Qualitative Research Methods to Improve Engineering Retention

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Introduction

The retention of engineering students is a major concern of most engineering departments. Students leave engineering at alarming rates. Where do these students go? And, more importantly, why are they going? Most studies of retention involve such quantitative data such as high school grades, ACT or SAT scores, and college grades but quantitative data can not answer questions that begin with the word "why."

In this paper we argue that
1. The kinds of questions we need to answer to improve engineering retention require qualitative approaches.
2. Various qualitative approaches are available and are doable.
3. Some qualitative approaches have been used in engineering and these studies provide models for us to follow.

In order to support these arguments, this paper has three sections:
1. Questions. What types of questions do we need to ask and answer?
2. Qualitative approaches. What qualitative approaches are available? We also discuss examples in which these techniques have been applied in studies in engineering education, although not all are studies of retention. We examined all papers in the *Journal of Engineering Education* and the *ASEE Proceedings* from 1996 to 1999.
3. Three well known examples. We review the qualitative methods used in *They're not Dumb They're Different,*[26] by Sheila Tobias, *Talking About Leaving,*[24] by Elaine Seymour and Nancy M. Hewitt, and "Studying Students Studying Calculus,"[27] by Uri Treisman.

While we focus on qualitative research methods for studying retention, Bengiamin[3] argues that an assessment program for ABET 2000 should include quantitative and qualitative data analysis.

1. Questions

Quantitative study of retention is, of course, the appropriate way to begin study of retention at a university. Of an entering cohort of students, one examines how many have completed their degrees, how many have switched to other majors, and how many have left the university, within various specified time periods.

Our quantitative studies at USC show a substantial loss of students and we now are asking: among the many factors that we know affect our students, which ones are important reasons for why our students leave? We believe that we cannot be effective in retention programs until we have a much better understanding of this "why" question.

Others have suggested doing quantitative studies first and then qualitative studies. Fountain and Llewellyn[14] explicitly used a quantitative study of major switching to determine if a qualitative study was needed. A qualitative study, they said, "provides no information on why students change majors and why they drop out…"

An additional motivation for turning to qualitative methods is related to the fact that much of the first two years of engineering education occurs outside engineering, in math, physics, chemistry, and English. Paradoxically perhaps, we believe that *qualitative* results may speak more forcefully to our colleagues in these predominantly *quantitative* fields. We believe the qualitative research methods will give us ways to approach our colleagues with solid evidence on what engineering students are actually experiencing, learning, feeling, and thinking in those initial classes. We believe that this evidence will not match what those professors believe is happening in their classes.

We undertook this investigation of qualitative research methods in order to be able to use solid methods in tackling our "why" questions. We hoped that and have found that qualitative research methods give us more rigor and therefore more confidence in our findings than simply saying "let's talk to some students." As we will show, qualitative research methods lead to defensible conclusions.

2. Qualitative approaches

Qualitative research methods emerged from the social sciences, especially from sociology. The hallmarks of qualitative research[10] include the idea that there are multiple valid ways to understand a social setting, the attempt to capture the perspectives of the people being studied, awareness of the social world of everyday life in which all action is embedded, and value placed on rich, not sparse, descriptions of the social world.

A deep understanding of qualitative research involves four phases,[10] the understanding of the researcher's cultural stance, the selection of a theoretical paradigm, the selection of a research strategy, and the selection of methods of collection and analysis. However, we will present a simpler (even simplistic) discussion based on the fourth phase: methods to collect and analyze information. *We discuss five methods to collect information: individual interviews, group interviews, observation, analysis of documents, and personal experience. We also discuss "the art of interpretation."*[10]

We do not discuss questionnaires or surveys. Surveys that require answers on a numerical scale are generally considered quantitative research methods. Even surveys with open-ended questions do not allow the interaction between researcher and subject that is usually characteristic of qualitative research. Surveys are used to gather relatively simple information, whereas qualitative interviews are used to learn more about complex

phenomenon.[22] Finally, surveys are not usually used in an exploratory approach to generate theory but rather to test and confirm preexisting ideas.

