Standards for quality of research in engineering education

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Abstract: The conception of quality in scientific work is fundamental and determines what researchers judge as reliable knowledge in their field. Although criteria of quality is used daily in research there are few extensive reviews available especially in Engineering Education Research (EER). For the development of high-quality research in EER in the future we argue that it is necessary that the EER-community begin to negotiate criteria for quality. In our reflection we consider: quality of a study in general, quality of the results and validity of the results.

Introduction

In recent years research studies into critical factors for learning in engineering education (EER) have started to emerge worldwide (Baillie & Bernhard, 2009; Borrego & Bernhard, 2011). In a review by Case and Light (2011), it was “argued that methodological decisions need to be more explicitly represented in reports … in engineering education research”, and in the review and meta-analysis conducted by Koro-Ljungberg and Douglas (2008), it was found that the issue of methodology has received limited explicit discussion in EER-literature and that many studies lacked epistemological consistency. As will be suggested below methodological and perspective awareness and epistemological consistency are important aspects of quality.

The conception of quality in scientific work is fundamental, and determines what researchers judge as reliable knowledge in their field. Although quality criteria are used daily in research, extensive reviews discussing research quality, especially in EER, are lacking. When a thorough discussion is lacking it poses the risk that the criteria applied are subjective and randomly applied. Also, it could lead to an unquestioning acceptance of one research paradigm, or epistemology, which is often the dominant paradigm. This can lead to an inappropriate matching of research questions to methodologies, a confusion of reliability with validity, and a lack of transparency in the criteria being applied for what constitutes quality in research. Although what we communicate in this paper will be relevant to quantitative research, we will focus on qualitative research since it is the area that induces the most controversial discussions about quality in contemporary EER.

Critical features in the debate about criteria for quality

Methodology and epistemology

Epistemology is a branch of philosophy concerned with the theory of knowledge. It attempts to provide answers to the question, ‘How, and what, can we know?’ This involves thinking about the nature of knowledge itself, about its scope and about the validity and reliability of claims to knowledge. Research methods provide ways of approaching, and hopefully answering, our research questions… However, first we need to identify our goal and be able to justify our choice. We need to be clear about the objectives of our research and we need to have a sense of what kinds of things it is possible for us to find out. In other words, we need to adopt an epistemological position. (Willig, 2008, p. 2)

In order to study learning, we need to think about what we mean by the terms ‘learning’ and ‘knowledge’. This will influence the underlying theory we choose to adopt and the way we conduct our research. Epistemology is the term used to describe ways of knowing. Recently is was pointed out:

Some … interpretations of the Gold Standard have privileged a single research approach and type of evidence regardless of the development of the problem space, specific research question, available technologies and instrumentation, and cost
or ethical considerations. If such interpretations of this policy exclusively privilege [randomized controlled trials] and quantitative evidence, it would disregard high-quality, qualitative research approaches and other contemporary approaches and, thus, the evidence flowing from such inquiries. (Shelley II, Yore, & Hand, 2009, p. 5, our italics)

We perceive from the above quote that high quality in research requires that the approach, and type of evidence collected, be aligned to the “the problem space, specific research question, available technologies and instrumentation, and cost or ethical considerations”. On this note, Case and Light (2011) argue that “methodological decisions need to be more explicitly represented in reports … in engineering education research”. However, in an earlier review and meta-analysis of qualitative research in EER conducted by Koro-Ljungberg and Douglas (2008) it was found that the issue of methodology has received limited explicit discussion in the EER-literature and that many studies lacked epistemological consistency. Therefore, methodological and epistemological awareness and consistency are clearly examples of important factors contributing to the quality of an EER research paper but which appear to be rarely discerned.

Method versus problem led research

Streveler and Smith (2006) define “rigorous research in engineering education by using the guidelines provided by the [US] National Research Council (NRC) in Scientific Research in Education” (National Research Council, 2002). According to the NRC, scientific research in education should:

1. Pose significant questions that can be investigated empirically
2. Link research to relevant theory
3. Use methods that permit direct investigation of the question
4. Provide a coherent and explicit chain of reasoning
5. Replicate and generalize across studies
6. Disclose research to encourage professional scrutiny and critique

