

Use of the Critical Incident Technique for Qualitative Research in Engineering Education: An Example from a Grounded Theory Study

Abstract

The critical incident technique is a well-established qualitative research method that is useful in exploring significant experiences in order to better understand resulting behavior. The critical incident technique is emerging as a tool for research and for building theories in engineering education.^{1, 2} This paper describes the initial state of a grounded theory study. The purpose of the larger study is to develop a theory that relates how students perceive the role of their family in making engineering-related academic decisions. The population under study is first generation college students. Specifically, this paper describes the development of an interview protocol based on the critical incident technique and demonstrates its usage in drawing out thick, rich descriptions which help increase the trustworthiness of qualitative research.

Initial interview data are presented to highlight our usage of the critical incident technique to elicit specific information about how participants experienced various critical family interactions that influenced academic decisions about engineering. This paper contributes to the engineering education body of literature by illustrating the critical incident technique and discussing the advantages and disadvantages of the approach for other researchers who may seek to employ the critical incident technique for their own work.

Motivation

The motivation for this work is two-fold. For the work presented in this paper, which is a part of a larger study, the aim is to illustrate the use of the critical incident technique. For the larger study, the research questions addressing students' experiences with family influences are motivated by the dearth of empirical studies addressing such influences on the academic decision-making of first generation college students majoring in engineering. In today's technological society, the need for engineers in the work force is at an all time high.^{3, 4, 5, 6} Both the number and ethnic diversity of the work force are of concern. Dr. William Wulf, former president of the National Academy of Engineering, stated that diversity in the engineering workforce is a necessity: "My argument is essentially that the quality of engineering is affected by diversity (or the lack of it). ... Without diversity, the life experiences we bring to an engineering problem are limited. As a consequence, we may not find the best engineering solution. We may not find the elegant engineering solution. ... To sum up, I believe that diversity is essential to good engineering!"⁷

A number of researchers have reported that having a parent or family member who is an engineer is an influencing factor for students, particularly females, to choose engineering as a college major.^{8, 9, 10, 11} Yet, the academic and career choices of students without an engineering or college-educated role model are not well understood.

It is also known from the higher education literature that certain family roles in academic decisions vary based on parental education level. In the field of engineering education, the

attitudes and expectations that parents communicate about engineering, their ability to provide guidance, and ability to serve as role models can be dependent on the parents' own educational and professional experiences - or lack thereof.¹⁰ This research addresses the nation's urgent need to better understand students' academic choices related to engineering by examining the academic decisions of a previously over-looked demographic – students who are among the first generation in their family to attend college, termed "first generation college students", or "FGC". For this study, FGC is defined as students whose parents have attained less than a bachelor's degree.¹² Many engineering students, particularly females, have an engineering parent and "inherit" the occupation from that parent according to Mannon and Schreuders.⁹ Because FGC engineering students do not have an engineering parent, understanding the family influence can be important to their recruitment and retention to the field. The aim of this critical incident technique (CIT) study, guided by grounded theory, is to gain a better understanding of how students connect their engineering academic decision making to the influence of their family.

Background

Dr. John C. Flanagan, based on his work in the U.S. Army Air Forces Aviation Psychology Program during World War II, developed the CIT. Flanagan emphasizes that "the critical incident technique ...should be thought of as a flexible set of principles which must be modified and adapted to meet the specific situation a hand."¹³ Bitner, Booms & Tetreault and Grove & Fisk described a critical incident as "one that makes a significant contribution, either positively or negatively, to an activity or phenomenon."^{14, 15} One objective of critical incident technique is to gain understanding of an incident of interest to the researcher from the perspective of the participant, taking into account cognitive, affective, and behavioral elements.¹⁶ These incidents are the source of thick, rich data used to gain an in-depth picture of individual's academic and career choice process. CIT allows the participant to select which incidents are important to them as it relates to an activity under study.