We relied heavily on Denzin and Lincoln.[9] This large book is also available section by section in paperbacks.[8,11,12]

Since qualitative methods arose in the social sciences, the language can be a barrier for engineering professors. We found some of the widely referenced qualitative research classics[15,30] to be very hard going. Even the book we came to rely on[9] is not an easy read. A shining exception to the rule of difficult reading is *Qualitative Interviewing*[22] and we recommend it highly.

The method of *qualitative interviews* builds on ordinary conversation, but differs in that the conversation is a tool of research, that it is usually between strangers, and that the researcher guides the conversation. The researcher "intentionally introduces a limited number of questions and requests the interviewee to explore these questions in depth. The researcher encourages the interviewees to reflect, in detail, on events they have experienced."[22]

Qualitative interviewing is most appropriate for "topics that require in-depth understanding that is best communicated through detailed examples and rich narratives."[22] Qualitative interviews are especially useful when you need to bring light on puzzling questions.

The design of a qualitative interviewing study takes shape gradually, and is flexible and interactive. "In early interviews the researcher begins to test ideas of why things happen and chooses the concepts and themes to be explored. Then he or she designs subsequent interviews to examine these explanations and preliminary themes."[22] The interviewer asks three types of questions.[22]

- Main questions. "The wording of a main question should be open enough to encourage interviewees to express their own opinions and experiences, but narrow enough to keep interviewees from wandering too far from the subject at hand."[22]
- Probes. Probe questions signal that the interviewer wants a longer and more detailed answer, seek clarification, and signal that the interviewer is listening.
- Follow up questions. These questions seek depth by pursuing themes and seeking elaboration and explanation.

Fontana and Frey[13] discuss the ethical considerations in interviewing, including informed consent, right to privacy, and protection from harm. They stress that one must always consider the human side of those being studied.

In engineering studies, Seat[23] uses a thematic analysis of interviews with 21 women engineers to reach two major conclusions about the socialization and to present strategies for changing the self-perception of women engineers. Pavelich and Moore[21] used interviews, but the interviews were structured and were designed to determine the student's thinking according to the Perry Model, which scores students from 1-9. The

interviews were quoted only to illustrate the type of thinking exhibited by students at different stages of the model, not to build theory.

Millar *et al.*[20] describe the results and, interestingly, the impacts on faculty of interviews of 200 students by 25 faculty members. Faculty from outside chemistry interviewed students from a newly redesigned section and a comparison section, without knowing in which section the student was enrolled, in order to assess the competence of the students. Faculty completed quantitative and open-ended survey questions and each faculty was also interviewed.

Group interviews or focus groups have been widely used in marketing and are having growing use in political campaigns.[13] The approaches are similar to those used in individual interviews but the group interviewer must keep one person or group from dominating discussion and must encourage recalcitrant respondents.[13]

Van Aken *et al.*[28] used focus groups to assess a Minority Engineering Program because they thought the group setting would bring out issues better than individual approaches.

> "Because the focus group methodology assumes that attitudes and perceptions are developed in part by interaction with other people, this methodology is effective in providing information about people's motives to think or feel the way they do, and in allowing issues, attitudes, perceptions, and opinions – that the researcher might have overlooked – to arise in the group setting."[28]

They provide a discussion of focus groups drawing on Krueger[18] and emphasizing the importance of selection of participants, nature of questioning and the establishment of rules for the group. They used techniques from Miles and Huberman[19] to analyze notes and flipchart pages recorded during each group. The authors have now incorporated focus groups into the regular assessment strategy for the program.