Nevertheless, Borrego and Bernhard note that the NRC’s report (National Research Council, 2002) is situated in the “curriculum studies” tradition and furthermore, these criteria are not quality criteria, but criteria for what would count as scientific research in education. They have also explored differences in US-based “curriculum studies” and EU “didaktik” traditions (Hopmann & Riquarts, 1995; Westbury, 2000). In the “didaktik”-tradition what should be learned and why it should be learned is an important question where quality of instruction is judged in terms of the professional appropriateness of knowledge and skills learning. “Bildung”, i.e. the formation of the individual as a whole beyond knowledge and skills is also deemed an important concept (Henriksen, 2006). In the “curriculum studies” tradition how a given topic is best taught is an important question where quality of instruction is judged in terms of student achievement on (objective) tests and student perception of classroom activity. Borrego and Bernhard relate these differences to Bishop’s (1992) analysis of mathematics education research where he explains that differences in conceptions of quality in research can be traced back to “problem-led” and “method-led” educational research traditions. According to Bishop, problem-led researchers “would judge research quality by what light is shed by the research on the problem under consideration,” in other words, “the quality of the ideas and insights generated” (p. 716). In contrast, a “method-researcher would argue that, without methodological criteria, such research is worthless” (p. 716). Method-led researchers would judge research quality in terms of the proper use of methodology and quality of the evidence.

Qualitative versus quantitative research

One of the dangers in conducting qualitative research is that it may appear easy and less rigorous than quantitative research. While quantitative research requires use of statistical methods which can provide an aura of trustworthiness, qualitative research can appear at first glance as if it simply involves interviewing a few people and then writing up a summary. … In fact, qualitative research can be just as difficult to conceptualize, and be as methodologically and theoretical challenging, if not more challenging, than quantitative research. (Koro-Ljungberg & Douglas, 2008, p. 172)

Qualitative research is often more difficult for engineers to become accustomed to than technical studies (cf. Borrego, 2007). Quantitative research usually relies heavily on positivist traditions that assume it is possible to measure an objective reality and conduct statistics on the data in order to reveal the ‘truth’ about a particular context, or in post-positivist traditions, falsify a hypothesis generated by theory. This implies that we can state that one teaching method is ‘better than another’. Qualitative researchers would rarely make such a claim but might question what ‘better’ actually means.
The above argument is further complicated by the fact that rarely do scientists and engineers discuss their underlying epistemology, nor necessarily know what it constitutes. The implication of this is that many researchers who move from technical to educational research, intent on ensuring ‘rigour’ and proving to their engineering peers that their work is valid, often adopt a positivistic stance that in their own technical research may not have been so immediately apparent. This concern for their work to be accepted as being rigorous often leads to an over-dependency on quantitative studies. What results from the above is an unhealthy dichotomy between qualitative and quantitative studies, which is often confused with the underlying epistemology. Quantitative studies are, as stated above, usually, but not necessarily, related to positivist or post-positivist traditions. It is equally possible to undertake qualitative work that resides firmly within these traditions. This is why stating the underlying epistemology is so critical. It is not possible to comprehend or judge the quality of work and the claims it makes unless its epistemology is understood.

A prolegomenon to quality criteria for EER

In this section we propose tentative criteria for quality in (qualitative) engineering education research that draws from criteria proposed by Borrego and Bernhard (2011) as well as Larsson’s (2005) criteria and those suggested by Eybe and Schmidt (2001), Niss (2010) and by Tracy (2010). The reviewed criteria are summarized in Table 1 and our tentative criteria are summarized in Table 2. We maintain that there are sometimes contradictions or tensions between criteria and the adequate balance has to be found, and depending on the type of study, certain criteria are more important than others. Beside the criteria described in Table 1 for educational research we note that there is an ongoing scientific debate related to qualitative engineering research. It is not possible for us to review this discussion in this short paper and we mention Dittrich, John, Singer, and Tessem (2007) and Halldórsson and Aastrup (2003) as examples of discussions related to quality criteria for qualitative engineering research. Both authors of this paper are educated as engineers and we claim that engineering praxis in its practical epistemology is pragmatic rather than positivist or post-positivist. In engineering praxis and in engineering research qualitative as well as quantitative methods are used. In the following sections, we provide a more explicit discussion about the criteria given in Table 2. In our view, these criteria are important, although given slightly different interpretations in different traditions, for qualitative as well as quantitative research in education.