Purpose of This Paper

The aims of this paper are to:

- Illustrate how a CIT qualitative interview protocol can be used in engineering education. To illustrate its use, a grounded theory study using a CIT protocol is described. In particular, this overarching study's use of CIT elicits how participants experienced various critical family interactions which influence FGC engineering students' academic decisions about selecting engineering
- Help the reader adapt his/her own research design to include CIT-based interviews if appropriate.

The population under study is undergraduate, FGC students currently majoring in engineering and classified as a junior or senior at Clemson University.

Research Design

When completed at the start of a study, carefully considering epistemology, theoretical perspective, methodology and methods as it relates to the research design improves the rigor of a study. Those four elements of the research design are discussed below.

Epistemology

Epistemology refers to what is considered knowledge and the basis for such knowledge. This study employs the constructionism view. In this view, meaning is not discovered but constructed. Specifically, all knowledge is derived by looking at the world through a perspective or viewpoint and person have a definable and discoverable nature and are “concerned” with the dynamics of social interaction.¹⁷

Theoretical Perspective

The perspective becomes the overarching guide for the design of the study's data collection and analysis methods. Constructivism, the perspective used by this study, embraces the idea that the participants can actively make meaning of their various critical experiences with family members and relate how those experiences influenced their academic decisions about engineering.¹⁷

Methodology

Once the research questions were formed, a methodology was selected. Strauss and Corbin state that qualitative methods can be used to better understand any phenomenon about which little is yet known.¹⁸ FGC students, especially those majoring in engineering, are not well studied and are known to face unique academic challenges.¹⁹ Further, qualitative studies yield results that are reflective of the descriptive experiences and feelings of the participants.²⁰

To better understand the family influence required exploring personal interactions between students and their parents in a way that the students' experiences could be completely chronicled in their own words. Therefore, the methodology needed to include a rigorous data collection mechanism using a semi-structured interview protocol where open-ended questions could be posed and followed with clarifying questions in order to completely understand the interaction. The specific methodology also needed to include a process by which a theory could be emerged from the data collected. The general research approach for this study is constructivist grounded theory. The result of a grounded theory study is a description of relationships among concepts (theory) uncovered in the data (grounded).²¹ Charmaz, while acknowledging the constructivist grounded theory research process is not linear, advocates seven steps: (1) collecting rich data, (2) coding the data, (3) memo writing throughout the study, (4) theoretical sampling, saturation, and sorting, (5) reassessing what theory means, (6) writing a draft, and (7) reflecting on the process.²¹ This paper will discuss data collection and initial coding.

Methods

The specific procedures and techniques for this study include developing and using a demographic questionnaire, employing a purposive sampling protocol, and developing and using the CIT-based, semi-structured interview. To make the interviews more efficient and to ensure the selection of FGC students majoring in engineering, students completed a brief demographic questionnaire using Survey Monkey.

Development of interview protocol

An interview protocol based on the CIT was developed to facilitate the discovery of factors which could help better understand the family influences on FGC undergraduates' academic choices about engineering. The CIT protocol included guidelines governing both the interview guide development and the facilitation of the interview. The CIT is a useful method to explore significant experiences in order to better understand resulting behaviors. Interviews can be helpful in providing access to perceptions and attitudes. Further, an interview guide that would elicit the kind of rich, thick data needed to develop a theory grounded in the data was imperative. The interview questions, found in the appendix, were created to correspond to the research questions, and included queries about how academic decisions were made and the family influence on each decision.

The interview approach was also based on the CIT. From the CIT perspective, certain interactions and thoughts are critical to understanding resulting actions and behaviors. Therefore, the interview was structured to support elicitation of these thoughts and actions. The interview questions were framed as open-ended probes beginning with words such as “describe,” “how,” and “what” rather than “why.” These question stems were deliberately chosen to elicit a descriptive narrative rather than justification for past actions.²² Specifically, the goal of each interview was structured to discover the following as it relates to the family influence on the participant's engineering-related academic choice process:

1. Triggering factors
2. Critical steps
3. Final outcomes and follow up, if any
4. Verbal and non-verbal clues to influences
5. How influences impacted participant's decisions and/or actions

In this paper, two of interview participants in the emerging grounded theory study will be used to illustrate the use of the CIT. The next section details how the sample was selected.

