

SQUIRE-EDU (Standards for Quality Improvement Reporting Excellence in Education): Publication Guidelines for Educational Improvement

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Abstract

The SQUIRE 2.0 (Standards for Quality Improvement Reporting Excellence) guidelines were published in 2015 to increase the completeness, precision, and transparency of published reports about efforts to improve the safety, value, and quality of health care. The principles and methods applied in work to improve health care are often applied in educational improvement as well. In 2016, a group was convened to develop an extension to SQUIRE that would meet the needs of the education community. This article describes the development of

the SQUIRE-EDU extension over a three-year period and its key components. SQUIRE-EDU was developed using an international, interprofessional advisory group and face-to-face meeting to draft initial guidelines; pilot testing of a draft version with nine authors; and further revisions from the advisory panel with a public comment period. SQUIRE-EDU emphasizes three key components that define what is necessary in systematic efforts to improve the quality and value of health professions education. These are a description of the local

educational gap; consideration of the impacts of educational improvement to patients, families, communities, and the health care system; and the fidelity of the iterations of the intervention. SQUIRE-EDU is intended for the many and complex range of methods used to improve education and education systems. These guidelines are projected to increase and standardize the sharing and spread of iterative innovations that have the potential to advance pedagogy and occur in specific contexts in health professions education.

In the past decade, publication guidelines have been developed for the many methods of scientific inquiry, the goal being to improve the transparency and completeness of published reports.¹ Such reporting structures enable authors, reviewers, editors, and readers to focus on the content of the information exchange, knowing that studies follow well-established guidelines considered critical for scholarly reporting. Reports of scholarly health care improvement work became standardized in 2008 with the initial publication of the Standards for Quality Improvement Reporting Excellence (SQUIRE)² guidelines, and

these have been superseded by revised guidelines (SQUIRE 2.0) in 2015.³ Here, we describe the developmental process for and introduce SQUIRE-EDU, an extension of the SQUIRE guidelines, applicable for reporting work done to improve health professions education.

Health professions education is a dynamic area where continuous educational improvement is a source for building knowledge. Reporting of such changes in health professions education is often done using the frameworks associated with hypothesis-generating and testing approaches, ranging from case studies to randomized controlled trials.⁴ Using testing methods is appropriate to answer certain questions, but the improvement that occurs in local educational settings requires, and often uses, an explanatory approach that encourages broader evaluations of the context and lessons learned. Not sharing these approaches in a systematic way can limit the learning from and spread of the work and lead to redundancy as educators repeatedly “reinvent the wheel.”

Many health professions educators use systematic methods to assess, change, and improve their educational curricula and systems. These improvements often follow change cycles that are similar to improvement methodology: having a

clear aim, understanding the processes, creating an intervention, assessing the intervention's success, and modifying it for the next cycle.⁵ We refer to this work as “educational improvement,” which often focuses on the local needs and problems where the intervention occurred but also generates lessons that can be extrapolated to educational improvement in similar contexts.

Using the SQUIRE 2.0 guidelines as a foundation, we developed, tested, and revised the SQUIRE-EDU extension to increase the completeness, transparency, and replicability of reports that describe systematic efforts to improve the quality and value of health professions education.

Development and Testing of the Guidelines

Between February 2016 and January 2018, a five-person interprofessional leadership team (G.O., G.E.A., M.A.D., M.K.S., L.D.) guided a three-phase process to recruit an advisory group, test a draft version of SQUIRE-EDU, and sharpen the final version of the SQUIRE-EDU extension.

Phase one

The first phase focused on identifying an advisory group within health professions education from education and

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improvement thought leaders. The group consisted of 27 members representing medicine, nursing, pharmacy, education, and journal editors from the United States, Canada, and the United Kingdom. As a starting point, advisory group participants identified example articles that could be used to isolate key elements for inclusion as candidate items in SQUIRE-EDU. The advisory group contributed to the drafting and editing of potential items through an iterative process facilitated through asynchronous group communication (to an email mailgroup) punctuated by four conference calls. The feedback and input from the advisory group conference calls were used to create the first five versions (0.1 through 0.5) of SQUIRE-EDU.

At a one-day in-person developmental meeting in Orlando, Florida, in December 2016, the advisory group and leadership team members split into small groups, discussed example articles, and modified candidate concepts and items using SQUIRE-EDU 0.6. Next, in groups of five to six members, the candidate concepts for each section of an article were explored—introduction, methods, results, and discussion. This process clarified the intention and definition of the emerging concepts and items. After the development meeting, the SQUIRE-EDU leadership team collated and distilled the findings from the development meeting into SQUIRE-EDU 0.7. The advisory group subsequently provided comments, which guided the development of version 0.8.

Phase two

The second phase focused on testing SQUIRE-EDU 0.8 using a unique process for end user testing that was created for the development of SQUIRE 2.0.⁶ We issued invitations to participate to the advisory group members with instructions to extend the invitation to colleagues, fellows, and learners who might be interested in participating. Nine individuals volunteered to participate in this project, which was approved by the institutional review board (IRB) of Dartmouth College (the home institution of authors G.O. and L.D.).