Quality of a study in general

Perspective awareness

*Without theory there is nothing to research.* … In this way, theories provide both a framework for critically understanding phenomena [and] a basis for considering how what is unknown might be organized. … However, as used here, models, concepts and theories are self-confirming in the sense that they *instruct us to look at phenomena in particular ways.* This means that they *can never be disproved but can only be found to be more or less useful.* … A methodology refers to the choices we make about cases to study, methods of data gathering, forms of data analysis etc. in planning and executing a research study. So our methodology defines how we will go about studying any phenomenon. … *Like theories, methodologies cannot be true or false, only more or less useful.* (Silverman, 2001, pp. 3-4, our italics)

We suggest that the theoretical framing provides a ‘lens’ through which we see our subject/object of study. Learning theories will help frame what we mean by good quality learning, research theories will help us decide what constitutes good quality research and what question/aspects of learning we might focus on. As proposed in the above quote, the bias of the authors and their perspective and positioning theoretically and methodologically needs to be made explicit, as interpretation of data will be based on this. In order to appreciate the communicated results and their validity, the reader needs to “see through the lens” of the authors.

Acknowledging different knowledge traditions and cultures

No research paradigm has a monopoly on quality. None can deliver promising outcomes with certainty. None have the ground for saying ‘this is it’ about their designs, procedures, and anticipated outcomes. (Peshkin, 1993, p. 36)

High quality in this criterion is to display an awareness of, and respect for, *other* researchers’ perspectives, and to understand a piece of work within its own theoretical framework. This criterion is critically important for anyone involved in reviewing or editing other’s work. As quality is negotiated by the community within this category, it will be possible for more appropriate matching of reviewers
to work to be solicited by Journal Editors. It is especially important for reviewers to acknowledge their ignorance of others traditions and to decline to review studies not in their area of expertise.

Table 1. Some proposed quality criteria for education research.

<table>
<thead>
<tr>
<th>Quality criteria in Chemistry Education Research</th>
<th>Quality criteria in Engineering Education Research</th>
<th>Quality criteria in Qualitative Education Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory-relatedness:</td>
<td>Quality scholarship in engineering education is:</td>
<td>Worthy topic: The topic of the research is:</td>
</tr>
<tr>
<td>• The theory base</td>
<td>• Inspired by real educational problems.</td>
<td>• Relevant</td>
</tr>
<tr>
<td>• Reference to previous studies</td>
<td>• Informed by theory and other literature</td>
<td>• Timely</td>
</tr>
<tr>
<td>The quality of the research question:</td>
<td>describing prior work and beyond the field/home</td>
<td>• Significant</td>
</tr>
<tr>
<td>• Connection to existing literature</td>
<td>country.</td>
<td>• Interesting</td>
</tr>
<tr>
<td>• Relevance for practice</td>
<td>• Systematic and intentional, with</td>
<td></td>
</tr>
<tr>
<td>• Ethical issues</td>
<td>documented decisions ideally based on well-</td>
<td></td>
</tr>
<tr>
<td>• Falsification of hypotheses</td>
<td>planned collection and analysis of empirical data.</td>
<td></td>
</tr>
<tr>
<td>Methods: Appropriateness of the method</td>
<td>• Consistent with the perspectives and</td>
<td></td>
</tr>
<tr>
<td>a) Quantitative methods</td>
<td>chosen methodologies (quantitative,</td>
<td></td>
</tr>
<tr>
<td>• Reliability</td>
<td>qualitative or mixed).</td>
<td></td>
</tr>
<tr>
<td>• Validity</td>
<td>• Presented (at least in part) in a form that</td>
<td></td>
</tr>
<tr>
<td>• Level of significance</td>
<td>engineering academic staff can understand</td>
<td></td>
</tr>
<tr>
<td>b) Qualitative methods</td>
<td>and use, including by discussing implications</td>
<td></td>
</tr>
<tr>
<td>• Documentation of procedures</td>
<td>of the research.</td>
<td></td>
</tr>
<tr>
<td>• Interpretation by logical inference</td>
<td>• Situated in international and inter-</td>
<td></td>
</tr>
<tr>
<td>• Systematic</td>
<td>disciplinary contexts, by demonstrating</td>
<td></td>
</tr>
<tr>
<td>• Closeness to subjects</td>
<td>awareness of how common the problem is,</td>
<td></td>
</tr>
<tr>
<td>• Communicative validity</td>
<td>what is being pursued elsewhere, and the</td>
<td></td>
</tr>
<tr>
<td>• Triangulation</td>
<td>likelihood that results are or are not generali-</td>
<td></td>
</tr>
<tr>
<td>Presentation and interpretation of results</td>
<td>zable/transferable to other contexts</td>
<td></td>
</tr>
<tr>
<td>Implications for practice</td>
<td>(disciplines and/or countries). We note that</td>
<td></td>
</tr>
<tr>
<td>Competence in chemistry</td>
<td>in order for an EER topic to be worthy of</td>
<td></td>
</tr>
<tr>
<td></td>
<td>inquiry, it need not be broadly generalizable.</td>
<td></td>
</tr>
</tbody>
</table>

