AC 2012-4659: CHALLENGES TO ENSURING QUALITY IN QUALITATIVE RESEARCH: A PROCEDURAL VIEW

Dr. Joachim Walther, University of Georgia

Joachim Walther is an Assistant Professor of engineering education research at the University of Georgia (UGA). He is Co-director of the Collaborative Lounge for Understanding Society and Technology through Educational Research (CLUSTER), an interdisciplinary research group with members from engineering, art, educational psychology, and social work. His research interests span the formation of students' professional identity, the role of reflection in engineering learning, and interpretive research methods in engineering education. He was the first international recipient of the ASEE Educational Research Methods Division's Apprentice Faculty Award, was selected as a 2010 Frontiers in Education New Faculty Fellow, and is currently a UGA Lilly Teaching Fellow. His teaching focuses on innovative approaches to introducing systems thinking and creativity into the environmental engineering program. In this context, he is involved in the development and implementation of the Synthesis and Design Studio series at UGA.

Dr. Nicola Wendy Sochacka, University of Georgia

Nicola Sochacka received her doctorate in engineering epistemologies from the University of Queensland in 2011. Her research interests span socio-technical transitions, with a particular focus on sustainable urban water management, and integrating socio-technical methods of inquiry into engineering practice and education. She currently holds a research and teaching position at the University of Georgia.

Dr. Nadia N. Kellam, University of Georgia

Nadia Kellam is an Assistant Professor and Engineering Educational Researcher in the Department of Biological and Agricultural Engineering at the University of Georgia. She is Co-director of the CLUSTER research group with faculty members from engineering, art, and educational psychology. Her research interests include interdisciplinarity, creativity, identity formation, and the role of emotion in cognition.

Challenges to ensuring quality in qualitative research: A procedural view

Abstract

Qualitative research methods are increasingly being used in engineering education research. In this context there is an ongoing discourse in the community around ways of ensuring interpretive research quality. This paper presents a process-oriented framework of research quality that was developed while undertaking a study that was recently published in the Journal of Engineering Education. Drawing on the concept of Total Quality Management (TQM), the framework consists of two components i) a procedural view of the research process, broadly defined as Making Data and Handling Data, and ii) a flexible typology of fundamental processes of validation (theoretical, procedural, communicative, pragmatic) and the notion of process reliability. Both of these aspects of the framework are illustrated with examples from the aforementioned study. Future work is planned to further develop the conceptual framework as a language for the engineering education community to engage in a discourse around shared, contextual and flexible understandings of research quality.

Introduction: Questions of quality in qualitative engineering education research

Engineering education research is an inherently interdisciplinary endeavor [1-3] that is currently being undertaken by a community of engineers, social and educational researchers with diverse and contrasting disciplinary and epistemological perspectives [4]. An ongoing discourse in the community is consequently centered around appropriate research methods [5-9] and ways of conducting research of acceptable quality [4, 10, 11]. In this context, Borrego [12] asserts that "the field of engineering education has not yet developed its first paradigm" with the term paradigm being defined as "consensus with regard to [among other aspects] standards of rigor"(p. 6).

Addressing this pre-paradigmatic nature of the field, this paper is concerned with questions of research quality in qualitative approaches to engineering education research. More specifically, we draw on an example study recently published in the Journal of Engineering Education [13] to present and explore a number of challenges to research quality in the context of concrete examples from the data collection and analysis. Based on these reflections, we present a process-oriented framework of research quality that was developed while undertaking the example study and offer it here as a further step in the ongoing discussion of interpretive research quality in the engineering education research context.

Example study: Interpretive investigation of Accidental Competency formation

The interpretive study that provides the context for the illustrations used in this paper (see part 3) is an exploratory investigation of engineering students' competence formation from a broad, holistic perspective [13]. More specifically, the authors conceptualized the notion of Accidental Competencies as a lens through which to investigate how students' overall competence formation emerges from the complex interplay of explicit instruction and a wide range of influences from the learning environment [14]. Accidental Competencies were conceptualized as the unintended

consequences, positive and negative, of students' overall experience of completing an engineering program.