We asked participants to complete two tasks within two months. First, they were to use SQUIRE-EDU 0.8 to write a manuscript they were working on, or to rewrite one they had recently finished.

With this writing or editing, they were asked to annotate sections of their manuscript, using the “Track Changes” function of Microsoft Word (Microsoft Corporation, Redmond, Washington) to show which SQUIRE-EDU 0.8 items they had used and to which text the item applied. Second, they completed a confidential survey about their item usage and their interpretation of key concepts in the SQUIRE-EDU 0.8 guidelines.

We collected the survey data and manuscripts electronically using Qualtrics Survey Software (Qualtrics, LLC, Provo, Utah). The survey contained open-ended items on key concepts and potential areas of controversy in SQUIRE-EDU as well as Likert scaled questions to assess comfort with item usage. Quantitative data from the survey were transferred into Excel (Microsoft Corporation, Redmond, Washington), and descriptive statistics were interpreted in the context of the item usage in the manuscripts and the qualitative data from the open-ended questions. We evaluated SQUIRE-EDU items 3, 5, 7, 8, 9, and 14–17 (described below) for concordance between the item usage as identified by the respondent and the intended application of the item as defined by the advisory group. Finally, we determined the SQUIRE-EDU core concepts that emerged in the papers. These data guided our work in further refining the SQUIRE-EDU items for version 0.9.

Phase three

In the third phase, we shared version 0.9 with the advisory group for additional feedback and also posted it on the SQUIRE website⁷ for public comment for two months. Email invitations for public review were extended to the more than 500 individuals who are registered on the SQUIRE website. We also posted an invitation to review version 0.9 on the Quality and Safety Education for Nurses website.⁸ We received about 40 comments during this third phase, which we used to create the final version, SQUIRE-EDU 1.0.

SQUIRE-EDU Guidelines

About SQUIRE-EDU

Three core concepts emerged in the development of SQUIRE-EDU (Table 1). First, authors should describe the local educational gap (EDU 3). This description is a vital step as the current functions of the local educational system

are compared with the intended future state. For educational improvement, this step requires a clear description of why the improvement was initiated at the site at that point in time.

Second, it is important to consider how the educational improvement affects stakeholders beyond the learners and the learning (EDU 7b, 9a, 10, 15c). Early in phase one, the advisory group expressed clear expectations that health professions education should be deliberate in articulating how educational improvement affects not just learners, faculty, or the educational program but also patients, families, health care systems, communities, or the delivery of care. The latter elements are normally considered distal to educators, but a key goal of SQUIRE-EDU was to create explicit connections between curricula and these elements. SQUIRE-EDU recognizes that such connections may be difficult to establish, but the ultimate goal of health professions education should be to improve the health care system and the health of patients, families, and communities. Thus, efforts to report the improvement and *potential impact* of educational programs should include these elements.

Third, describing the fidelity of the iterative changes surfaced as an important point of emphasis (EDU 9b, 13a). In research, fidelity is defined as the extent to which an intervention adheres to the planned protocol for that intervention. In improvement work, the intervention is expected to be modified through each cycle of change as the team gains insight into what works, for whom, and in what context. Thus, fidelity specific to SQUIRE-EDU has two components. It refers to the adherence of the intervention to the planned protocol within each cycle of change *and* to the faithful use of data to inform the next cycle of change, thus ensuring that changes are driven by the findings of the previous iteration.

A combination of quantitative and qualitative data (EDU 10) can often help assess the fidelity, which requires record keeping not just of results but also of the reasoning for changes based on more nuanced observations. Educational improvement is a process of social change within complex systems, and this reporting of how the intervention changes over time provides important contextual knowledge. Simply reporting

Table 1
Standards for Quality Improvement Reporting Excellence in Education: SQUIRE-EDU