Quality criteria in Mathematics Education Research  
Niss (2010)  
Quality criteria in Qualitative Education Research  
Larsson (2005)  
Quality of the underlying research:  
• Quality of the research question(s)  
• Quality of the research design  
• Quality of the research findings  
Quality of the dissertation as a report of the work done:  
• Scientific/scholarly quality of the exposition,  
• Communicative quality.  
Quality of a study in general:  
• Perspective awareness  
• Internal consistency in a study  
• Ethical values  
Quality of the results:  
• Richness in meaning  
• Structure  
• Contribution to theory development and new knowledge  
Validity of the results:  
• Discourse criterion  
• Heuristic value  
• Empirical anchorage  
• Consistency  
• Pragmatic criterion.

Upholding ethical values

Research quality … in a broad sense is a holistic judgement, from which no individual requirement could be removed. ... Quality is judged by the compounded qualities originality, external and internal validity, precision and ethics. This means that the requirement of good research ethics is also included. (Vetenskapsrådet, 2011, p. 24, our translation and italics)

While ethical considerations are very briefly discussed in the National Research Council (2002, p. 93) report and in parts even described as something that “may weaken the strength of [a] research [design]”, the Swedish Research Council on the other hand maintains good research ethics as an essential requirement for high quality as demonstrated in the quote above. Furthermore, the Swedish Research Council (Vetenskapsrådet, 2011) proposes the following eight ‘commandments’:

1. You should speak the truth about your research; 2. You should consciously scrutinize and describe the basis for your studies; 3. You should openly describe methods and results; 4. You should openly account for commercial connections and other liaisons; 5. You should not steal results of research from others; 6. You should keep good order in your research, for example through documentation and keeping archives; 7. You should aim to conduct your research without harming humans, animals or the environment; 8. You should be fair in your judgement of other persons’ research.

The above are important because they maintain that ethics is much more than only conducting research “without harming humans or animals”. Fraud, withholding contradictory data, abuse of intellectual property, plagiarism, or lack of precision, in for example superficial studies about intelligence, criminality, ethnicity and so forth are all seen as examples of poor research ethics.

**Table 2. Tentative quality criteria for (qualitative) engineering education research.**

<table>
<thead>
<tr>
<th>Quality of a study in general</th>
<th>Quality of the results</th>
<th>Validity of the results</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>Perspective awareness</strong> All studies have a perspective or ‘lens’ through which the researchers have chosen to view their subject</td>
<td>• <strong>Richness in meaning</strong> Capture the essentials and at the same time maintain the nuances. Highlight what is unique to the specific phenomenon at hand.</td>
<td>• <strong>Discourse criterion</strong> In this criterion validity is viewed as a conversation about the world (or reality). The quality and exposition of argumentation and interplay of meanings.</td>
</tr>
<tr>
<td>• Acknowledging different knowledge traditions and cultures Respect and awareness of the perspective of other researchers</td>
<td>• <strong>Structure</strong> Interpretations should have a good structure. It should be possible to follow the reasoning.</td>
<td>• <strong>Heuristic value</strong> To what extent will a reader be convinced by the presentation of the study in seeing a particular aspect of reality in a new way?</td>
</tr>
<tr>
<td>• <strong>Upholding ethical values</strong> How can the study contribute to enhancing the human condition?</td>
<td>• <strong>Contribution to theory development and new knowledge</strong> How well does one relate to earlier theory. What is the original contribution of the study; something decisive or just a note in the margin?</td>
<td>• <strong>Empirical anchorage</strong> The relation between ‘reality’ and interpretation</td>
</tr>
<tr>
<td>• Informed by theory and other literature describing prior work A researcher cannot perform significant research without first understanding the literature in the field.</td>
<td>• <strong>Presentation of results</strong> Presentation relevant to proposed audience, clear and precise language, and a good balance between different parts of the presentation.</td>
<td>• <strong>Consistency</strong> (including epistemological and theoretical underpinnings) The interplay between part and whole</td>
</tr>
<tr>
<td>• <strong>Research question</strong> Worthy topic: Relevant, timely, significant, interesting</td>
<td></td>
<td>• <strong>Pragmatic criterion</strong> Consequences of what the results brought about (for example in relation to teaching). This is an aspect of what also is called ecological validity.</td>
</tr>
<tr>
<td>• <strong>Internal consistency in a study</strong> Consistency between research questions, methodology, epistemology, ontology and data analysis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Informed by theory and other literature describing prior work within and beyond the field/home country.**