Data was collected in focus groups based on critical incident techniques [15-17] with 67 students in their transition from university studies into professional practice. The students were selected from a range of innovative placement programs (i.e. industry, co-op and service learning programs) from institutions in Australia, Germany, Thailand and the United States. This international selection ensured that a wide range of students' experiences could be captured and the focus on placement students meant that participants were able to recall detailed experiences from their education while having also had a significant exposure to engineering practice. The focus groups were digitally recorded and transcribed for the subsequent data analysis using the qualitative software NVivo7. The iterative analysis based on a grounded theory approach and constant comparative methods yielded clusters and subordinate categories of competencies that the students had developed. Similar codes described the educational influences and work experiences that contributed to these learning processes [for more information see: 13].

The illustrations of challenges to ensuring research quality are based on one dominant theme (role models) that emerged from the analysis. In the focus groups the students reported that teachers and industry engineers were role models who had a significant impact on the development of their professional self-perception. These development processes resulted from a complex interplay of the influence of teachers and engineers with other educational factors to significantly shape the students' "professional way of being" [18, p. 389].

Challenges to research quality: Socially constructed reality

In investigating student learning that emerges from these complex interactions it became apparent that the 'object' of our research interest was neither "out there" [19, p. 37] to be observed in a materialistic sense, nor was it is it solely 'in the individual's head'. Rather, it extended beyond the individual, in that it was constituted through, and emerged from, the shared lived experience ["Lebenswelt" in: 20] of groups of individuals [21]. Put another way, this meant that the reality we were interested in investigating was socially constructed [22-24], by the participants and the researcher [1] in the data gathering situation.

> *<u>Illustration:</u> To clarify this point, this illustration considers an example from the above-described study that is concerned with the function of teachers as professional role models. Examining this result more closely illustrates the emergent and inter-subjective nature of the social reality under investigation. More specifically, the teacher's influence for the individual student was found to be constituted of concrete psychological realities – examples are feelings of consternation, or experiences of tensions between their own professional way of being and their perception of the workplace. The phenomenon of the teacher as a role model, however, emerged only from a sustained and complex interaction of the student with various teachers, other students and industry supervisors. More specifically, the influence of role models as the phenomenon under investigation consisted of, but at the same time, exceeded the individual*

student's psychological realities, emerging on a higher level from complex social interactions.

This ontological assumption of a socially constructed reality poses the question as to whether the researcher can derive truthful knowledge claims about a social system as the research object. The traditional scientific paradigm assumes a transcendent, materialistic reality that can be known independent of context and time. In contrast, the above illustration identifies a constructed, or, inter-subjective, reality as the object of interpretive research.

Equally, interpreting the data entails a subjective process of making sense of the participants' multiple perspectives. Considering the multitude of possible outcomes from such interpretations suggests that the social system under investigation does not "determine absolutely the one and only correct view that can be taken of it" [25, p. 14]. This, in turn, means that knowledge is socially constructed both in its production by the researcher and in its representation within the research community. In communicating knowledge claims to the research community, the constructivist nature of knowledge implies that representations must follow the meaning conventions of the research community by "calling things by the right names" [25, p. 23]. An example of how these aspects of qualitative research manifested in the example study is presented below.

<u>Illustration:</u> Drawing on the prior illustrative example, the following illustrates the constructivist process of generating knowledge from interpretation by examining more closely how the final interpretation of the teachers' influence as role models was derived.

During the data gathering, the students spoke of their individual experiences with academics, industry supervisors and of other educational influences. In this discussion, a shared multi-faceted view of the phenomenon emerged among the students. This understanding was constituted by their multiple perspectives but was, at this point, of a tacit nature, i.e. everyone knew what was being talked about and contributed their related stories. In the initial data analysis this shared understanding emerged across several transcripts and was, at this stage, captured in a preliminary node with the 'in-vivo' description "academics vs. real engineers". This first interpretation was socially constructed, in that it emerged from the students' shared understanding in several focus groups. Additionally, an expression taken directly from the respondents' own words was used to categorize this type of contribution. In terms of useful knowledge, however, this interpretation did not extend far beyond the context of the focus groups.

