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Essentials of the Nurse+Engineer: Qualitative Methodology Applied to Foods Systems in Environmental Engineering

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Sarah Oerther

Essentials of the Nurse+Engineer: Qualitative Methodology Applied to Food Systems in Environmental Engineering

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Abstract

Previously, we reported on a revamping of an existing design course to shift from a focus on sewage treatment plant design to a focus on the (re)design of local food systems. To introduce engineering students to qualitative research methods as part of community-based participatory research, we used instructional materials from the nursing profession. Results from student feedback suggests that the approach is viable, and the students uncovered examples of lived experience from the community with regard to the availability of food and the local approach to the problem of food loss and waste. Our results suggest that qualitative research methods may be taught to students of engineering by adopting instructional approaches from nursing. In this article, we make the argument that qualitative research methods as part of community-based research is as an essential skill of the nurse+engineer, a convergent V-shaped profession, and we demonstrate the value of this approach to solve problems of sustainable development such as food systems.

Introduction

According to the United States (US) Bureau of Labor Statistics (BLS), the definition of environmental engineers includes, "…[using] engineering disciplines in developing solutions to problems of planetary health," [1]. Sustainably feeding the human population is one of the problems of planetary health, which environmental engineers are particularly well suited to contribute solution [2]. Current agricultural production:

1. contributes to a loss of biodiversity from land use (i.e., sensitive habitat is cultivated);
2. transfers embedded/embodied/virtual water among watersheds (i.e., excessive groundwater pumping for irrigation in dry, warm regions to produce wintertime fruits and vegetables for consumption in wet, cold regions);
3. emits greenhouse gases (i.e., NOx emission from soil microbes during plant growth);
4. consumes large amounts of energy (i.e., fossil-fuel powered equipment); and
5. requires substantial inputs of fertilizers (i.e., NPK – nitrogen, phosphorus, and potassium – which may contribute to eutrophication) [3].

In addition to agricultural production, addressing the problem of food loss and waste (i.e., FLW) – including food that never leaves the production field as well as food that is scraped from the plate into the compost bin – is another area where environmental engineers have the ability to make a positive impact to improve sustainability.

Environmental engineers are not alone in their ability to make a positive impact to planetary health. Nurses – who focus on the health of patients, whether they are individuals, families, populations, or communities – also have a history of supporting healthy food systems. For example, Florence Nightingale, the founder of modern nursing, promoted the importance of food systems as part of, "Nightingale's Environmental Theory," when she noted in her chapter on diet that, "the main question is what the patient's stomach can assimilate or derive nourishment from, and of this the patient's stomach is the sole judge. Chemistry cannot tell this. The patient's stomach must be its own chemist," [4]. Advocating on behalf of patients and helping to educate patients about the availability of resources to support health is another area where nurses have the ability to make a positive impact to improve health.

Increasingly there has been a call for nurse and engineers to collaborate from the bedside and into the community to work together as professionals to solve challenging problems of public health [5, 6, 7]. For example, a recent systematic review identified more than 50 peer reviewed articles, which described partnerships among engineers and nurses [8]. These partnerships include training the next generation of practitioners [9], working together in academic settings [10], and collaborating on technologies [11], including technology as a paradigm of interprofessional collaboration [12].

These collaborative approaches between engineers and nurses often focus on attaining sustainable development [13] through a collaboration among two professions known for caring, namely nursing and environmental engineering [14, 15]. While nursing is not yet recognized as a STEM – science, technology, engineering, and math – discipline [16, 17, 18, 19], nursing is known for empathy [20], which often includes the use of research techniques that seek to understand the values of individuals.

Previously, we reported on the success of leveraging nursing practice to inform teaching environmental engineers to design improvements to local food systems [21]. We suggested that the parallel work of environmental engineers and public environmental health nurses could be leveraged to support the attainment of the United Nations Sustainable Development Goals – including Goal 2: Zero Hunger – while working in local communities [22] in a manner that "leaves no one behind" [23]. We argued that the modern practice of nursing and the modern practice of environmental engineering represent professions that can be pointed towards a common future where societal challenges – such as sustainably supplying food – may be solved through transprofessional partnership [24, 25] from the bedside and into the community [26, 27].

As part of our design course on local food systems, we invited students of engineering to learn from nurses' approaches to qualitative research [21]. Previously, we reported extensively on the use of quantitative research methods as part of a community-based participatory research [28, 29, 30, 31, 32, 33, 34]. Unlike quantitative human research – where rigid questions are asked and scored using Likert-type scales– qualitative human research is focused on eliciting stories from individuals and groups, identifying recurring themes, and developing an understanding of the situation using an open-ended approach, which allows for unexpected results to be identified [35].

As we described previously, the (re)design of a local food system depends upon a local understanding of the four pillars of food security, including: the physical availability of food; economic and physical access to food; the ability to utilize food; and the stability of the other three pillars over time [21]. Often, these four pillars are abbreviated with the terms: availability; access; utilization; and stability.

To help engineering students learn to conduct qualitative research, we provided them with expert instruction from a nursing educator. We invited the students to develop interview guides and interview local stakeholders in the community and to report the information they collected in an essay that answered the question, "What is the problem with the food system in Phelps County, Missouri?" [21].