A substantive, thorough, sophisticated literature review is a **pre-condition** for doing substantive, thorough, sophisticated research. ‘Good research is good because it advances our collective understanding. To advance our collective understanding, a researcher or scholar needs to understand what has been done before, the strength and weaknesses of existing studies, and what they might mean. A researcher cannot perform significant research without first understanding the literature in the field. (Boote & Beile, 2005, p. 3, our italics)

A thorough review of previous literature serves as a foundation for any research project by placing it in the broad historical context of previous studies both nationally and internationally. Furthermore, “a good literature review is the basis of both theoretical and methodological sophistication, thereby improving the quality and usefulness of subsequent research”. (Boote & Beile, 2005, p. 4, our italics)

**Research question**

A crucial but typically undervalued aspect of successful scientific investigation is the quality of the question posed. (National Research Council, 2002, p. 55)

For example, Niss (2010) maintains that “the issue of quality of the research undertaken takes its point of departure in research question(s) posed”. The question(s) clarity, precision, if they are genuine and non-rhetorical, their scientific and scholarly interest, if they are significant, relevant, original and researchable were seen as important aspects of quality. It is often argued “that research questions should drive data collection techniques and analysis rather than vice-versa” (Howe & Eisenhart, 1990, p. 16). However, Larsson (2005) argues this is too simplistic since the choice of methods and approaches also includes choice of perspectives that will influence the kind of results obtained. In a similar vein, it is reiterated that research “is always conducted within some broader understanding of
what constitutes legitimate inquiry and warrantable knowledge” (Henwood & Pidgeon, 1992, p. 98, our italics). This is expressed by Case and Light (2011, p. 189) as “one’s choice of methodology will constrain what questions one can ask”. The explicit formulations of research questions do not play a prominent role in some disciplines and research traditions while in others they are formulated post hoc. Nevertheless, we claim that all research attempts to answer research questions even if they are implicit. Good research is about asking good questions. Even if the explicit formulation of the research question is post hoc it serves the function of being a “clear signpost [without which] the readers will be lost … not know[ing] the central ideas addressed in [the] study” (Creswell, 2012, p. 112).

**Internal consistency in a study (including epistemology, ontology with methodology)**

Harmony should exist between the research question, assumptions about the research and the nature of the phenomenon to be studied, data collection, and methods of analysis. (Larsson, 2005, p. 21)

This is perhaps (Larsson, 2005) the most commonly used criterion but as was mentioned previously, one that is often missing (Case & Light, 2011; Koro-Ljungberg & Douglas, 2008). Beneath the surface of this criterion is the idea of construction of a whole where single parts are integrated and contribute to the building of a whole. It requires much self-reflection about ‘what I think knowledge means’ – both the developing knowledge of the learner and how we develop knowledge as researchers.

**Quality of results**

**Richness in meaning and Structure**

Qualitative and quantitative research procedures are but different forms of the analytic practice of re-representation in science, in that both seek to arrange and rearrange the complexities of ‘raw’ data. [They] differ ... in their approach to re-representing complexity. [The] very strength [of quantification and numbers] – that of simplification – is also its Achilles’ heel! (Henwood & Pidgeon, 1992, p. 42, our italics)

The quotation above brings the tension between richness in meaning and structure to the fore. In qualitative research, it is essential to not lose sight of the complexities, and hence, richness in meaning is important. However, even in these studies there is a tension between richness and structure since an overview may be sacrificed if descriptions are “too rich”. For good quality in regard to the criteria richness in meaning it is necessary that the essentials are captured and at the same time the nuances are maintained. It is important to highlight what is unique to the specific phenomenon at hand. For the criterion structure it is important that interpretations should have a good structure and it is possible to follow the reasoning. We point to that many quantitative studies in education have low quality in regard to richness in meaning since, for example, settings and interventions often are poorly described and hence it is very difficult for a reader to understand what was done. Erickson and Gutierrez (2002, p. 121) reminds us that a “logically and empirically prior question to ‘Did it work?’ is ‘What was the it?’”