Purposive selection of interview participants

Interview participants were selected purposively from those completing an online demographic questionnaire and invited to participate in a semi-structured interview. Student participants were selected using the following selection strata:

1. Majoring in an engineering discipline

2. First generation college students
3. Junior or senior university classification at time of interview – students believed to be best able to answer the interview questions

The sample resulting from the use of the selection strata contained 22 juniors and 24 seniors in engineering that were FGC. This paper highlights interviews from one junior and one senior FGC engineering student.

Data collection using semi-structured interview guide

Participant interviews were face-to-face, in-depth, semi-structured conversations that were about two hours in length. Participants were interviewed on campus in a private office room. Each participant received a definition sheet explaining academic choice during the interview. The sheet provided a definition of academic choice and examples of research-based, positive and negative family influences on engineering-related academic choices. During the interview, the definition sheet was represented as containing examples only. Participants were told that the examples were not all inclusive and that the participant may or may not have experienced the influences listed. The definition sheet was available to each participant for him or her to refer to throughout the interview.

The interview began with the following questions allowing the participants to convey his or her engineering-related academic choice process and the persons, including family members, with whom they discuss these choices:

1. Tell me how you selected your major. Why did you select this major?
2. Tell me with whom in your family you discuss your academic choices?

Participants were encouraged to reflect back on how they first learned about engineering as a college major, through the point at which they chose engineering as a major, and to their present-day engineering-related academic decisions. From these narratives, various triggering factors and critical steps taken to enable each participant to make engineering-related academic decisions were noted and explored thoroughly.

Once the participants' engineering-related academic choice process was explained and family influences disclosed, the interview questions could then focus on specific interactions with each family member that were critical to the engineering-related academic choice process using the following questions:

1. How frequently have you sought the guidance of (name of family member) in making academic decisions?
2. How frequently does (name of family member) provide guidance on your academic decisions?
3. Tell me about a specific conversation with (name of family member) on your academic decisions and describe what was said.
4. In what ways did the discussion influence your academic choices?
5. How did you use the guidance provided?

6. How did the situation work out?

Care was taken to ensure incidents shared were important and relevant to the participant's engineering-related academic choices. The questions were open-ended and allowed the participants to describe the behavior of the family member and relate the behavior to a particular engineering-related academic choice. Participants were also asked to tell how long they knew each family member, how frequently they engaged each family member in discussions about their engineering-related academic choices and to rank each family member from most influential to least influential according to the impact each had on their academic choices about engineering. To ensure trustworthiness of the method, the second author reviewed the initial two transcripts and provided feedback that will be used to improve the remaining interviews.

The interviews were recorded, professionally transcribed and checked for accuracy. Data collected from the interviews were then analyzed to search for themes on students' influences from family members on their engineering-related academic choices. The data coding was facilitated by the use of qualitative data analysis software. Charmaz describes three levels of coding to emerge a grounded theory: initial, focused and theoretical coding.²¹ In the results section of this paper, the initial coding or classification of data was discussed. In initial coding, segments of data that reflect action were coded according to that action.²¹ This approach is aligned with data collection and analysis steps from grounded theory methodology.

Results

Overview of Initial Interviews and Initial Coding

Two interviews are used here to illustrate the interview approach and initial classification of the data. Participant 1 was a fifth year senior majoring in electrical engineering and the Participant 2 was a fourth year senior majoring in industrial engineering. Participant 1 had a strong influence from his stepfather and readily mentioned his mother and a male church member as influences. The stepfather provided access to various technology-based activities that sparked this participant's interest in computers. The stepfather also verbalized and exemplified a commitment to "be the best". Participant 2 had less identifiable family influences, but many critical incidents that occurred along the academic path. A major, hometown, bridge construction project and a plant tour influenced the participant's initial college major choice. Prior to coming to Clemson University, Participant 2 spent one semester at a junior college.