The next step of representing this knowledge thus involved "calling things by the right names" [25, p. 23]. One term commonly used to describe the teachers' influence is that of the "role model". However, this name for the category was one of several choices and was, as such, not directly "imposed by the structure of empirical reality" [25, p. 15]. More importantly, choosing this concept on the basis of my interpretive judgment also applied a range of

> *pre-existing conceptions and frameworks from the literature to this category. To provide a brief historical perspective, before becoming part of everyday language the notion of a role model was proposed as a specific sociological concept by Robert Merton and colleagues [26, 27] in their study of medical education. They defined a role model for students as "a figure in the profession, a personality or one only known by repute, as a model [...] with which to compare their performance" (p 137). This defined meaning convention of the term shows that the naming of that category in a sense did not occur in an empty space, but was always socially constructed in that it used terms that are associated with meaning within a research community. Interestingly, in his later work, Merton [26] refers to the specific nature of this concept as "that once well-defined sociological term, now become blurred if not vacuous by frequent and indiscriminate use" (p. 374).*

The above paragraphs demonstrate that the complex nature of social reality requires the researcher to derive knowledge from interpretation which entails that knowledge is socially constructed both in its production and representation. This also indicates that conceptions of research quality from the engineering sciences (accuracy and precision) and congruent notions from quantitative educational research (validity and reliability) are not directly applicable to interpretive work [13, 19, 25, 28-31]. More specifically, traditional engineering science research applies criteria or benchmarks for research quality to the results of an inquiry (e.g. statistical significance). However, as shown in the prior illustration an *a posteriori* application of quality standards cannot appropriately capture the characteristics of the socially constructed knowledge developed to represent a socially constructed reality [19, 25, 28-31]. Put another way, Flick [32] argues that "quality in qualitative research cannot be reduced to formulating [...] benchmarks for deciding about good and bad use of methods" (p. 384).

In this context, some researchers advocate alternative quality criteria, while others propose a re-interpretation of the traditional criteria of validity and reliability. Alternative criteria such as *trustworthiness* or *confirmability* [19] were formulated to overcome the narrow perceptions of research quality that are shaped by assumptions of an external reality that can be neutrally observed. The re-interpretation of traditional criteria is, in principle, congruent to alternative criteria and some authors suggest that a relatively clear mapping can be achieved between different types of validity, reliability and the concepts of *confirmability*, *transferability*, *credibility* and *dependability* [33]. While these approaches provide a more thoughtful avenue to conceptualizing quality in interpretive research, the criteria remain on a programmatic level and have not "yet given a really satisfactory answer to the problem of grounding qualitative research" [32].

To move beyond the limitations of criteria, this paper proposes to embed re-interpreted notions of validity and reliability into a process-oriented model based on the engineering metaphor of Total Quality Management (TQM) (see Figure 1). The purpose of this model is to capture fundamental aspects of substantiating knowledge claims (see Table 1), thus becoming independent of the particular research approach. It is important to reiterate here that this conceptual framework, in its current form, was developed in the context of the above-described Accidental Competency study. Future work is planned to further develop the conceptual

framework as a language for the engineering education community to engage in a discourse around shared, contextual and flexible understandings of research quality.

An engineering metaphor of quality management

As a basis for developing a quality framework using the engineering metaphor of TQM, it is first necessary to define quality in a way that is appropriate to the intellectual traditions of qualitative research across a wide range of methodological orientations. Most crucially, we emphasize that the constructivist nature of knowledge discussed above does not suggest relativism. To this way of thinking, Kirk and Miller [25] remark that "the way we perceive and understand the world is largely up to us [but] the world does not tolerate all understandings of it equally" (p.11). More specifically, this means that social construction does not preclude the conception of research quality in the qualitative inquiry. Having established that there are possible distinctions in the quality of different "understandings" of the world, below we work towards a definition of quality that is appropriate for the context of qualitative research in the field of engineering education.

In line with Kirk and Miller [25] we define quality of interpretive research as its capacity to generate "knowledge that is of interest on its own merits to those other than the friends and admirers of its creator" (p. 13). This definition of quality through its "worth" [19] to others integrates notions of quality from method-led and problem-led research traditions [6]. More specifically, method-led research emphasizes the "proper use of methodology and quality of evidence" (p. 31), while problem-led research judges "quality on light shed on the problem under consideration" (p. 31). While we do not advocate rigid, mechanistic application of methods as an indicator of quality, the contextual, reflexive adoption of methodologies and their explicit documentation and communication are a core aspect of the process-focused quality framework presented here. The value of research is thus infused throughout the entire research process and the explicit inclusion of the research community as the "consumer" of research highlights the "focus on the quality of insights generated that [6] associate with problem-led approaches. We therefore contend that "quality cannot be reduced to formulating criteria and benchmarks for deciding about good and bad use of methods" [32; p. 384]. Quality, rather, is based on an overall judgment of knowledge claims that considers the trustworthiness of their production as well as the value of their application in generating understanding or effecting positive change in other social contexts. The frameworks presented here makes the various elements of this definition explicit, from aspects of procedural validation in the research design, processes of communicative validation with both participants and the research community, to attempts of pragmatic validation through the tentative transfer of results.

