “soft skills” needed by engineering students for business, especially language proficiency. The study is applicable to health-related fields.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[57] Henriksen, K. et al.	Pursuing Patient Safety at the Intersection of Design, Systems Engineering, and Health Care Delivery Research: An Ongoing Assessment Journal of Patient Safety	• Health care professionals and systems engineers involved in patient safety projects.	• The use of patient safety learning laboratories that engage in a systems engineering process including problem analysis, design, development, implementation, and evaluation. • The AHRQ Patient Safety Learning Lab (PSLL) grant program officers aimed to share lessons learned and compare their perspective to the grantees' perspectives. • Methods: PSLL efforts to include design thinking methods and the 5 phases of systems engineering (problem analysis, design, development, integration, and evaluation) were assessed. • Learning health systems are a newer concept and focus on expanding the capacity to generate higher-quality and safer futures. Learning laboratories, learning organizations, and learning health systems are examples of entities where improving high impact learning methods can enhance critical thinking.	• Improvement in understanding patient safety problems, generating fresh ideas, developing and implementing prototypes, ensuring system integration, and evaluating the systems in clinical or simulated settings. Identification of obstacles and best practices for deploying the systems engineering methodology in patient safety projects. • Results: Lessons learned include difficulty engaging multidisciplinary team members in effective teamwork; high variability in deploying the 5-phase method; technical and IT difficulties; and the fit of QI "research" in a traditional academic medical journal. • Healthcare is moving from a systems approach to directly engaging systems engineers and design to address patient safety concerns. The PSLL methodology described here is a new approach for initiating action and creating an opportunity for intersectional, transdisciplinary engagement. • Themes and implications: team training is essential before teamwork.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[58] Meeuwissen, S. et al.	Enhancing Team Learning through Leader Inclusiveness: A One-Year Ethnographic Case Study of an Interdisciplinary Teacher Team Teaching and Learning in Medicine	• Interdisciplinary teacher undergraduate medical education.	• Leader inclusiveness behavior promoting team learning behavior.	• Manifestation of leader inclusiveness behavior leading to effective team collaboration, engagement, feelings of inclusion, and team learning behavior.
[59] Tarras, S. et al.	Effective Large Group Teaching for General Surgery Surgical Clinics of North America	• Surgeons responsible for educating in large group settings. • Large group educational settings in the field of surgery.	• Implementing principles from rhetoric, neuroscience, cognitive science, learning models, and teaching theory into lecturing; incorporating active learning opportunities and modern innovations in information technology.	• Effective lecturing skills and more engaging, impactful lectures.
[60] Franic, D. et al.	Doctor of pharmacy student preferences for computer-based vs. paper-and-pencil testing in a social and administrative pharmacy course Currents in Pharmacy Teaching and Learning	• First-professional year pharmacy students.	• Computer-based testing for a required social and administrative pharmacy class. • The objective was to assess student preference for computer vs. paper-based testing methods. • Methods: End-of-term student survey (n = 138) re: preference for computer vs. paper-based testing.	• Student preferences regarding the testing method, perception of impact on grades, and views on the convenience, feedback, and effectiveness of each testing method. • Results: Computer-based testing was preferred by 79%, nor did 91% perceive that a difference was likely in grading. The statistically significant results are a preference for computer-based testing due to convenience, immediacy of feedback, and effectiveness. • The study revealed that millennials and generation Z students preferred computer-based testing over paper-and-pencil testing, mostly because they value the immediate grading feedback. The COVID-19 pandemic required pharmacy schools to transition all classes online, so it is reassuring that computer-based tests are preferred. • Themes and implications: Increased use of online teaching methods during SARS-CoV-2 did not negatively impact student perception of testing and grading.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[61] Mills, M. & Winston, B.	Designing and Implementing Problem Based Learning Techniques to Supplement Clinical Experiences Journal of Allied Health	• Health care students.	• Supplemental clinical education using problem-based learning model of virtual patient cases.	• Student feedback regarding the effectiveness of supplemental clinical exposure, development of clinical reasoning and decision-making skills, and experience with complex/rare/nuanced situations.
