Editorial: A New Direction for the IEEE TRANSACTIONS ON EDUCATION: Part I. Developing Shared Understanding of the Scholarship of Application

I. INTRODUCTION

THE IEEE TRANSACTIONS ON EDUCATION provides an important forum through which the global community of engineers and educators exchange discoveries, innovations, and syntheses. Here they can share insights and contributions to improve engineering education. Over the next decade, the journal intends to emerge as the definitive source of scholarship for education in electrical engineering, computer engineering, software engineering, computer science, and other fields within the scope of interest to the IEEE. To accomplish this, the major goal is to increase the quality and value of the published work. A first step, implementing new review criteria, has been taken to establish an intellectual foundation on which to build a repository of valuable engineering education experience and knowledge.

To achieve the vision, all colleagues educating the next generations of engineers are strongly encouraged to contribute papers to the TRANSACTIONS and to collaborate with the editorial staff (Editor-in-Chief and Associate Editors) to drive this important enterprise. Manuscripts from those engaged in engineering education research, from engineering faculty members, and from collaborations between these two groups are actively solicited. Feedback and suggestions for improving the journal and the review process are also welcome and appreciated; these can be sent to the Editor-in-Chief or any one of the Associate Editors.

This editorial is the first in a series of editorials intended to address the new review criteria.

II. REVIEW CRITERIA

For any journal, authors submitting their work to the journal are interested in publishing their work, while the editorial staff is charged with maintaining or improving quality over time. Review criteria mediate interactions between the two groups: It is through review criteria that the editorial staff explicitly articulates their expectations for publishable manuscripts. Authors can then consider the review criteria and have a clearer understanding of what is expected for a publishable manuscript.

The TRANSACTIONS publishes original scholarly contributions to education in electrical engineering, computer engineering, computer science, software engineering, and other fields within the scope of interest to the IEEE. Contributions to the TRANSACTIONS have come in many varied forms and modes. However, before 2013, types of scholarly contribution were not categorized or recorded, which can lead to confusion in the review process. Therefore, the editorial staff of the TRANSACTIONS developed a new set of review criteria that became effective July 1, 2013. In this editorial, the Editor-in-Chief describes why the new criteria were developed, briefly overviews the nature of the new criteria, and then offers in-depth explorations of specific review criteria that appear to need clarification, based on an informal analysis of recently submitted manuscripts.

III. WHY WERE NEW REVIEW CRITERIA NEEDED?

New criteria were needed to address the broad range of manuscripts that authors submit to the TRANSACTIONS. Some authors intend to present new knowledge obtained by investigating, for example, students who are studying electrical engineering, computer engineering, computer science, software engineering, and other fields within the scope of interest to the IEEE. Some authors present instructional strategies as well as tools (e.g., laboratories, simulations, hands-on artifacts, etc.) that support implementation of instructional strategies. Some authors synthesize collections of published papers to identify trends, patterns, gaps, opportunities, relationships, etc. A single set of review criteria would be inadequate to address this wide range of manuscripts because the intended scholarly contributions for each class of manuscripts are very different. Therefore, new review criteria were needed. To develop new review criteria, the editorial staff must either create intellectual foundations for the criteria from scratch or build on an existing intellectual foundation. For the TRANSACTIONS, the staff chose the latter alternative. They chose the framework developed by Ernest Boyer [1] because it already encompassed the breadth of submitted scholarly contributions, and because it offered a structure that others have already used to develop review criteria for some of the areas of scholarship that Boyer identified.

Boyer's framework offered four distinct areas of scholarship: discovery, application, integration, and teaching. Many papers have been published on the scholarship of teaching. Review of some of these papers convinced the editorial staff that Boyer's first three areas were sufficient to describe the scholarship of teaching. The scholarship of teaching can be considered to be the union of the scholarships of discovery, application, and integration where the underlying field of knowledge is considered to be research on learning and teaching fused with relevant disciplinary knowledge. For example, if a manuscript intended to make scholarly contributions on the teaching of circuits, it would draw upon the disciplinary knowledge of circuits together with