Naturalistic observation means observation (with all the human senses) without manipulation of the subjects. The goal is that "[b]ehavior and interaction continue as they would without the presence of a researcher, uninterrupted by intrusion."[1] *Participant observation,* on the other hand, involves deliberate interaction while gathering data. Intermediate roles are possible. In any case, the observer looks for "concepts or categories that appear meaningful to subjects."[1] The observer must select a setting, gain entrée, and then begin observing. After initial observations to gain familiarity, observers may choose to focus on particular people, events, settings, or behaviors.[1]

Observation seems most susceptible to bias without subjects' quotes or other observers to confirm the researchers' findings. Validity can be gained by multiple observers, by actively seeking cases that would disprove one's findings, and by presenting the data as richly as possible to demonstrate internal coherence.[1]

The unobtrusive nature of observation makes it vulnerable to ethical issues in the form of invasion of privacy. Deliberate disguise by the researcher has come under particular attack.[1]

Whittaker and Eschenbach[29] asked the question: "what do engineers do?" Their students observed 10 engineers at work, recording all the engineer's activities. The data were used to create categories and then to search for patterns. They reached conclusions regarding changes that should be made in engineering education to better prepare students for the real world of work.

Documents and other artifacts, including diaries, memos, letters, and other physical evidence offer the chance to obtain important information that may or may not agree with information obtained in other ways.[17]

Winiecki[31] uses several examples from transcripts of student email in an on-line course to illustrate socioliniguistic concepts regarding language games. He did not, however, use the transcripts to build theory, but rather to illustrate pre-existing theory. Other artifacts that might be relevant to studying retention include student course notes.

While some believe that the researcher's own *personal experience* is inappropriate data, others argue that experience is exactly what we seek to know and explain.[6] Clandinin and Connelly argue that such experience can be appropriately studied as stories or narrative.[6]

Burkett *et al.*[5] used personal experience to comment on the issues facing dual-career couples. The six authors comprised three couples. Most of the paper tells each couple's story, but some comparisons are made in the conclusions.

Miles and Huberman[19] offer many methods for *analyzing qualitative data*. They frankly pose the question of how to avoid self-delusion. Their book is a "practical sourcebook" describing 49 "manageable and straightforward" methods for data reduction, data display, drawing conclusions, and verifying conclusions, illustrated with examples from their own work in schools. However, they counsel an inventive method-creating stance, recommending the "creation, testing, and revision" of methods by all researchers.

A *contact summary sheet* is completed immediately after each contact by reviewing notes to answer questions such as[19]

- who was involved,
- what were the main issues or themes,
- which research questions were central,
- what new hypotheses were suggested, and
- what follow up should be planned.

Creating this sheet encourages reflection by the researcher and makes the main points more available for later use.

Miles and Huberman[19] give many recommendations concerning the *creation of codes* that categorize words according to "research questions, hypotheses, key concepts, or

important themes." For example, they say that 80 to 90 codes can be kept in a researcher's memory if the codes have a clear structure. They advise on when to determine codes, how to revise them, and how to name codes. They caution very strongly against numerical codes. "Converting words into numbers, then tossing away the words, gets a researcher into all kinds of mischief."[19]

An *event listing* "arranges a series of concrete events by chronological time periods, sorting them into several categories."[19] For example, in a study of improvements in schools, events can be displayed by year but also by empirically derived phases or stages. Using columns as periods and rows for different actors, a matrix results.[19] We believe that displaying one student's progress through required math courses as an event listing and then adding other students in one listing may help us detect patterns.

Emphasizing that "people are meaning-finders," but also that researchers must avoid bias, Miles and Huberman[19] recommend methods for extracting meaning and then verifying it. They recommend using the *patterns* that "jump out" during the study, but seeking out and remaining open to disconfirming evidence. For example, "do we find it elsewhere in the data where predicted?"