TQM model of research quality

TQM was originally developed in the context of product manufacturing [34] and transfers the responsibility for quality from an assessment of the final product to a process of continuous improvement that involves all stakeholders throughout the production process [35, 36]. Transferring this model to interpretive research quality in engineering education thus allows us to conceptualize a procedural, continuous and holistic approach to quality that shifts the attention from defining standards of rigor applied to the research results to viewing, demonstrating and assessing research quality throughout the entire research process. In this way, we propose that

this concept can synthesize existing notions of research quality in a coherent way and also provide a useful bridging paradigm for engineering education researchers with traditional engineering backgrounds.

The proposed TQM framework conceptualizes a space along two dimensions. First, the TQM process model (Figure 1) provides a procedural view of the research process, broadly defined as Making Data and Handling Data. The second dimension consists of a flexible typology of fundamental processes of validation (theoretical, procedural, communicative, pragmatic) as well as the notion of process reliability (Table 1).

Figure 1 illustrates the process model where Making Data comprises research design, data gathering and aspects of analysis. In the language of Quality Management, this stage focuses on the internal customers such as participants and co-researchers. The stage of Handling Data includes processes of analysis, publication and application of results and, as such, focuses on the research community and the broader public as external customers.

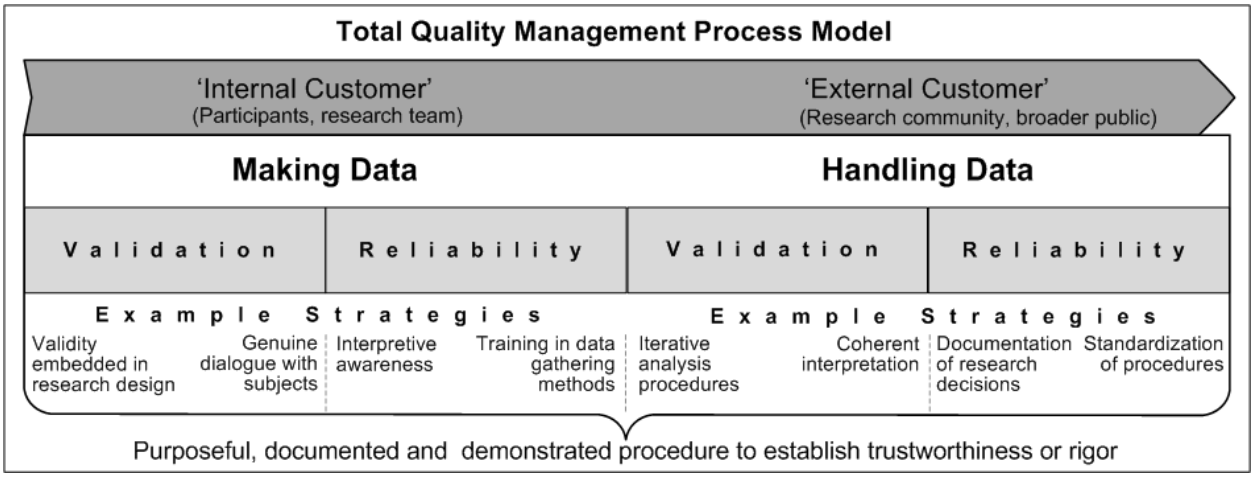

Figure 1: TQM model of the research process to locate quality strategies in the context of a particular inquiry

The function of this model is to locate quality strategies (for examples see Figure 1 and Table 1) within both the context of a particular inquiry and the stage of the research process. This view facilitates a contextual discussion and conceptualization of quality measures and their reflective documentation throughout the entire research process.