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TABLE I
AREAS OF SCHOLARSHIP AND REVIEW CRITERIA TITLES

Scholarship of Discovery	Scholarship of Application	Scholarship of Integration
Relevance	*Relevance*	*Relevance*
Context	*Context*	*Context*
Focus	Intended Outcomes	Focus
Contribution	Application Design	Contribution
Methodology		Methodology
Findings	*Findings*	*Findings*
Conclusions	*Conclusions*	*Conclusions*
Organization and Clarity	*Organization and Clarity*	*Organization and Clarity*
Illustrations	*Illustrations*	*Illustrations*

relevant knowledge of learning and teaching. If a fusion of disciplinary knowledge and knowledge on learning and teaching is used as the underlying domain knowledge, then the scholarship of teaching, as discussed in many articles, can be sufficiently encompassed by the scholarship of discovery, the scholarship of application, and the scholarship of integration. Having worked with the Associate Editors to formulate the review criteria, the Editor-in-Chief is convinced that Boyer's framework will enable the Transactions to consider the wide range of manuscripts submitted by authors from across the world.

IV. How Can the New Review Criteria Be Described?

Using Boyer's framework, review criteria were developed for each of the three areas of scholarship. The new review criteria can be found at a Web site developed to provide authors with this information [2], and so will not be repeated in detail in this editorial. Table I presents the three areas of scholarship and titles for each of the review criteria.

Note that six review criteria are common to the three areas of scholarship: relevance, context, findings, conclusions, organization and clarity, and illustrations. *Relevance* examines strength of relationships between the issues, research, practices, findings, or applications described in the manuscript and in the existing literature on education in electrical engineering, computer engineering, and fields within the scope of interest of IEEE. *Context* analyzes the degree to which their authors have situated intended contributions within the body of existing work. Context considers how well authors have related their work to prior scholarship. *Findings* investigates how well authors have analyzed and summarized their data, evidence, artifacts, etc. *Conclusions* appraises how well authors have connected implications for practice, policy, future research, etc. Future editorials will address these four review criteria—relevance, context, findings, and conclusions—in greater depth. Manuscripts are evaluated with respect to *organization and clarity* in terms of the quality of writing, presentation, and organization of a manuscript, while manuscripts are evaluated with respect to *illustrations* in terms of the quality and contributions of figures, graphs, illustrations, pictures, etc., to the manuscript.

V. Scholarship of Application

The remainder of this editorial will focus on the scholarship of application for two reasons. First, as a rough estimate, over 80% of the papers previously published and manuscripts submitted to the TRANSACTIONS would be categorized as falling within the scholarship of application. Given that the scholarship of application characterizes such a large percentage of manuscripts submitted to the TRANSACTIONS, the first editorial on the new review criteria should focus on this area. Second, there are few models available for review criteria on the scholarship of application. There are many journals across a wide variety of disciplines that emphasize the scholarship of discovery; that is, development of new knowledge. As a result, there are many existing examples of review criteria for the scholarship of discovery, and the editorial staff used some of these examples as they developed the review criteria for this area of scholarship for the TRANSACTIONS. Although there are fewer examples of review criteria for the scholarship of integration than for discovery, examples also exist, and the editorial staff used these examples for the scholarship of integration. However, there are almost no examples of review criteria for the scholarship of application, and the editorial staff was forced to develop the review criteria almost from scratch.

Summarized very briefly, when authors submit a manuscript in the scholarship of application, they are, implicitly or explicitly, asserting that they have applied existing knowledge well. What is meant by "existing knowledge"? Given the diversity of manuscripts and breadth of imagination of the authors, it is difficult to describe precisely and accurately the applicable field of knowledge, but such knowledge would include the knowledge of the disciplinary subject as well as the knowledge of learning and teaching. Therefore, in submitting a manuscript for the scholarship of application, authors should be prepared to employ relevant disciplinary knowledge as well as pertinent knowledge of learning and teaching. Having established what existing knowledge means, what does it mean to have applied this existing knowledge well? To address this question, the editorial staff developed eight review criteria, of which six are common to the other areas of scholarship and two are unique to the scholarship of application:

- Intended outcomes;
- Application design.

In addition, a third criterion, Findings, will be given special attention for the scholarship of application; many authors struggle to address this criterion in this area of scholarship. Each of the three criteria will be explored in the following sections.