Text section and item name	SQUIRE item description	SQUIRE-EDU extension description
Notes to authors	<p>The SQUIRE guidelines provide a framework for reporting new knowledge about how to improve healthcare.</p> <p>The SQUIRE guidelines are intended for reports that describe system level work to improve the quality, safety, and value of healthcare, and used methods to establish that observed outcomes were due to the intervention(s).</p> <p>A range of approaches exists for improving healthcare. SQUIRE may be adapted for reporting any of these.</p> <p>Authors should consider every SQUIRE item, but it may be inappropriate or unnecessary to include every SQUIRE element in a particular manuscript.</p> <p>The SQUIRE glossary contains definitions of many of the key words in SQUIRE.</p> <p>The Explanation and Elaboration document provides specific examples of well-written SQUIRE items, and an in-depth explanation of each item.</p> <p>Please cite SQUIRE when it is used to write a manuscript.</p>	<p>The SQUIRE-EDU extension of the SQUIRE guidelines provides a framework intended to increase the completeness, transparency, and replicability of published reports that describe systematic efforts to improve health professions education.</p> <p>They apply to all learning settings (e.g., classroom, simulation, clinical, etc.).</p> <p>The guidelines encourage the description of the process and context of educational change, use of iterative cycles, and use of data over time.</p> <p>Authors should consider every SQUIRE and SQUIRE-EDU item, but it may be inappropriate or unnecessary to include every SQUIRE and SQUIRE-EDU element in a particular manuscript.</p> <p>Not all items have an EDU extension. If there is no EDU extension, use the SQUIRE item. If there is an EDU extension, it may be used on its own or in conjunction with the SQUIRE item.</p> <p>Educators use a range of systematic methods to make education and healthcare demonstrably better. SQUIRE-EDU may be adapted for reporting any of these methods.</p> <p>Please cite SQUIRE-EDU when it is used to write a manuscript.</p>
Title and abstract		
1. Title	Indicate that the manuscript concerns an initiative to improve healthcare (broadly defined to include the quality, safety, effectiveness, patient-centeredness, timeliness, cost, efficiency, and equity of healthcare)	EDU 1: Indicate that the manuscript concerns efforts to improve health professions education systems and learning
2. Abstract	<p>a. Provide adequate information to aid in searching and indexing</p> <p>b. Summarize all key information from various sections of the text using the abstract format of the intended publication or a structured summary such as: background, local problem, methods, interventions, results, conclusions</p>	EDU 2: Keywords include a focus on education and learning
Introduction: Why did you start?		
3. Problem description	Nature and significance of the local problem	EDU 3: Description of the nature and significance of the need for change in the local educational system
4. Available knowledge	Summary of what is currently known about the problem, including relevant previous studies	—
5. Rationale	Informal or formal frameworks, models, concepts, and/or theories used to explain the problem, any reasons or assumptions that were used to develop the intervention(s), and reasons why the intervention(s) was expected to work	EDU 5: Identify the guiding theory (learning, change, implementation, or other) and how it aligns with the need for change in the local educational system
6. Specific aims	Purpose of the project and of this report	—
Methods: What did you do?		
7. Context	Contextual elements considered important at the outset of introducing the intervention(s)	<p>EDU 7a: Contextual elements for learning (e.g., setting, program, people, resources, social, geopolitical influences) before the intervention(s)</p> <p>EDU 7b: The interrelationships between the contextual elements and the local educational and healthcare systems before the intervention(s)</p>
8. Intervention(s)	<p>a. Description of the intervention(s) in sufficient detail that others could reproduce it</p> <p>b. Specifics of the team involved in the work</p>	<p>EDU 8a: Description of the primary interventions and co-interventions (e.g., faculty or tool development)</p> <p>EDU 8b: Specify how the interprofessional education team (e.g., faculty, staff, patients, and learners) was part of the design of the intervention</p>
9. Study of the intervention(s)	<p>a. Approach chosen for assessing the impact of the intervention(s)</p> <p>b. Approach used to establish whether the observed outcomes were due to the intervention(s)</p>	<p>EDU 9a: Approach used to understand the impact of the educational intervention(s) on the learner and beyond, such as impact on patients, families, the community, faculty, educational program, or the healthcare system</p> <p>EDU 9b: Approach to assess the fidelity of and the iterative changes to the planned intervention(s) over time</p>

(Table continues)

Table 1

(Continued)