[62] Clapper, T.	Getting Better Together: The Two-Team Training Approach in Simulation-Based Education The Journal of Continuing Education in Nursing	• Clinical teams in healthcare (e.g., more than one nurse and other professionals involved in patient care).	• Two-team training approach in simulation-based education. • The objective was to design a two-team simulation for multidisciplinary training. • Methods: two-team training, based on imitation and vicarious learning.	• Results: an efficient model in which teams alternate between the active participant and an active observer role. • Improved use of training time. • Increased training volume. • Desired behaviors recognition, correction, and immediate application. • Improved simulation do-over process. • Improvement in self-efficacy. • Applicable use of research and evidence-based educational practices. • Themes and implications: an excellent review of seminal works on team-based learning, including SR and meta-analyses; vicarious learning; learning via imitation/modeling behaviors; adult learning principles; application to simulation-based learning. A validated checklist for the active observers is similar to peer review using a grading rubric.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[63] Brown, J. et al.	Team-Based Coaching Intervention to Improve Contrast-Associated Acute Kidney Injury: A Cluster-Randomized Trial Clinical Journal of the American Society of Nephrology	• Patients in the United States undergoing cardiac catheterization at Veterans Affairs medical centers (VAMCs), including those with preexisting CKD.	• Team-based coaching in a virtual learning collaborative (collaborative). • Collaborative with automated surveillance reporting (surveillance). Both interventions promoted hydration, limited NPO, and contrasted dye dosing for AKI prevention.	• Incidence of postprocedural AKI in each intervention cluster. • Case-mix-adjusted differences in AKI event proportions among the four intervention arms. • Adjusted odds ratio for AKI events comparing each of the four arms, especially comparing the collaborative with the surveillance intervention cluster to the assistance-alone cluster.
[64] Parker, Z. et al.	Changing Geographic Distributions of Coccidioides Spp. in the United States: A Narrative Review of Climate Change Implications International Journal of Infectious Diseases	• Geographic regions in the United States historically considered non-endemic for the *Coccidioides* spp. pathogen.	• Evaluation of changing climate patterns within those areas.	• Expansion of the endemic range of Coccidioides spp. to regions as far east as Texas and as far north as Washington State. • Identification of climate change as the primary underlying cause, especially due to regional climate changes and large dust storms. • Implications for timely diagnosis, treatment, reporting, and public health surveillance. • Recognition of climate change mechanisms leading to recommendations for mitigation and further research. • Current climate model predictions indicating an increase in *Coccidioides* spp. infections.
[65] Guzman, V. et al.	A Comparative Case Study Analysis of Cultural Competence Training at 15 U.S. Medical Schools Academic Medicine	• U.S. medical schools.	• Implementation of cultural competence training, as mandated by the Liaison Committee on Medical Education (LCME).	• Differences in formal curriculum emphasizing communication skills, patient-centered care, and community-based projects. • Integration of cultural competence into the preclinical years. • Engagement with sociocultural issues. • Perceptions of preclinical and clinical curricula by students. • Institutional commitment to cultural competence. • Effectiveness and impact of cultural competence training on medical education.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[66] White, K. et al.	Engaging Online Graduate Students With Statistical Procedures: A Team-Based Learning Approach Nurse Educator	• Nurse practitioner students (master's and bachelors-to-DNP) in a biostatistics and epidemiology course.	• Use of a modified team-based learning (TBL) pedagogy in a synchronous distance environment to facilitate comprehension of statistical computations. This included the use of small groups, immediate feedback, student accountability for work, and activities that promote learning. • The objective was to describe a modified team-based learning (TBL) method to teach statistics online. • Methods: descriptive with rationale.	• Improved comprehension of statistical computations. • Student engagement with statistical concepts, computations, and interpretations. • Effective application of statistical concepts to real-world scenarios. • Confidence and accuracy in completing statistical assignments. • Results: No data presented; students like the low-risk team method; faculty like addressing questions and misconceptions in real time. • Themes and implication: Kolb's experiential learning theory collaborative learning; TBL 4 principles; iRAT and tRAT (readiness assessment testing) of prep work; team size references; modified TBL is applicable to the teaching of complex skills and competencies.