Typology of Fundamental Aspects of Validation and Process Reliability

To complement the process model presented above and to move beyond the limitations of *a posteriori* and/or prescriptive criteria, this paper proposes to embed re-interpreted notions of validation and process reliability into the process-oriented model (see Figure 1). These notions of theoretical, procedural, communicative, and pragmatic validation and the concept of process reliability capture the most fundamental aspects of substantiating knowledge claims that were found to be relevant to the example study.

This terminology – the use of validation versus validity and the introduction of process reliability – reflects the focus on the research process as a key conceptual feature of the model presented. Within the framework that is comprised of the TQM stage model and the typology of aspects of validation and process reliability, achieving research quality takes the form of striving for trustworthiness through the systematic selection of appropriate quality strategies and the explication of their function in the context of a particular inquiry.

Table 1 shows the typology of four fundamental aspects of validation (theoretical, procedural, communicative and pragmatic) and the notion of process reliability. Each row of the table provides a general description of the respective concept and outlines their focus within each stage of the research process, thus embedding the TQM process model into the four columns on the right. In addition, a number of example strategies are listed to practically illustrate each concept.

It is important to emphasize here that Table 1 provides neither a comprehensive nor a definitive view on possible quality strategies. The strategies offered are drawn from the literature and were used in the example study [13] that led to the development of the quality framework presented here. The following paragraphs provide further details on each of the four fundamental aspects of validation as well as the notion of process reliability.

Table 1: Typology of fundamental processes of validation and the notion of process reliability with example strategies

		Making Data		**Handling Data**	
Concept	**Description**	**Focus**	**Strategy**	**Focus**	**Strategy**
Theoretical Validation	Do the concepts and relationships of theory rightly correspond to the observations?	The research process needs to capture the full extent of the social reality studied.	• Purposive Sampling • Emergent Research Design	Interpretations need to reflect the coherence and complexity of social reality.	• Analytic Induction • Negative Case Analysis
Procedural Validation	Which features of the research design improve the fit between reality and the theory generated?	Strategies implemented in the research design to mitigate threats to validity.	• Critical Incident Techniques • Triangulation • Withholding prior understandings in the field	Integrated processes to mitigate risks of misconstructing the participants' reality in the interpretations.	• Constant Comparative Method • Interpretive Awareness
Communicative Validation	Is the knowledge socially constructed within the relevant communication community?	The data gathering needs to capture the respondents' inter-subjective reality.	• Establish "subject agreement" • Member Checks • Development of shared narrative	Representation of knowledge in accordance with the meaning conventions of the research community.	• Peer Debriefing • Exposure of knowledge claims to the discourse in the research community

Pragmatic Validation	Do the concepts and knowledge claims withstand exposure to the reality investigated?	The concepts underlying the research design need to be compatible with reality in the field.	• Diversity of respondents • Prolonged exposure to practice	The knowledge produced needs to be meaningful in the social context under investigation.	• Applicability Studies • Explanatory power of results
Process Reliability	To what extent is the research process independent from random influences?	The data needs to be collected and recorded in a dependable way.	• Documented focus group protocol • Digital recording and verbatim transcription • Checking of transcripts	Procedures for generating and representing knowledge need to be established and documented.	• Standardized notes and memos • Procedures of cross-checking

Theoretical Validation focuses on the extent to which knowledge claims represent the empirical reality under investigation. In other words, whether the "theoretical paradigm rightly corresponds to observations" [25]. In Making Data, this means that the research needs to be able to capture the full extent of the social reality under investigation. Strategies to accomplish this, for example, purposive sampling and emergent research design, both of which were used in the example study, are suggested by a number of authors [19, 29, 31, 37]. In Handling Data, theoretical validation means that the researcher's experience-distant constructs [38] need to adequately represent the participants' reality. That is, the research results must reflect patterns across participants' multiple perspectives and thus establish coherence, or resonance [39] in the interpretation. Strategies, such as analytic induction, are suggested by various authors [32, 40, 41]. Coherence, however, does not mean uniformity and claims to theoretical validation can also be supported by exploring the inherent complexity [42] or the "intricate relationships" [43] within the data. This entails a particular focus on the demonstrated analysis of contradictions or deviant cases to support claims to validation [19, 32, 44, 45].