Text section and item name	SQIRE item description	SQIRE-EDU extension description
10. Measures	<ul style="list-style-type: none"> a. Measures chosen for studying processes and outcomes of the intervention(s), including rationale for choosing them, their operational definitions, and their validity and reliability b. Description of the approach to the ongoing assessment of contextual elements that contributed to the success, failure, efficiency, and cost c. Methods employed for assessing completeness and accuracy of data 	EDU 10: Quantitative and/or qualitative measures chosen to assess the educational processes and outcomes on learners, faculty, educational programs, patients, families, healthcare systems, or communities
11. Analysis	<ul style="list-style-type: none"> a. Qualitative and quantitative methods used to draw inferences from the data b. Methods for understanding variation within the data, including the effects of time as a variable 	—
12. Ethical considerations	Ethical aspects of implementing and studying the intervention(s) and how they were addressed, including, but not limited to, formal ethics review and potential conflict(s) of interest	EDU 12: Approaches to address vulnerability of learner participants
Results: What did you find?		
13. Results	<ul style="list-style-type: none"> a. Initial steps of the intervention(s) and their evolution over time (e.g., time-line diagram, flow chart, or table), including modifications made to the intervention during the project b. Details of the process measures and outcome c. Contextual elements that interacted with the intervention(s) d. Observed associations between outcomes, interventions, and relevant contextual elements e. Unintended consequences such as unexpected benefits, problems, failures, or costs associated with the intervention(s) f. Details about missing data 	EDU 13a: For each educational intervention and co-intervention, provide details about iterative modifications based on the assessment of the learning
Discussion: What does it mean?		
14. Summary	<ul style="list-style-type: none"> a. Key findings, including relevance to the rationale and specific aims b. Particular strengths of the project 	EDU 14: Connect the findings to the guiding theory (learning, change, implementation, other) used to direct the change in the local educational system
15. Interpretation	<ul style="list-style-type: none"> a. Nature of the association between the intervention(s) and the outcomes b. Comparison of results with findings from other publications c. Impact of the project on people and systems d. Reasons for any differences between observed and anticipated outcomes, including the influence of context e. Costs and strategic trade-offs, including opportunity costs 	EDU 15c: Include the impact of the intervention(s) on learners, faculty, educational program, patients, families, healthcare systems, or communities
16. Limitations	<ul style="list-style-type: none"> a. Limits to the generalizability of the work b. Factors that might have limited internal validity such as confounding, bias, or imprecision in the design, methods, measurement, or analysis c. Efforts made to minimize and adjust for limitations 	—
17. Conclusions	<ul style="list-style-type: none"> a. Usefulness of the work b. Sustainability c. Potential for spread to other contexts d. Implications for practice and for further study in the field e. Suggested next steps 	EDU 17b: Scalability of the work to other learners and contexts EDU 17d: Lessons learned for clinical practice, education, and policy
Other information		
18. Funding	Sources of funding that supported this work. Role, if any, of the funding organization in the design, implementation, interpretation, and reporting	—

before-and-after data about course evaluations or exam scores is not enough because readers should know exactly how and why each iteration of the intervention was executed to determine whether and how they might implement similar changes in their local context.

How to use SQUIRE-EDU

SQUIRE-EDU consists of extensions to 13 of the 18 SQUIRE 2.0 items³ (with corresponding numbering). Like SQUIRE, SQUIRE-EDU authors are requested to include a clear rationale and theory (EDU 5 and 14), description of the context of where the work occurred (EDU 7a and 7b), and plan for studying the interventions (EDU 9a and 9b). If there is no EDU extension item (SQUIRE 4, 6, 11, 16, 18), the author should consult the SQUIRE item. If there is an EDU extension, it may be used on its own or in conjunction with the SQUIRE item. Authors should consider every SQUIRE item (Table 1, middle column) and every SQUIRE-EDU item (Table 1, righthand column), but it may be inappropriate or unnecessary to include every SQUIRE and SQUIRE-EDU item in a specific manuscript.

Each of the SQUIRE-EDU items is presented below with brief comments about what was learned in the development and testing phases. Pilot testing in phase two demonstrated which items engendered differing interpretations and which were unfamiliar. These data informed the explanations below. Additionally, Tables 2 and 3 provide a detailed example about how each SQUIRE-EDU item might be written in a manuscript, along with comments about the example.

Notes to authors. These guidelines are intended to apply to educational improvement that use iterative cycles to test interventions. The guidelines do not prescribe a particular design and may be applied to the many ways educational improvement work is done.

Title and abstract. EDU 1 and EDU 2. The manuscript should be easy to locate using conventional scholarly literature search strategies—thus the requirement that the title, abstract, and key words specify the educational improvement methodology and note the educational focus.

Problem description. EDU 3. Educational improvement explicitly

focuses on the local need for the work (e.g., Nursing School A has a decreasing national board pass rate). In educational improvement, there should be a clear connection between the local need and the broader considerations outside the local institution. Educational improvement is focused on addressing a specific problem in the local setting. EDU 3 focuses on showing a clear indication of why the described change was needed at the identified locale.

Rationale. EDU 5. A clear rationale, or theory, has historically not been used in improvement work. Davidoff and colleagues^{9(p228)} describe the need for theory to guide improvement work as follows: “Personal intuition is often biased . . . formal theory enables maximum exploitation of learning and accumulation of knowledge, and promotes the transfer of learning from one project, one context, one challenge, to the next.” The theory used in educational improvement addresses why the planned intervention would be effective for the specific context at the identified site at that point in time. The rationale for educational improvement may be a straightforward cause–effect statement or a more complex driver diagram showing the anticipated primary and secondary drivers leading to the desired outcome. Formal or informal theory is acceptable, but the key is to make the theory explicit in the planning, the work, and the writing.

For educational improvement work, authors may also, or alternatively, incorporate formal learning theory. Learning theories identify the underlying assumptions about mechanisms of learning and interaction of the learners with the content and context. SQUIRE-EDU strongly encourages the use of a rationale or theory before the educational improvement work begins.