[67] Haley, C.	Adapting problem-based learning curricula to a virtual environment Journal of Dental Education	• Dental students (D1 and D2) and a team of 14 facilitators transitioning from face-to-face PBL sessions to virtual instruction due to the COVID-19 pandemic.	• Implementing virtual PBL through the WebEx platform, providing facilitator training, modifying PBL cases to include daily objectives, and having troubleshooting facilitators for technical issues. • During SARS-CoV-2, the objective was to design an active problem-based learning (PBL) synchronous online dental course for Year 1 and 2 students, facilitated by the faculty. • Methods: PBL was modified to include daily objectives, vs. end of case objectives, as the cases required more than one day to complete; training sessions for facilitators; additional troubleshooter facilitators during sessions; feedback sessions at the end of term.	• Student and facilitator satisfaction with virtual PBL. • Effectiveness of virtual PBL sessions in terms of knowledge retention and active participation. • Assessment results comparing the virtual PBL to traditional methods. • Challenges encountered such as an inability to read body language and distractions during sessions. • Results: Daily case objectives helped students to focus their individual prep for the next meeting. Students reported difficulty reading body language and avoiding distractions. Training for non-tech savvy faculty took 1-2 h longer than other faculty. • Themes and implications: PBL; group work; online and increased commitment of time and technical assistance; during SARS-CoV-2; individual student and faculty prep; active learning; distractions; feedback from students.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[68] Wilson, M.	Interprofessional Education on Pain and Opioid Use Meets Team-based Learning Needs Pain Management Nursing	• Staff nurses from the Great Lakes Chapter, which is mostly composed of advanced practice nurses.	• Coaching and mentoring staff nurses to develop pain-related practice questions, complete literature reviews, and answer questions for participation and poster abstract submission for the national conference.	• Increase in the participation of staff nurses at the national conference, development of PICO questions, setting up virtual workspaces, collaboration for literature answers, and the presentation of findings at the conference. • Themes and implications: IPE; pre and post testing; collaborative strategic planning for opioid population.
[69] Soncrant, C. et al.	Sharing Lessons Learned to Prevent Adverse Events in Anesthesiology Nationwide Journal of Patient Safety	• Anesthesiology chiefs and staff within the Veterans Health Administration (VHA).	• Implementation of the lessons learned process for anesthesia adverse events, where root cause analysis related to anesthesiology care is reported and reviewed.	• Awareness, accessibility, perceived usefulness of the lessons learned, change or reinforcement of patient safety behavior, acquisition of new knowledge about patient safety, and preventing adverse events.
[70] Raff, A.	Great nephrologists begin with great teachers: update on the nephrology curriculum Current Opinion in Nephrology and Hypertension	• Medical students, residents, and fellows studying nephrology.	• Exposure to dynamic nephrology teaching methods like case discussions, problem-based learning, team-based learning, flipped classrooms, microskills framework, bedside teaching, evidence-based medicine, and blended nephrology/subspecialty fields.	• Enhanced motivation and active learning in nephrology students, attracting talented learners to the field, effective didactics in graduate medical education, and overall development in the field of nephrology education.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[71] Awan, O.	The Flipped Classroom: How to Do it in Radiology Education Academic Radiology	• Radiology trainees and medical students.	• Flipped classroom techniques, including providing web-based documents, using videos, and assigning scrollable anonymized cases in a DICOM viewer.	• Improved engagement, active learning, peer-to-peer learning, improved student-teacher relationships, efficient use of classroom time, and fostering students' ownership of learning.
[72] Souza, I.	Teaching syndemic theory in a High School class: a Problem Based Learning approach International Journal of Epidemiology	• Students in a classroom in Paracambi city (Rio de Janeiro, Brazil).	• Problem-based learning with two topics: food wastage research (Group A) and an opinion survey about ultra-processed food consumption and health self-perception (Group B).	• Group A found a significant food wastage in the presence of homelessness in the city. • Group B found that individuals across age groups consumed ultra-processed foods, and younger people perceived their health negatively. • Improved understanding of epidemiological phenomena such as the syndemic of obesity, undernutrition, and climate change.