In addition to explaining how the CIT approach was used in the study, the initial coding of the data is also shared here. In each passage, the underlined sections represent the initial classification of the data. As the larger grounded theory study progresses, the segments of data (initial code) will be synthesized into larger and significant data segments (focused coding) resulting in major categories. Finally, theoretical coding will support development of the relationship among categories and construction of the initial theory.

Participant 1 recalled the many early experiences associated with choosing a college major in engineering. The following question and answer illustrates how a researcher can use CIT to elicit such experiences:

[Interviewer] Tell me how you selected your major.

[Participant 1] Um, okay. With my major I basically, when I was a kid my [step-father] gave me a computer, I was like I think six, he gave me like Windows 3.1, one of the first, you know, first one. And then he kind of said you know, for me to learn it on my own, figure it out and I started learning it and over the years he'd upgrade it. And I'd start learning how to program it and make games on it and it was some pretty cool stuff so I did that through middle school and high school and in high school I learned how to program a bunch of different language. And so I was thinking about doing computer science because, you know, computer science is based on programming. But then I started to think, you know, like that's kind of a one-way street and that's where I'd end up and I'd really want to be able to, I'd love to know how the computer works as a whole. So I did electrical engineering so I'd have a broad based knowledge of electrical engineering and computer science. Computer science is obviously a self-taught thing for me but I wanted to have the whole genre, I guess. And so I had made that decision junior year in high school and didn't look back. ... the men in my family have this big stride to be the best so I guess that's kind of where it's coming from, but ultimately I like to know as much as possible about my major.

The response above allowed the researcher to note several incidents involving the participant's stepfather, such as the early involvement with computers, which resulted in the participant's engineering academic choice. The researcher noted each incident and asked additional open-ended questions that allowed the researcher to probe the incident further. For example, the exchange below, with the initial codes underlined, depicts how a better understanding of the academic influences from the male members in the family was gained.

[Interviewer] So you mentioned that your family, especially the men in your family has this mantra or goal to strive for the best. How did you get to know that? How was that conveyed?

[Participant 1] Um, my, well, let me start with a quick history. My mother divorced my biological father when I was young. Like when I was about one year old they got divorced, you know. And he is a big, very strong kind of guy. He's opened up a bunch of stores, he owns [a franchise restaurant], he works very hard and he's always tinkering with things like that. But my stepfather is the one that had the more environmental influence on me. He's the one that kept teaching me new things and showing me how to do things right. Once I learned how to do it right he'd say, [participant], there's always a better way to do it you know, but you have to find that for yourself and figure it out and strive to be the best in everything you do. A lot of that came with, because I played baseball when I was young, too. I was a big baseball fan. I played since I was four years old in a league up until college. And so he always wanted to see me get in All Stars and, so he kind of was an environmental [influence] from sports to my academics to everything. They really strove for me to be the best in knowledge ... what I knew how to do.

The pre-college influence from the participant's stepfather was now better understood. The participant conveyed that the stepfather and mother divorced before the participant entered

college, but the stepfather remained actively involved in the participant's life. The participant transferred the encouragement to perform well and to gain a deeper understanding of everything from sports to academics into a strong drive to perform well in engineering. The participant also noted that the stepfather himself demonstrated the family mantra or goal to strive for the best by leaving the family farm after high school to attend a two-year college. The participant relayed the following:

[Participant 1] ... [my stepfather] paid his way through [college], it's like an electronic degree program and two year associate program though he didn't have a strong [education] background, but he was able to learn a lot from it. He took what he knew and took new steps and he got a great career. He can fix about anything. He's fixed everything I've ever broken: electronics wise and automobile wise and motorcycle wise. So seeing that in him kind of drove me to want to know how to do everything I guess, you know, I want to know how to do a lot of stuff.