Context. EDU 7a and 7b. Context is broader than setting because it encompasses an ecological sense and interacts with interventions over time. The EDU items focusing on context recommend identifying the initial contextual elements and relationships that exist. The evolution of these elements over time affects the interventions and the overall educational improvement. SQUIRE and SQUIRE-EDU account for these shifts by including context in

subsequent items (SQUIRE: 10a, 13a, 17c; SQUIRE-EDU: 17b). The dynamic relationships between contextual factors mean that the perceptions of the context may shift over time. This shift is to be expected as context is created, manipulated, and controlled by the way the elements are perceived.¹⁰

There is no formal instrument or survey to describe the context. Several excellent frameworks exist to support clinical quality improvement work (e.g., MUSIQ,¹¹ PARIHS,¹² and CFIR¹³). A common theme among these frameworks is consideration of internal elements (e.g., faculty, staff, classroom space, champions, quality improvement training), external elements (e.g., accreditation, mandate from the dean), and characteristics of the individuals (e.g., readiness for change). Context must be assessed at the outset and at regular intervals to determine how the elements have evolved, how the perception of these have changed, and how these changes have affected the intervention and outcomes.

Any educational improvement has a wide variety of contextual elements, but authors must decide which are most important. These choices begin with the planning and development of the work and assessing which elements had an impact on the intervention over time. When preparing the manuscript, the authors know the conclusions of the work, so they should take the outcomes into account when describing the context.

Intervention(s). EDU 8a and 8b.

Describe the interventions in sufficient detail (or offer additional detail in an appendix or online) so that others can attempt to replicate. In both clinical and educational improvement, it is expected that the intervention will change over time, so descriptions of the initial intervention provide an important baseline for understanding the modification of the intervention over time. SQUIRE-EDU strongly encourages an interprofessional team to design, assess, and implement interventions (e.g., learning specialist, physician, nurses, respiratory therapist) because education and health care are naturally collaborative undertakings.

Study of the intervention(s). EDU 9a and 9b. Beyond making changes to improve systems, scholarly work intended for

Table 2

Example and Explanation of Each SQUIRE-EDU (Standards for Quality Improvement Reporting Excellence in Education) Item^a

SQUIRE-EDU item	Example of text in a manuscript	Comments
EDU 1. Indicate that the manuscript concerns efforts to improve health professions education systems and learning	Student-Focused Improvements in a Preclinical Medical Physiology Course	—
EDU 2. Keywords include a focus on education and learning	medical education, physiology, educational improvement, flipped classroom	—
EDU 3. Description of the nature and significance of the need for change in the local educational system	Based on student feedback and national trends, the medical school preclinical physiology course started a multi-year transformation to a flipped classroom experience. This shift was initiated because of low student satisfaction from the lecture-based class structure.	The course director undertook a major, iterative redesign because the current structure was not meeting the needs of the students. Student dissatisfaction is the local gap that was addressed using educational improvement.
EDU 5. Identify the guiding theory (learning, change, implementation, or other) and how it aligns with the need for change in the local educational system	Adult Learning Theory supports that by flipping the pedagogy to a student-centered model, medical students will develop a deeper understanding of the material and be more able to apply their learning to patient care.	This statement encompasses both the rationale for the change as well as the learning theory (adult learning theory) that were key components of the design of this educational improvement project.
EDU 7a. Contextual elements for learning (e.g., setting, program, people, resources, social, geopolitical influences) before the intervention(s)	Physiology is one of eight foundational science courses at the SOM. Each course is led by a faculty member who has oversight of the course and leads approximately 75% of the sessions. For the past 12 years, the course has used mostly large group lecture format.	This description gives the reader a sense of the education program structure, the recent history of leadership in the course, volume of students, and relationship of the course to external influences, such as the dean and the accreditation committee. A reader gets a sense of what the authors believed to be important in starting the work to improve the physiology course and can determine how similar or different it is to his or her own context.
EDU 7b. The interrelationships between the contextual elements and the local educational and healthcare systems before the intervention(s)	A new course director was named in 2014. The SOM matriculates 125 students each year and recently completed its accreditation visit. Although it received full accreditation, the dean noted that the preponderance of lecture style teaching was a vulnerability noted by the accreditation committee and encouraged faculty to update pedagogy.	—
EDU 8a. Description of the primary interventions and co-interventions (e.g., faculty or tool development)	The physiology course is divided into four different sections. The respiratory physiology section leader created the initial flipped classroom experience in 2014 by making online recordings of the lectures from the previous academic year.	This section describes the initial planned change with a recognition that most curricular changes require multiple interventions.
EDU 8b. Specify how the interprofessional education team (e.g., faculty, staff, patients, and learners) was part of the design of the intervention	Students' evaluation provided data that they wanted more pre-work prior to class to use class time in a more interactive way. The lecture recordings were processed by the course assistants to be used as the pre-work for students to watch prior to class so that they could work on respiratory physiology questions and problems in groups during the class session. Instructional designers and faculty collaborated to build the in class sessions.	In educational improvement, it is common to have students' feedback serve as a catalyst for initiating improvement. Other input, such as care gaps identified by patients or families, would be included in this section. Specify the specific individuals who helped to build the interventions.
EDU 9a. Approach used to understand the impact of the educational intervention(s) on the learner and beyond, such as impact on patients, families, the community, faculty, educational program, or the healthcare system	In order to monitor the development of the changes to the course, four students who were enrolled in the course were recruited each year to gather field notes. After training to ensure reliable data gathering, the students wrote down observations and reflections about the design and execution of the flipped classroom activities. The students wrote these anonymously during the course. Field notes were not part of the students' grade and were important data that were assessed after grades were finalized.	This is one example of how a team might study the intervention while the intervention is being implemented. By enlisting students to provide detailed feedback, the teaching team is able to gather first-hand information about the efficacy of the intervention. This approach differs from course feedback that occurs subsequent to the intervention and may only provide insight into satisfaction with the learning experience.
EDU 9b. Approach to assess the fidelity of and the iterative changes to the planned intervention(s) over time	Data from the student field notes were used to modify the flipped classroom experience in each subsequent iteration.	Field notes are one way to gather detailed, deep, and real time data about a change process.