Procedural Validation refers to elements and procedures incorporated into the research design which aim to mitigate threats to validity. While the literature offers a wide range of such strategies [46], these are particularly specific to the individual research setting and approach. In Making Data, one of the most significant threats to validity of research involving informants is the possibility that they "consciously or unconsciously construct a specific, that is, biased version of their experiences that does not or does only correspond with their views in a limited way" [31]. Mitigation strategies, such as critical incident techniques, are suggested by various authors [13, 16, 17, 47, 48]. In Handling Data, procedural validation entails systematic and documented processes of analysis and interpretation that mitigate the risk of misconstructing participants' shared, lived reality in the interpretation. Strategies, such as constant comparative methods, are suggested by various authors [29, 37, 49] to ensure that interpretations are grounded in the respondents' perspectives and reflect the complexities of their social reality.

Communicative Validation establishes a "community of interpretation" [50] with both the internal and external customers of the research (see Figure 1). More specifically, this form of

validation occurs in the social construction of knowledge [51], both in the data gathering and in the representation of theory, thus "depending on a consensus within the relevant community" [30]. In Making Data, "the relevant consensus rests to a substantial extent in the community studied" [30]. Strategies of demonstrating this consensus, such as subject agreement and member checks, are described in [19, 32, 33, 47]. In Handling Data, communicative validation is concerned with the "consensus [...] in the research community about the categories used in description" [30]. In this process of deriving the experience-distant concepts [38] from the data, the researcher needs to ensure that abstractions are appropriately represented within the meaning conventions of the research community through various forms of peer debriefing with the research team or the entire research community [19, 51].

Pragmatic Validation entails ways of demonstrating that the knowledge claims are meaningful in, or can withstand prolonged exposure to, the research setting or a similar context. This has been variably conceptualized as "transferability" [33] or "applicability" [19]. In Making Data**,** this exposure can be created through gathering data in a "natural setting" [19], a social context with all its complexities, tensions and multiple viewpoints [30, 52] to test the theoretical concepts that the researcher brings to the study. Pragmatic validation in Handling Data is concerned with examining the impacts or benefits from the "tentative application" [19] of knowledge in practice and thus places the "emphasis on a pragmatic proof through action" [53].

Process Reliability: As reliability in the interpretive inquiry cannot, in principle, be achieved through repeated measurement, the notion of process reliability conceptualizes strategies to make the research as independent from random perturbations as possible. This can be achieved through the development and explicit documentation of dependable procedures in Making and Handling Data – "the criteria of reliability are [thus] reformulated in the direction of checking the dependability of data and procedures" [32]. In Making Data**,** process reliability is focused on specific strategies for collecting and recording data in a dependable way [25, 30, 54]. Similarly, in Handling Data**,** the definition and documentation of interpretation procedures is central to achieving process reliability [54]. This includes a "reflexive exchange about [both] interpretative procedures and […] methods of coding" [32].

Summary of theoretical quality framework

The above paragraphs described a process-oriented quality framework along the two dimensions of (i) a generic model of the research process and, (ii) a typology of fundamental ways to substantiate knowledge claims. However, although this framework may appear quite detailed, neither the framework nor the quality strategies introduced for illustration constitute a comprehensive or definite view on research quality. As previously mentioned, future work is planned to further develop the conceptual framework as a language for the engineering education community to engage in a discourse around shared, contextual and flexible understandings of research quality.

Application of the quality process model: Communicative validation

To illustrate the application of the quality framework in the context of the example study, the following provides detailed illustrations of communicative validation strategies that were used to

i) ensure that the data gathering captures the respondents' inter-subjective reality (Making Data) and, ii) ensure that the knowledge derived is represented in accordance with the meaning conventions of the research community (Handling Data).

Communicative Validation

As outlined above, the key function of communicative validation is to establish a "community of interpretation" [50] with both the internal and external customers of the research (see Figure 1). Considering the emergent and inter-subjective nature of social reality, the generation of knowledge depends on the communication of multiple perspectives. In other words, since knowledge does not rest on "an exchange between man and the world of objects, but [...] an exchange between men in a communication-community" (p. 27), validation occurs in the social construction of knowledge [51]. This construction of knowledge takes place both in the data gathering situation and in the representation of theory within the research community. Communicative validation thus spans the entire research process and in each stage "depends on a consensus within the relevant community" [30, p. 291].