[73] Ha, T. et al.	A new strategy for teaching Epidemiology in Public Health Education: Hybrid Team Based Learning-Personalised Education International Journal of Epidemiology	• Students enrolled in the Bachelors of Public Health at the University of Wollongong.	• Hybrid team-based learning and personalized education (HTBL-PE) strategy for teaching epidemiology.	• Increase in interest in epidemiology (93%). • Improvement in critical thinking (92%). • Increase in confidence as independent learners (86%). • Application of learning from this subject in other settings (67%). • Students' final mark being significantly higher than their weighted average mark.
[74] Ackermann, D. et al.	Rapid Evidence for Practice modules: using team-based learning to teach evidence-based medicine International Journal of Epidemiology	• Year 2 graduate medical students.	• Rapid evidence for practice (REP) modules adapted from team-based learning (TBL) framework focusing on RCTs.	• 91% of students agreed REP helped them to develop a way to approach clinical questions using evidence. • 81% satisfaction with the REP teaching method. • Feedback regarding the REP method for RCTs.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[75] Snow, T. et al.	Implementation of a Virtual Simulation-based Teamwork Training Program for Emergency Events in the Perioperative Setting Journal of PeriAnesthesia Nursing	• Perioperative Department members, including physicians, nurses, and ancillary staff.	• Implementation of the communication tool within the TeamSTEPPS platform. • Experiential-learning-rich presentation with pre-recorded clinical emergency videos of participatory, active simulation. • Role-playing communication aids based on the observed simulation video clips.	• Improved communication openness scores. • Enhanced effective communication during emergency clinical events. • Increased opportunities for effective communication based on shared goals, knowledge, and mutual respect. • Intentions among participants to apply TeamSTEPPS concepts in future practices.
[76] Cai, L. et al.	Implementation of flipped classroom combined with case-based learning: A promising and effective teaching modality in undergraduate pathology education Medicine	• 117 third-year medical students.	• Flipped classroom (FC) combined with case-based learning (CBL).	• Post-quizzes scores, especially scores related to clinical case analysis. • Students' perceptions of learning motivation, knowledge comprehension, critical thinking, patient management, teamwork, and pre-class burden compared to traditional LBC.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[77] Beebe, H. et al.	A COVID-Related Inquiry-Focused Online Assignment for Undergraduate Nursing Students The Journal of Nursing Education	• Undergraduate nursing students from the University of Tennessee enrolled in the Transforming Roles in Community-Based Integrated Primary Care (TRIP) curriculum.	• An inquiry-focused online assignment that focused on COVID-19 and its implications. This involved listing high-risk groups, explaining reasons for testing and the procedure, identifying resources, and designing a COVID-19 screening tool. • The objective was to review the objectives, content, and evaluation of the inquiry focused COVID-19 learning assignment developed for online implementation during the spring of 2020, when the COVID-19 pandemic precluded face-to-face instruction. • Methods: After completion of the COVID-19 assignment, students were to (a) list COVID-19 high-risk groups, (b) explain reasons to seek medical care or testing for COVID-19, (c) explain the COVID-19 testing procedure, (d) identify resources for online COVID-19 information, and (e) design a COVID-19 screening tool for health care workers. Each student was tasked with producing a COVID-19 screening tool for health care volunteers at a regional call center to help to answer the questions of individuals requesting COVID-19 testing.	• Students' ability to complete the assignment accurately and comprehensively. • Student reactions and lessons learned, including understanding of national and state agency interactions, comprehension of the complexity of early COVID-19 information, and adapting to rapidly changing guidelines. • Results: Students learned the critical nature of locating credible resources, communicating accurately to clients, and considering both state and federal guidelines. This assignment illuminates the value of rapid faculty response to prepare students for practice in a changing world. • Themes and implications: COVID-19 state response, undergrad RN students, learning assessment.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[78] Griswold, C. & Koss, J.	