A. Intended Outcomes

If someone asserts in a scholarly forum that they have applied existing knowledge well to create their design, then the intent for their design must be clear. For this reason, review criteria for the scholarship of application include the criterion of intended outcomes. In the literature on design, more effective designs are developed when designers articulate their intent at a functional level, before they offer embodiments, that is, physical realizations of the design. Similarly, the review criteria for the scholarship of application expect that authors will both articulate their intent of their application as well as describe their application. For example, if the authors present a set of laboratory experiments, they are expected to articulate their intent for the experiments before proceeding to describe and discuss the individual experiments. Authors may describe an instructional strategy, for example, a set of laboratory experiments, and claim that they work, without describing their intent. The result resembles, in

some ways, the character in the movie *Butch Cassidy and the Sundance Kid*, who faces a hill littered with rocks, pulls out a gun, shoots, and exclaims, "I hit it," to demonstrate his exceptional marksmanship. When asked which rock he was aiming at, he explains, "The one I hit." Quality of any design cannot be evaluated independently of clear articulation of intent. Authors of the example laboratory experiments can indicate that the experiments are intended to help students understand a set of concepts better. If the authors can then describe how they will recognize better conceptual understanding, then they have laid a foundation that can be used to help evaluate their laboratory experiments.

B. Application Design

In the process of applying research on learning and teaching as well as disciplinary knowledge to construct contributions of the manuscript, authors have made numerous design decisions. For each decision, authors select a specific alternative from a range of generated alternatives. Therefore, a second criterion, application design, invites authors to evaluate the quality of their application by reflecting on the central design decisions made in the course of the development process. To address this criterion, authors must articulate key design decisions that had to be made during the development process and describe how their choices were made. For example, if authors were developing a laboratory experiment to help students understand transmission lines, authors must decide what transmission line concept, or what very small number of concepts, students regularly misunderstand. When they choose this set of concepts, they should rely on more than just their own guesses about what students misunderstand. Often, such questions have been studied by researchers; authors can use this research to guide their choices of concepts. To support assertions that knowledge was applied well, authors must do more than simply describe what was created. Authors must understand where they have made crucial decisions, identify these critical junctions, and then argue that they made these decisions well. Alternatives must have been generated and evaluated to show why the selected alternative was superior to the alternatives that were considered. Application design, as a criterion, is analogous to what faculty members expect of students when faced with a design task. Students are expected to generate alternatives for the design, develop criteria to evaluate alternative designs, evaluate the alternative designs, and show that the selected alternative was superior. Therefore, in addressing the application design criterion, authors will be expected to make and support their case that a quality alternative was selected for each crucial design decision in the development process.

C. Findings

For a third criterion for quality of application, authors will be expected to study the extent to which their design achieved its intended outcomes. Suppose, for example, authors indicated that improved conceptual understanding, broadly described, would be their intended outcome. In a publishable manuscript, they would be expected to provide more specific details. Starting with their intended outcome, the authors would be expected to show that improved conceptual understanding was achieved. Student satisfaction, often cited to support assertions of effectiveness, would not be sufficient to demonstrate improved conceptual understanding because, for one reason, the intended outcome was improved student conceptual understanding, not student satisfaction. Student self-reports, via surveys, for example, would not be sufficient to demonstrate improved conceptual understanding because student self-reports rarely have sufficient validity to demonstrate achievement of conceptual understanding. For example, the author has never met a faculty member who would assign student grades based solely on student responses to questions similar to "Did you think you understand how to write nodal equations for circuits?" An in-depth exploration of strategies to assess student learning is beyond the scope of this editorial. However, authors can select from a wide range of methods to assess student learning. An author's best course of action would probably be to add one or more authors with expertise in assessment. In addition to improved student conceptual understanding, authors may choose to address other important outcomes, such as improved student retention, improved problem solving abilities, improved moral reasoning, etc. As a starting point, authors might consult the area of the Cutting Edge Web site that deals with assessing student learning [3].

VI. Conclusion

Making a substantive contribution to the scholarship of application in education in electrical engineering, computer engineering, computer science, and other fields within the scope of interest of IEEE can be a challenging undertaking. Authors often do not have resources and models on which they can build. If authors consider what constitutes a scholarly contribution in their own technical disciplines and then transfer this understanding to reporting their work in education, they have taken important steps toward crafting a publishable manuscript. Hopefully, this brief editorial will help simplify the process of making the transfer.

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