Participant 1 was able to actively make meaning of the significant experiences related to the family mantra to strive for the best and, in turn, relate how those experiences influenced his engineering-related academic behavior.

Participant 2, in sharing the influences on her engineering major choice, mentioned many influences: sister, aunt, uncle, mom and dad. The exchange below shows how the researcher was able to understand the influence of a fictive kin: a church member that was also an engineer. The parents encouraged the participant to seek out and speak with engineers they knew. Fictive kin is a term used to refer to individuals that are unrelated by either birth or marriage, who have an emotionally significant relationship with another individual that would take on the characteristics of a family relationship.²³

[Interviewer] In an earlier statement you mentioned that there were several other sources you used. So what were those sources that you used to narrow from the many different types of engineering majors to a specific choice?

[Participant 2] Okay, a few things. Definitely the Internet is huge. There were a few people in my church who were engineers and my parents are friends with them, so you know, my mom's like well maybe you should talk to so and so because they're an engineer, they're this type of engineer. And I was like wait a minute, what? [Up to that point, I did not know there were different types of engineers.] So, you know, my mom and dad just were like yeah, you know, go talk to so and so. I actually took a tour of a power plant with one of them, I was like ohhh, it was really cool.

[Interviewer] At the time that you went in 11th grade and toured [local utility company], were you thinking [industrial engineering] then or was it still open for you?

[Participant 2] Actually, it was open. That's also when the [name of major bridge] was being built so I was like who does that? I want to do that! But then I was like hmmm, I don't know.

Participant 2 later related how the decision to major in industrial engineering was made with the information gained through departmental tours that were provided through the first year engineering program. The participant had made choices to *not* select certain engineering disciplines due to lack of interest in the practice of these disciplines: mechanical and chemical. Other disciplines, such as ceramics and material engineering and electrical engineering, were judged as being too tough to handle. Civil engineering was most aligned with Participant 2's interests and was selected. Shortly after starting the civil engineering program, Participant 2 judged the curriculum focus as actually *not* aligning with her interests. The participant desired a strong design and build focus and did not perform well in the initial engineering mechanics courses (i.e., statics), therefore, decided to switch to industrial engineering.

Now that the path to making the decision to major in industrial engineering had been explained, other inputs into that decision, including family influence, could be explored. The participant had already mentioned having academic-related discussions with a sister, aunt, uncle, mom and dad. The passage below depicts the beginning of an extended exchange to explore the role each family member may have had in influencing her choice to major in industrial engineering.

[Interviewer] Through any of your major choice decision-making, did you have discussions with your sister, aunt, uncle, mom and/or dad about your thoughts or decisions?

[Participant 2] Well, I think my parents were still, you know, maybe you should give civil more than just a semester. I was like yeah, but I'm not doing so great in these classes. I'm not saying I hate it. I do really like it still however it's just not clicking. And so my parents are kind of thinking the money aspect, they're like okay, then you need to pick something. And so I was like okay, well kind of like IE, don't 100% know what it is. I looked it up, you know, I was like yeah, it's pretty cool. Talked to my uncle because he's like yeah IE is pretty cool, you know, you're in groups and you know, you make things better, you know. You don't have to reinvent the wheel like in the other engineering majors, so, per se.

While other academic choices were discussed with this participant, the choice in major seemed to dominate the discussion due to the many critical incidents related to major choice. While other sources were mentioned, the participant's parents also had an influence on many engineering-related academic choices according to the participant.