Experiential Learning Through a Board Presentation Assignment Nurse Educator	• Nursing students in the Master of Nursing Leadership and Administration (NLA) program.	• Experiential learning activities that require students to identify a work-related practice issue, complete a literature search, and develop a practice change proposal. • Presentation of the developed practice change in a 10-min PowerPoint presentation to a live mock Board of Directors comprised of 3 community leaders and alumni. • The objective was to summarize the experiential learning of the curriculum in a Master Nursing Leadership and Administration (NLA) program. • Methods: evaluation of a 10-min PowerPoint presentation to a live mock Board of Directors (3 community leaders and 1 alumni). • Results: presenting an evidence-based solution to a mock board prepares students for real work experience. • Themes and implications include nursing leadership, experiential learning, SMART aims, presentation to Board, and grad level.	• Students' ability to professionally present evidence-based solutions, justify the financial impacts, and articulate their projects concisely. • Development of skills necessary for real-world leadership roles, including advocating for innovative practice changes, developing evidence-based proposals, and presenting them for approval. • Enhancing students' understanding of fiscal responsibility, critical thinking, and the importance of connecting academic learning to real-world practice.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[79] Ajayi, T. et al.	Cross-Center Virtual Education Fellowship Program for Early-Career Researchers in Atrial Fibrillation Circulation: Arrhythmia and Electrophysiology	• Early-stage AF (atrial fibrillation) basic, clinical, and population health researchers.	• A virtual AF Strategically Focused Research Network (SFRN) Cross-Center Fellowship program was designed to enhance competencies through experiential education and mentorship. This includes a curriculum that focuses on enhancing AF scientific competencies, fostering career/professional development, and cultivating grant-writing skills.	• Productivity metrics including the production of AF-related manuscripts, publications, presentations, and grant award applications. • Satisfaction and evaluation outcomes included satisfaction with the fellowship, webinar content, facilitation, staff communication, support, and program organization.
[80] Wiljer, D. et al.	Exploring Systemic Influences on Data-Informed Learning: Document Review of Policies, Procedures, and Legislation from Canada and the United States Journal of Continuing Education in the Health Professions	• Physicians engaged in continuing professional development (CPD).	• Using data-driven learning for performance improvement in CPD.	• Advocacy for data-informed self-assessment and team-based learning strategies. • Understanding of how privacy and confidentiality concerns intersect at the point of patient data collection and physician-generated outcomes. • Acknowledgement of the need for a nuanced data strategy approach for each medical specialty.
[81] Kaul, V. et al.	Delivering a Novel Medical Education Escape Room at a National Scientific Conference: First Live, Then Pivoting to Remote Learning Because of COVID-19 Chest	• Medical professionals attending the national scientific meeting.	• Use of an escape room as a continuing medical education modality.	• Augmentation of knowledge acquisition, team-based learning, and edutainment experience.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[82] Moran, V. et al.	Changes in attitudes toward diabetes in nursing students at diabetes camp Public Health Nursing	• Nursing students.	• Exposure to residential diabetes camps for children with type 1 diabetes mellitus (T1D).	• Changes in attitudes toward diabetes care and management, as measured by the Diabetes Attitude Survey 3 (DAS3).
[83] Abuqayyas, S. et al.	Bedside Manner 2020: An Inventory of Best Practices Southern Medical Journal	• Medical trainees in academic medical centers.	• Exposure to best bedside practices through literature review, personal experiences, and expert consulting.	• Optimization of inpatient care and potentially improved bedside manner.
[84] Martinchek, M. et al.	Active Learning in the Virtual Environment Journal of Allied Health	• Students in the first year of the Physician Assistant program.	• Transitioning to a virtual format for team-based learning (TBL) with the use of online technologies and innovative methods.	• Successful meeting of program competencies, favorable ratings by students, and long-term knowledge retention and application.