(Table continues)

Table 2

(Continued)

SQUIRE-EDU item	Example of text in a manuscript	Comments
EDU 10. Quantitative and/or qualitative measures chosen to assess the educational processes and outcomes on learners, faculty, educational programs, patients, families, healthcare systems, or communities	The physiology course assessed the changes to the curriculum across several domains. Achievement in physiology was measured with scores on the written quizzes, final exam, and on USMLE Step 1 physiology scores. Student satisfaction was assessed through the usual course feedback system. Field notes from selected students tracked the impact and fidelity of the iterative changes to the curriculum. Finally, impact on patients was assessed through an observed structured simulation exercise that required students to react to physiologic changes in high fidelity mannequins.	The variety of data measures in the example allows the teaching team to understand the breadth of impact of the educational changes. A reader of the manuscript will immediately be able to understand whether the changes relate to his or her own context or not.
EDU 12. Approaches to address vulnerability of learner participants	Improvements in the physiology course were reviewed and approved by the local IRB. Additionally, student participation in gathering field notes was voluntary and clearly communicated as not connected to students' grades in the physiology course.	Learners are a vulnerable population and require adequate protection from the appropriate institutional ethics review committee. Addressing the perception of coercion is an important element of ethical conduct of educational improvement.
EDU 13a. For each educational intervention and co-intervention, provide details about iterative modifications based on the assessment of the learning	See Table 3. Example of Iterations to the Physiology Course, 2014–17	A table such as the example is not the sole outcome but is intended to complement other identified outcomes.
EDU 14. Connect the findings to the guiding theory (learning, change, implementation, other) used to direct the change in the local educational system	Active learning theory and data guided the iterations of the interventions. While this appeared straightforward at the outset, many unforeseen consequences occurred as the changes were made over the four years. First, faculty development was paramount, and faculty required boosters along the way. As the faculty became more comfortable with the flipped teaching method, the sessions became smoother. Second, students preferred the active learning, but only to a point. Students expressed a desire for a combination of lectures and active learning. These requests were unexpected for the teaching team, but no less important to address in future iterations.	In the example, there is no change in knowledge assessment, some unexpected results from student reactions, and promising application of the knowledge. Together, these findings provide a comprehensive assessment of the development and changes made to the physiology course.
EDU 15c. Include the impact of the intervention(s) on learners, faculty, educational program, patients, families, healthcare systems, or communities	Student performance on exams and USMLE national board exams were unchanged. Students performed very well on the simulation exercise, indicating that they were capable of learning complex respiratory and renal physiology and able to apply it in a patient setting. This application of knowledge was a significant step forward for the physiology course and will be explored further in the curriculum.	Performance on USMLE was one important data outcome that was carefully tracked. The physiology course team also created a specific assessment (integrated high-fidelity simulation) to determine how the new teaching method might impact patient care. Keeping in mind that the impact of health professions education is ultimately on the care provided, this outcome tried to assess the potential effect of the improved physiology course.
EDU 17b. Scalability of the work to other learners and contexts	Although the improvement in physiology was quite successful over four years, the school has struggled to make similar active learning advances in other courses. The mandate from the dean to increase active learning led to some starts and stops in other courses, but not the sustained effort that was seen in Physiology.	Included in this section might be the perceived barriers to adoption of the innovative pedagogy in other parts of the curriculum.
EDU 17d. Lessons learned for clinical practice, education, and policy	Others would be wise to ensure that a comprehensive evaluation system is in place so that the teaching team can react to and modify the curriculum as needed. Also, the connection to the integrated physiology simulation assessment created an important motivator for the students. This connection to "real" patient care was vital for the success of this project.	Describing the potential next phases of this work through the "lessons learned" will guide subsequent iterations of educational improvement for the readers.

Abbreviations: SOM indicates school of medicine; IRB, institutional review board; USMLE, United States Medical Licensing Examination.