In Making Data

In Making Data, "the relevant consensus rests to a substantial extent in the community studied" [30, p. 209]. Depending on the research context, communicative validation in this stage of the inquiry can take the form of a tacit agreement on the "experience-near" [38] concepts between the respondents, or a formal "member check" [19, p. 314] of the researcher's abstract interpretations.

On a tacit level, "subject agreement" [32, p. 373] can be achieved by establishing a "genuine dialogue" [24, p. 373] to access the respondents' multiple perspectives of their shared social reality. This genuine dialogue needs to be based on the participants' knowledge of the purpose and concepts of the research [24, 50] and can be supported, for example, by careful moderating techniques in focus groups or interviews [15, 55]. The following example describes various efforts that were made in the example study to support the development of a genuine dialogue in the focus groups.

> *Illustration: In the example study, the focus group procedure emphasized students' accounts of concrete situations and sought to avoid abstractions on the respondents' part. Yet, respondents often contributed a series of accounts related to a particular competence concept in the form of shared narratives [56] without having to define the abstract concept. This means that the students explored a shared facet of their lived experience based on an at least tacit agreement about the experience-near concepts that connected their accounts. This genuine dialogue was supported by the researcher who initiated and guided meaningful discussions around, for example, contrasting accounts of the focus group participants.*

For the purpose of establishing communicative validity with the respondents beyond the data gathering situation, the literature offers various strategies of respondent validation [33, 47]. Examples are member checks which are based on the possibility to gain explicit agreement from

the respondents concerning the data collected. In a basic form, this can include the confirmation of the accuracy of the data recording (see also process reliability). The researchers can also present the respondents with abstract interpretations and seek their confirmation. However, the very nature of the social construction of knowledge from multiple perspectives makes this form of validation problematic when "the research systematically goes beyond the subject's viewpoint, for example in interpretations [...] which derive from the distinctiveness of various subjective viewpoints" [32, p. 375]. In the example study, member checks were thus only planned for cases where the focus group recording did not allow for accurate transcription and the particular utterance was deemed crucial for the interpretation.

In Handling Data

In Handling Data, communicative validation is concerned with the "consensus [...] in the research community about the categories used in description" [30, p. 290]. In this process of deriving the experience-distant concepts [38] from the data through abstraction, the researcher needs to ensure, first, the grounding of the abstractions in the respondents' accounts and, second, the appropriateness of the terms used to describe theory with respect to the research community's meaning conventions.

In the first steps of interpretation, the researcher's "accounts of meaning must be based initially on the conceptual framework of the people whose meaning is in question" [30, p. 289]. In a way, this continues the communication community established in the data gathering situation through a systematic and sustained engagement with the respondents' accounts. As a specific example strategy, the selection of 'in-vivo' descriptions when forming the initial categories was described in a prior illustration – the category to capture the formation of the students' professional self-perception was borrowed from the students' utterances, initially termed "academics versus real engineers". The use of this experience-near category name in the first loops of iterative interpretation warranted sufficient flexibility for the development of the category and, at the same time, ensured that the subsequent abstract interpretations were "based on the construction [of knowledge] in the field" [32, p. 380].

In the increasingly abstract interpretation and the subsequent formulation of theory, communicative validation refers to "calling things by the right names" [25]. Due to the epistemological assumption that knowledge is socially constructed also within the research community, this aspect is not merely a matter of definitions. Rather, communicative validation entails the negotiation of appropriate representations of theory on several levels within the research community - "validity claims are tested through the ongoing discourse among researchers" [51, p. 415]. One immediate focus when interpreting data is thus the generation of theory through engagement with and reference to the literature. Within a team of researchers or an institution, systematic checks in the form of "peer debriefing" [19, p. 308] can be established. This was undertaken in the example study through regular discussions of the emerging coding structures with the research team. On the level of an international community of scholars, the publication of results becomes part of the process of validation. Kirk and Miller [25] describe this as "a commitment to integrating new findings into the cumulative body of collective knowledge and confronting ideas with data as well as argument" (p. 79). This means that in the same way theory draws on existing meaning conventions, validation of theory can be established through its "contribution to the formation of meaning conventions in the interpretation community" [50, p.

29]. The discussion below identifies this social construction of knowledge in the scientific discourse as the crucial factor in establishing overall research quality.