[85] Hughes, V. et al.	Strengthening internal resources to promote resilience among prelicensure nursing students Journal of Professional Nursing	• Prelicensure nursing students	• Educational strategies to enhance student nurse internal protective factors (e.g., reflection, positive reframing, problem-based learning, and mindfulness). The objective was to review selected literature, synthesize, and interpret the findings that point toward promising practices that educators can employ to support student resilience. • Methods: Four prominent prelicensure nursing student internal protective factors [1] associated with resilience and derived from the literature include self-efficacy, optimism, emotional intelligence, and self-stewardship/self-care.	• Improved resilience, evidenced by prominent internal protective factors (self-efficacy, optimism, emotional intelligence, self-stewardship/self-care) and reduced risk of burnout and improved retention in future nursing practice. • Results: Interventions to promote nursing student resilience are not well developed; however, there is promising evidence to inform concepts and interventions to guide the development, skills, practices, and strategies for nurse educators. • Educational strategies to enhance student nurse internal protective factors include reflection, positive reframing, problem-based learning, and mindfulness. Specific examples of each educational modality applied to prelicensure student nurse resilience are provided. • Themes and implications: Integrative strategies, internal protective factors to strengthen student resilience, nursing education and clinical nursing practice; PBL; complex case-study; evidence-based content; EI; miscommunication; patient safety.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[86] Blazer, D. et al.	The Great Health Paradox: A Call for Increasing Investment in Public Health Academic Medicine	• Medical students and physicians in the United States.	• The current US medical education system is primarily focused on acute care medical technology and personalized care, with lesser emphasis on public health. • Objective: commentary recommends increasing the understanding of public health interventions or society's health problems in medical schools. • Methods: Invited commentary by 4 geriatricians.	• Enhanced understanding and integration of public health interventions to better address society-wide health challenges and outbreaks, such as the COVID-19 pandemic. • Results: There are 5 steps outlined including the addition of PBL into medical school curriculum. • Themes and implications: PBL, Public Health, curriculum, IPE, collaboration.
[87] Vanderhoof, M. & Miller, S.	Utilizing innovative teaching methods to design a new geriatric pharmacy elective Currents in Pharmacy Teaching and Learning	• Pharmacy students.	• Geriatric-focused elective utilizing innovative teaching methods to promote problem-based learning (PBL). • Objective: commentary provides guidance on incorporating geriatric topics into the PharmD curriculum. • Methods: Commentary for geriatric elective by 2 pharmacists.	• Improved understanding and retention of material necessary for addressing the unique needs of geriatric patients, increased engagement, and creative thinking. • Results: An elective course was created and this commentary recommends questions to ask when creating an elective course, including the use of problem-based learning methods. • Themes and implications: PharmD curriculum, education topics; geriatric population; innovative assignments: caregiver, presentation to staff, interdisciplinary, CMS, geriatric screening, empathy, film/book reflection, drug regimen review, facility visit, patient interaction; assessment and feedback; faculty time and effort to create active learning assignments.

Article Number and Author(s)	Article Title and Publication	Population	Intervention/Study Design	Team-Based and/or Problem-Based Learning Attributes
[88] Morrow, E. et al.	Confidence and Training of Speech-Language Pathologists in Cognitive-Communication Disorders: Time to Rethink Graduate Education Models? American Journal of Speech-Language Pathology	• Speech-language pathologists (SLPs) and speech-language pathology graduate students in North America.	• Increased focus on cognitive communication in graduate education models through methods such as standalone cognitive-communication courses, integrated curriculum approaches, and problem-based learning frameworks. • The objective was to review survey findings. • Methods: Surveys sent to speech pathologists (SLPs) aimed to assess their thoughts on current training for cognitive communication.	• Enhanced preparedness, confidence, and critical thinking among SLPs in managing individuals with cognitive-communication disorders. • Results: Survey results indicated that SLPs are inconsistently trained on cognitive communication and lack confidence in managing cog comm disorders as a result. • Themes and implications: the article discusses pros and cons for improving training, including using PBL in undergraduate and graduate SLP curriculum to enhance student communication; PBL = collaboration gap analysis and planning with critical self-assessment; critical thinking; become independent life-long learners; PBL addresses scope of practice needs.

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