^aThis is a fictitious example we have created from a preclinical, medical school physiology course that systematically changed its teaching and evaluation over several annual cycles. This example is intended to demonstrate how educational improvement can be addressed in a manuscript using SQUIRE-EDU.

Table 3

Example of Iterative Changes to a Physiology Course, 2014–2017, Using SQUIRE-EDU (Standards for Quality Improvement Reporting Excellence in Education)^a

Year	Changes made	Outcomes	Lessons learned
2014	5 of 15 respiratory physiology 1-hour lectures replaced with flipped classroom	<ul style="list-style-type: none"> Data from field notes indicated prework too long Data from field notes indicated classroom sessions needed to be much more challenging 	<ul style="list-style-type: none"> Prework more focused Increase difficulty of classroom activities
2015	10 of 15 respiratory physiology 1-hour lectures replaced with flipped classroom	<ul style="list-style-type: none"> Test results indicate prework was focused better Data from field notes indicate that classroom sessions were a bit too difficult Scores on exams unchanged from historical controls 	<ul style="list-style-type: none"> Spread to renal physiology section Try a simulation of respiratory physiology for the student assessment
2016	15 of 15 respiratory physiology 1-hour lectures replaced with flipped classroom 5 of 15 renal physiology 1-hour lectures replaced with flipped classroom	<ul style="list-style-type: none"> Student evaluation data indicated that prework was acceptable and focused Data from field notes indicate that classroom sessions interactive and challenging, but renal faculty struggled with the format Exam scores increased, but not significantly Data from faculty running simulation indicate that simulation was challenging 	<ul style="list-style-type: none"> Faculty development for renal physiology faculty regarding teaching methodology Expand simulation to include combined respiratory and renal physiology
2017	All respiratory and renal physiology lectures replaced with flipped classroom activities	<ul style="list-style-type: none"> Data from student field notes suggest that classroom sessions were interactive and challenging Data from faculty indicate that renal faculty better prepared for facilitating the classroom sessions Data from student evaluation include student requests for foundational lectures Data from class evaluation indicate that simulation shows promise as interactive and challenging final exam 	<ul style="list-style-type: none"> Add in foundational content knowledge to assist students to be successful in the classroom sessions Add students to the course evaluation team Sharpen the simulation examination

^aThis accompanies Table 2 from the fictitious example from a preclinical, medical school physiology course that systematically changed its teaching and evaluation over several annual cycles. This table is an example of how the iterative changes to a course might be chronicled in a manuscript using SQUIRE-EDU.

peer-reviewed journals should include a study of the intervention(s). Studying the intervention allows the team to determine whether the system improved because of the intervention(s) or for some other reason, assess for unintended consequences, and determine the associated opportunity costs. This might range from using a specific design to introduce an intervention over time (e.g., step-wedge) or enacting detailed reflection and careful note-taking about the improvement process. Carefully studying the intervention also helps maintain the fidelity of each cycle of change with a clear description. Unlike some research designs where the intervention is intended to remain static over time, interventions in improvement are intended to change; however, implementation of such interventions should not be haphazard. The fidelity of each cycle of change should be reported to explain how the intervention evolved, why certain aspects of the intervention were sustained and others were not, and how and why the final version of the intervention was decided upon.

Measures. EDU 10. When deciding what to measure, it is often helpful to use a

framework, such as the Barr-Kirkpatrick hierarchy of educational outcomes.¹⁴ This framework enables a team to consider broadly what needs to be measured to determine whether the changes made to the learning experience result in an improvement. In educational studies, common outcomes include learner reactions, knowledge, skills, and attitudes. Well-done educational improvement must use the higher levels of the framework—namely, behavioral change, organizational change in practice, and benefits to patients.¹⁴ The measures will depend on the nature of the initiative, time frame of the improvement, data availability, feasibility, and resources. The higher-level outcomes offer the opportunity to connect educational processes to potential outcomes for patients, families, and communities. At the outset, the team should identify how their educational improvement will affect these stakeholders, even when the impact seems distal to the educational experience.

Ethical considerations. EDU 12.

Learners are a vulnerable population and require protection through

approval or exemption of the study by the appropriate institutional ethics review committee, especially addressing the perception of coercion. At many institutions, clinical improvement does not require human subjects IRB approval because it is considered more closely aligned to the clinician–patient therapeutic relationship than to research activities.¹⁵ Local IRB practices may vary for educational interventions. SQUIRE-EDU recommends that curricular changes undertaken with improvement methodology be discussed with the local IRB to ensure appropriate oversight for learners, patients, and communities.

Results. EDU 13a. This item details the inclusion of process and outcomes, context evaluation, interactions, and unintended consequences. EDU 13a emphasizes providing details about the important iterations that occurred. Rather than describing only the final iteration of the educational experience, disclosing details of the successes and failures of changes over time is extremely useful. These descriptions provide information that may guide the educational improvement work of

others. Chronicling the iterative changes, whether weekly or yearly, allows readers to determine what occurred, when, and for what reasons. Consider summarizing these in a table, figure, or appendix to the manuscript.