**Contribution to theory development and new knowledge**

The quality of the results in respect to this criterion is somewhat related to the quality of the literature review and the quality of the research as described above. The researcher must have a good understanding of the field and good quality is related to the original contribution of the study to our collective understanding; is it something decisive or just a note in the margin? How well are the results placed in its context and related to earlier theory and knowledge?

Poor quality research tends towards a focus on reliability, by producing many repeated test results, at the expense of any meaningful result. We need to always ask ourselves if the research is actually telling us anything meaningful, and if it is an honest reflection of the aims of the study

**Presentation of results**

If earlier criteria can be seen as related to the scientific and scholarly quality of a study this criterion is related its communicative quality. The presentation should be relevant for the intended audience, language should be clear and precise and there should be a good balance between different parts of the presentation. This is not only a matter of rhetorical quality with a more fluent language free from grammatical errors but it also enhances the precision and clarity of the presentation. However, not only the communicative/rhetorical quality is important but also what sometimes is called akribieia (from Greek ἀκριβεία; precision, carefulness) is essential; it is the matter of getting all the non-trivial...
trivialities such as, for example, citing and referencing right. Interdisciplinarity is a notable issue here also. Communicating across disciplines is not straightforward. We, as journal editors, note that when engineering educators attempt to traverse into other disciplines, such as social science, as many papers are rejected by reviewers who are social scientists and ignorant of engineering communication styles, as engineers, ignorant of social science methodologies. Studies of high quality are sometimes rejected from journals because they are not composed in the same style of narrative that is to be expected by some disciplines. For example, even presenting ‘methods’ is considered positivist by some scholars, such as strict Foulcauldian discourse analysts, and hence seems a contradiction of epistemologies.

Validity of results

In some approaches the distinction between quality and validity of results may not be clear and free from complication. Due to space limitations these criteria are not discussed in any detail.

Discourse criterion

Validity in this criterion is viewed as a conversation about the world and reality; validity is related to the quality of argumentation and the interplay of meanings and if the findings of a study are able to withstand careful scrutiny and convince the scientific community. Complications arise when the dominant discourse, or ‘common sense’ is questioned by the authors, but not by the readers/reviewers, If reviewing within the dominant discourse, then counter hegemonic arguments would not withstand the scrutiny of ‘rational argument’.

Heuristic value

This criterion is often seen as an essential validity criterion in qualitative studies and is related to the significance of the study, or to what extent the research develops a conceptual framework which brings new ideas and thought processes to the literature, worthy in themselves of further work and thought.

Empirical anchoring

This criterion is related to the relation between interpretation and ‘reality’ and it has relevance for empirical research in most paradigms. This will vary hugely between different epistemologies, as with some there is only one reality and with others multiple realities are assumed. This stresses again the importance of disclosing the underlying epistemology – as notions of interpretation are clearly more complex when it is acknowledged that subjectivity is always present.

Consistency (including epistemological and theoretical underpinnings)

A consistent interplay between the part and the whole is seen, for example, as important in heuristics.

Pragmatic criterion

This criterion is related to the consequences of the results (for example in relation to teaching) and this is sometimes referred as “ecological” validity. Engineers should be familiar with this criterion since it is related to what extent findings or a theory works in the “real world” and in education it could, for example, be related to what extent teaching based on the findings of a study result in better understanding of a certain content or better skills in some field.

Conclusion

Disciplined inquiry does not necessarily follow well established, formal procedures: Some of the most excellent inquiry is free ranging and speculative in its initial stages, trying what might seem to be bizarre combinations of ideas and procedures, or restlessly casting for ideas. (Cronbach & Suppes, 1969, p. 16)

The above closing quotation reinforces the notion that we should use criteria wisely and that they are certainly not “cast in stone”. Via this short paper we hope that we have given the reader some thoughts to stimulate critical reflection and debate, ideal for the REES community to be engaged in - to consider examples of high quality EER which address these criteria, in order to critique, negotiate and build on them. We hope in the future to elaborate the topic more extensively and would welcome comments on our criteria to contribute to raising the quality of research in engineering education.
References


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