Clustering involves sorting acts, people, events, etc., into similar classes.[19] For example, in the school improvement study, the researchers sorted teachers into categories and separately sorted implementation strategies into other categories. Typically initial clusters are found to be too simple and are revised. Thus, "clustering can also be seen as a process of moving to higher levels of abstraction."[19]

The various ways to verify findings include *checking the meaning of outliers.* "The outlier is your friend," since a good look at exceptions may test and strengthen basic findings, but also protects against some biases.[19]

Miles and Huberman conclude with these pieces of advice:[19]

- Think display.
- Be open to invention.
- Expect iteration.
- Seek formalization and distrust it.
- Stay self-aware.
- Share methodological learnings.

Several engineering studies present examples of the analysis of qualitative data. Courter *et al.*[7] selected qualitative research methods to evaluate a first year engineering design course. Their information included interviews with students, classroom observations, and interviews with faculty. "We employed the ethnographic research technique of analyzing the interview transcripts and classroom observations inductively rather than looking for evidence to prove or disprove hypotheses.[2] This means that we built our interpretation of the students' experience from the bottom up rather than the top down, a form of analysis called grounded theory.[25] Points that repeatedly emerged from the students' interviews and our classroom observations become our central findings." (We included Courter *et al.*'s references in this quote.)

Haller *et al.*[16] used conversation analysis to analyze work sessions of student groups. They give several references and explain such examination of dialogue. “Conversation analysis thus provides a helpful instrument for investigating how students use dialogue in their workgroups to perform joint activities, achieve communal goals, and manage social interactions.” They identified two interaction modes: transfer-of-knowledge sequences and collaborative sequences. They suggested ways to enhance group work.

3. Three well known examples

We very briefly review three well known qualitative studies in retention in science, engineering, and math. We found that Seymour and Hewitt[24] give the most information about their methods, and Treisman[27] gives little. Tobias’s[26] methods were very interesting, involving a form of participant observation.

In *They’re Not Dumb They’re Different*,[26] Sheila Tobias asked a group of graduate students without degrees in math or science to take a general physics or chemistry class and document their experiences. By having outsiders look at the classes she gained some interesting new insights, such as that students may find math and science hard but not stimulating, because of the nature of the tests that are given. While she does not discuss her methods, the book is a good example of how qualitative results can be presented to defend conclusions.

In *Talking about Leaving*,[24] Seymour and Hewitt interviewed 335 students at seven institutions about their science, math, and engineering courses, and used focus groups with another 125 students on six other campuses. About half the students had left these majors. The researchers found that leavers and stayers were hard to distinguish, with both groups struggling with similar problems. The authors describe their methods in chapter 2, including the use of a computer package for analyzing qualitative data (The Ethnograph, see http://www.QualisResearch.com). Like Tobias’s book, this book provides good examples of the presentation of the results of qualitative research, especially the interweaving of quantitative and qualitative data.

Uri Treisman[27] studied “20 Black and 20 Chinese students” to better understand why some students were not doing well in calculus. Hundreds of hours of videotape led to the conclusion that both groups studied and worked on homework as individuals, but the Chinese students also met to go over homework together. The researchers also noted, however, that neither group was inspired by the courses they took; indeed, Treisman concluded that their courses were “devoid of life and spirit.” Treisman and others have developed methods that emphasize teaching students how to work together but that also challenge students more than the traditional classes.

Conclusions

We have concluded that qualitative approaches are the appropriate next step for us and that we can use the books by Rubin and Rubin,[22] Miles and Huberman,[19] and Denzin and Lincoln[9] for excellent guidance. Among the qualitative approaches available, the

interview and personal experience approaches seem to most closely meet our needs. We are now developing questions for semistructured interviews. One preliminary interview already led us to postulate two classes of issues that arise in the first year classes:

1. the complicated set of factors that we call motivation, and
2. the application and acquisition of the tools (including but not limited to study habits) needed to succeed.

We also have concluded that some qualitative research methods are being used in research in engineering education, but more methods could be used more widely. We continue to believe that progress in engineering education requires asking and answering "why" questions that are usefully addressed with qualitative research methods.

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