Summary. EDU 14. After the teaching team has implemented the interventions through multiple cycles of change and assessed the context and outcomes, the accompanying manuscript should comment on the impact of the rationale and guiding theory and how it might be modified for future educational improvement. This section can be a quick reminder of the rationale and theory from EDU 5 with a reflection about why and how the results showed what they did.

Interpretation. EDU 15c. This section should discuss the impact on the learners, the sustainability of changes within the educational and health care systems, or the impact the educational changes had on health care providers. When measures are designed to assess the impact beyond the immediate learners, the breadth of interpretation of impact will be easier to analyze. Not every project will have a direct and measurable impact on elements external to the educational experience, but SQUIRE-EDU urges educators to consider the impact beyond the classroom.

Conclusions. EDU 17b and 17d.

Because SQUIRE-EDU is focused on improving the local educational system, extrapolation to other contexts may seem more challenging than with context-controlled studies. This EDU item is for describing whether and how the intervention might need to be modified to be implemented in other contexts.

Discussion

SQUIRE-EDU is an extension to the SQUIRE 2.0 publication guidelines, intended to guide the preparation of manuscripts that describe iterative cycles of improvement in health professions education. SQUIRE-EDU encourages expansion of educational science by offering an alternative to using a research design. SQUIRE-EDU incorporates rigorous methods from improvement science, which tests multiple hypotheses and interventions over time and includes a deeper integration of the influence

of the local context. This alternative approach leads to discovery that broadens the limitations of traditional research. SQUIRE-EDU can also be useful to assist the design of proposed interventions, the conduct of the work, and the analysis and dissemination of educational innovations. For example, using the SQUIRE-EDU elements in planning educational improvement work facilitates a comprehensive approach to creating and evaluating innovative educational approaches. SQUIRE-EDU may also be used during the peer review process for manuscripts by providing an agreed-upon set of elements for educational improvement reports. SQUIRE-EDU strives to enhance the alignment between health professions education and clinical care through the inclusion of learning outcomes *and* potential or real impact on the health care system, patients, families, and communities. Finally, the guidelines can increase the uptake and scalability of educational innovations. Standardized reporting will decrease the variation in published educational improvements and enhance the ability of systematic reviews to highlight the strategies and contextual factors that result in high-quality health professions education.

SQUIRE-EDU is different from the recently published educational intervention guidelines called the Guideline for Reporting Evidence-based practice Educational interventions and Teaching (GREET).¹⁶ The GREET guidelines apply to educational interventions for teaching the knowledge and skills of evidence-based practice. In contrast, the purpose of SQUIRE-EDU is to report a process of iterative improvement in health professions education and does not limit its application to any one content area or approach. For these reasons, SQUIRE-EDU provides a unique contribution to the standardization of educational improvement reporting. This broader scope is complementary to the GREET guidelines, and both can advance health professions education.

Applying improvement methods to health professions education might be new to health care educators; however, using improvement science methods has already been embraced by K–12 educators. The Carnegie Foundation for the Advancement of Teaching has led a movement to improve K–12 education

by encouraging and using improvement methods.¹⁷ The Carnegie approach identifies educational gaps; attends to context; develops educational innovation informed by stakeholders; and then tests, adapts, and scales up promising interventions. The six core principles of improvement in the Carnegie approach mirror quality improvement principles.¹⁷ SQUIRE-EDU provides health professions educators an opportunity to learn, apply, and report their educational improvement work in a way that aligns with Carnegie's leadership in this area.

If health professions educators want to demonstrate how education has an impact on clinical care and systems, then SQUIRE-EDU may provide opportunities for the design and methods to make these connections. This is a paradigm shift for many health professions educators. Health professions education is unique because of its complex clinical learning environments that demand critical, systems, emotional, and design thinking.¹⁸ SQUIRE-EDU encourages innovative approaches to health professions education by emboldening educators not only to improve learner outcomes but also to assess the impact of educational interventions on patient, health care system, and community outcomes. When looking to improve an educational experience, a novice teacher may ask, "How am I doing?" and a more seasoned one may inquire, "How are my students doing?" SQUIRE-EDU urges the health professions educator to inquire, "How are our patients, health care systems, and communities doing?"

Just as the SQUIRE guidelines standardized the reporting of efforts to improve health care, we anticipate that SQUIRE-EDU will have a similar contribution to health professions education. SQUIRE-EDU encourages expansion of educational science by incorporating rigorous methods from the emerging field of improvement science. The improvement science approach tests multiple hypotheses and interventions and includes a deep understanding of the influence of the local context, thus strengthening the evidence of how health professions education contributes to improved health care outcomes. This contemporary approach to change leads to discovery that complements traditional research. Sharing this work through peer-reviewed literature that employs

the standardized approach offered by SQUIRE-EDU will allow exploration of applying improvement science methods to health professions education.

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