Discussion

This paper presented reflections on a number of challenges to establishing research quality in a qualitative engineering education research project. Based on these challenges a conceptual framework for research quality was presented as a potential starting point for further discourse within the research community. From the above reflections, two points emerged that are particularly pertinent to such a discourse and are discussed in some more detail below. The first issue concerns the need for a way of conceptualizing research quality in qualitative research that is very different from existing notions within the engineering sciences. The second issue arises from the nature of the qualitative inquiry where approaches to quality are inherently context-specific thus pointing to the need for a flexible, overarching conception of research quality to frame the necessary debate.

The illustrations from the example study focused on the emergent, socially constructed nature of both the social reality investigated and knowledge produced by qualitative research. The example of students' role models demonstrated that the overall development of this pattern in the students' experiences was shaped by an intricate interplay of the influences of both teachers and engineers. Put another way, the emergent phenomenon was very real and significant in the students' shared experiences, but not "out there" in a materialistic sense to be measured by the researcher. Instead, the inquiry consisted of an iterative and inherently subjective process of piecing together subtle nuances in students' stories, conflicting accounts, and implicit references to underlying dynamics, not necessarily obvious to the participants themselves, into an overall picture. This was followed by finding the appropriate language to capture the essence of this picture that emerged in the researchers' minds so that it would resonate with and be potentially useful for other educators. From this description it is obvious that the research result "role model" as the description of the essence of the above-described mosaic cannot be judged in its quality by using an *a posteriori* measure to be applied to the result only (in a way one would apply the measure of statistical significance to the results of a survey study). Rather, the quality needs to be judged by somehow considering the entire intricate process described above, taking into account its overall trustworthiness while, at the same time, evaluating the worth of the results from the perspective of the practitioner or researcher who is using the findings. The process-oriented framework suggested here is a systematic attempt at reflectively applying existing quality strategies to document and explicitly demonstrate their use in order to enable such a holistic judgment.

Following this process-oriented approach, however, also demonstrated that the strategies we used in the example study were very specific to the particular research setting and were also determined by the views and preferences of the research team. The example of establishing tacit agreement in the data gathering situation and considering this as a way of supporting communicative validation was particularly useful for the particular focus group format. The semi-structured discussion protocol was designed to elicit related accounts of shared experience, which students' were usually eager to share in a group. Another study that focuses on more personal aspects of students' development might not benefit at all from such a strategy and individual interviews might be a more useful way of establishing a genuine dialogue. Similarly,

"member checks" concerning the abstract interpretations were not found to be useful in the example project since the results were based on a wide range of students' contributions and could, as abstractions, not be confirmed by individual participants. In another study, that investigates concepts where the experience-near concepts of the participants are closer to the experience-distant descriptions of the researchers (e.g. in a thematic analysis), member checks with participants could be a meaningful way of fostering the quality of the interpretations. These examples show that the selection of a quality strategy is highly specific to the context of a particular inquiry. Consequently, its contribution to research quality needs to be explicated in that particular context. More specifically, the researcher needs to consider and make explicit in which specific way a particular quality strategy contributes to improving the overall quality and trustworthiness of the research findings. The typology of aspects of validation and process reliability was used in the example study as a way to specifically describe such ways of substantiating knowledge claims.

The two components of the conceptual quality framework presented here, that is the process model and typology, address both issues outlined above. The process model of the research is intended to facilitate a holistic judgment of research quality that can capture all stages from research design, data collection and analysis to publication and use of the findings. The typology of fundamental aspects of validation and process reliability is intended to support a reflexive, contextual implementation of quality features and explicate their function relative to the specific setting of the particular research project.

Both components of the framework are not intended as a comprehensive or prescriptive view on research quality. Rather, the framework is offered here as a starting point and potential language for further dialogue within the research community around conceptions and practices concerned with qualitative research quality.

Outlook and future work

This work is part of a larger NSF-funded research project to foster and systemize the above described dialogue. The project will draw on the initial framework presented here in national and international workshops to stimulate conversations around actual practices that engineering education researchers engage in with respect to research quality in a wide range of qualitative inquiries. Using qualitative data analysis methods, we plan to systemize this conversation into an emergent, flexible framework of research quality that is reflective of and appropriate to current practices in the emerging discipline of engineering education research.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. #7164397 (NSF CAREER). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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