Lessons Learned

After collecting the initial data, the authors wanted to ensure specific incidents related to engineering-related academic choices were being drawn out from each participant. Upon review of the transcripts, the participants were able to share descriptions of specific periods, but not always distinct, single incidents. For example, when asked for a specific conversation related to an event, the participant was able to recall generally what advice was offered, but not the exact conversation. One objective of the CIT is to gain understanding of the incident from the perspective of the individual, taking into account cognitive, affective, and behavioral elements¹⁶. So, with this review of the CIT and check against data gathered, a participant's description of

specific periods will support the theory development. From the data collected, main and subcategories that emerged from the analysis can begin to be inductively developed.

The researchers have no preconceived notions about what is important. The context is entirely developed from the participant's point of view and experience. However, after a review of the transcripts, the authors realized the need to resist the temptation to explain what the participants were saying, but instead put forth the participant's perspective. The best approach is to ask the participant to fully explain the incident and outcomes to ensure full facilitation of the CIT process. The researcher plans to use more "how?," "why?" and "can you tell me more about that?" type questions in the future to probe for additional details.

Advantages

The researchers experienced the following advantages with the CIT in this study:

- The CIT framework allowed students to focus on the specific incidents of interest to the researcher.
- The interview guide was well constructed. The CIT informed the phrasing of the questions and helped gain enough detail to visualize how knowledge or skill gained had influenced various engineering-related academic choices.
- The academic choice definition sheet helped to define what was meant by an academic choice and helped the participant in recalling specific events.

Disadvantages

The primary disadvantage experienced during this CIT study is the length of the interview. A length of two hours should be the upper limit for CIT interviews. Even at two hours, there is a risk that the interviewer and/or participant may become fatigued. Consider scheduling interviews when both the interviewer and participant are most alert.

Conclusion

The CIT is useful in obtaining thick, rich data and in eliciting family influences. The participants in this study have begun to reveal the complexities associated with family influence on their engineering-related academic choices. From their constructed experience, a picture is beginning to emerge that will support the formation of a grounded theory. Several implications for engineering education research have emerged from this study and general line of inquiry. One implication is for the use of the CIT in engineering education research as a medium to draw out dense data containing numerous examples of specific incidents and behaviors. The implications related specifically to this work include facilitating the diversification of engineering and understanding of engineering-related academic choices of undergraduate FGC students.

Future research includes coding of the data to develop main and subcategories that emerged from the analysis, conducting additional interviews, and developing an initial theory.

Appendix I: Semi-structured Interview Guide (Employing Critical Incident Technique)

1. Tell me how you selected your major. Why did you select this major?
2. Tell me with whom in your family you discuss your academic choices?
3. What did your family think of your major choice?

The following questions will be asked in a loop equal to the number of persons mentioned to determine influences of each person mentioned.

Focus on your interaction with _____.

4. How frequently decisions?
5. How frequently does _____ provide guidance on your academic decisions?
6. Tell me about a specific conversation with _____ on your academic decisions and describe what was said.
7. In what ways did the discussion influence your academic choices?
8. How did you use the guidance provided?
9. How did the situation work out?
10. Please describe a particular incident or incidents that your _____ did that had a significant positive influence on your academic decision. Like ... what would say was the best guidance provided related to an academic decision?
11. Please describe a particular incident or incidents that your _____ did that had a significant negative influence on your academic decision. Like ... what would say was the worst guidance provided related to an academic decision?

After discussing the influence of each family member, now examine which was the most profound positive and negative influence.

12. What action, by any family or “like family” member, did you find most affirming and helpful in making a decision on your *academic choice*? Describe action and tell why it was affirming and/or helpful. How did you use _____?
13. What action, by any family or “like family” member, did you find most puzzling or confusing in making a decision on your *academic choice*? Describe action and tell why it was puzzling and/or confusing. How did you clear the confusion?
14. At what moment/point/period, since you started here at Clemson, did you feel least engaged with your *major*? Describe that moment/point/period. Did you seek guidance from a family member? If yes, describe how you went about seeking that guidance and what guidance your family member provided. What did you do as a result of the guidance provided? What was the result?

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