The current article describes our work as part of a design course entitled, "5605 Environmental Engineering Design", offered at the Missouri University of Science and Technology. Details of this course syllabus, teaching modules, and student feedback have been described previously [21]. In this article, we report on the materials that nurses used to teach engineers about qualitative research; provide examples of stakeholder feedback solicited from interviews; and share the responses of students discussing the strengths, weaknesses, and suggested improvements for the course. The work presented in this article is part of an overall line of research with the intent of demonstrating qualitative community-based participatory research is an essential skill of the nurse+engineer.

Methods

Institutional context. Today's Missouri University of Science and Technology (S&T) was established in 1870 as the Missouri School of Mines and Metallurgy. Located in Rolla, Missouri, S&T is a comprehensive public research university, which offers approximately 100 degree programs. With an undergraduate student enrollment of approximately 5,500 students, a graduate student enrollment of approximately 1,500 students, and average annual research expenditures of more than $50 million, S&T is currently characterized as Carnegie R2, a doctoral university with high research activity.

Course description. As described previously [21], 5619 Environmental Engineering Design includes a lecture and a design lab for students enrolled in the Department of Civil, Architectural, and Environmental Engineering. Typically, CArE 5619 is taken by seniors in their final year of baccalaureate study. Some juniors and some graduate students also enroll in the course. Historically, CArE 5619 focused on, "the functional design of water and wastewater facilities and other environmental cleanup systems," but the syllabus was modified to include the following,

> *"… Therefore, as an approach to "environmental cleanup", the design of the Phelps County food system will include a mass/energy balance approach of food import, food conversion, waste export, and food production/exchange from within Phelps County. In this way, life cycle concepts will be used to consider sustainability (i.e., food loss and waste), risk/safety (i.e., contamination of food supplies), uncertainty/reliability (i.e., access to nutritious, culturally appropriate food), and environmental impacts (i.e., how*

an individual's diet relates to planetary health). Therefore, water/wastewater treatment will be a part, but not the whole, of the design." [21].

Details of how the course is taught – including the use of blended style of delivery, flipped classroom management, and modified mastery learning to teach sustainability and life cycle principles – have been reported previously [21, 36]. For example, a portion of the content is provided through required readings while a portion is provided through watching digital recordings. These materials are reviewed by students before attending a required lecture. And students complete a required quiz using an available learning management system (LMS) before attending the required lecture.

The primary purpose of this current article is to provide details on teaching engineering students qualitative research using the perspective of nurse researchers as interprofessional partners. This current article builds upon the prior publication [21, 36], and elaborates on the details of how qualitative community-based participatory research was taught by nurses and how students of engineering responded to this instruction.

Results and Discussion

Leveraging prior research [37, 38, 39, 40], the content in Appendix A includes the slides used by a nursing instructor to teach students of architectural, civil, and environmental engineering how to conduct qualitative research in a community context. In particular, slide 6 of Appendix A provides a side-by-side comparison of qualitative and quantitative research. For example, while the goal of quantitative research includes prediction and control, the goal of qualitative research includes understanding. While the study of discrete (often isolated) variables is the approach used in quantitative research, the study of phenomena in context – often described as the "lived experience" – is the approach used in qualitative research. Therefore, one of the tools that is available to the qualitative researcher is the open-ended interview with a stakeholder in their home, place of employment, or other natural setting.

As part of 5619 Environmental Engineering Design, the University of Missouri Extension Service produced a series of videos that included interviews of instructors, students, and community stakeholders. These videos may be accessed on YouTube at the following URLs:

1. A look at the Phelps County Food System through the Eyes of an Environmental Engineering, at: https://www.youtube.com/watch?v=3mtXvmWA7UI;
2. Public House Brewing Company – more than a good neighbor, at: https://www.youtube.com/watch?v=XsCm4Q6fv1E; and
3. Rodney Southward's Cattle Farm, Rolla, Missouri, at: https://www.youtube.com/watch?v=EouXIJW3VsU.

These video resources provide examples of the kinds of qualitative approaches that have been adopted by students using the content provided in Appendix A.

As part of 5619 Environmental Engineering Design, students were invited to provide feedback using open-ended surveys, administered at the end of each semester, and collected using an anonymous process administered centrally by the University. Extensive examples of comments offered by students were included in our previous publication [21]. Here within, we offer an

example of the type of comment provided by students that specifically addresses the issue of teaching engineers qualitative research methods adapted from the profession of nursing,

> *"The strength and weakness are both in how different this is than usual. We experienced a new side of design* [namely qualitative community-based participatory research,] *and the expectations for each part* [of the syllabus] *could use refining* [such as clear grading rubrics to help students better understand expectations]. [For example,] *...providing the standards* [(i.e., learning objectives)] *for each part so we know exactly what we set out to gain.* ***I enjoy the open-endedness but making sure that the work is what's expected, especially if we bring them to people like Sarah, so it works well. With that in mind, the time with Sarah was a great addition to the class****."*

From this open-ended comment, a number of conclusion may be inferred. First, the tone and content suggest at least a degree of positive reception to the opportunity to engage in qualitative research. Second, the involvement of a recognized expert is highlighted as important. And third, the specific inclusion of an instructor of nursing was viewed positively by this student of environmental engineering. In contrast to the positive aspects of this comment, the student also conveyed a suggestion for improvement, namely: clear learning objectives and the use of grading rubrics so that students could better understand expectations being placed on them as part of the course. Similar positive comments and suggestions were offered occasionally by other students. Future research should specifically elicit comments regarding qualitative research, and the satisfaction of students with the instructional material used to teach these techniques.

To demonstrate how qualitative research enhanced understanding of stakeholders in a manner that was not immediately obvious from prior quantitative work, below, we provide two examples.

First, we note that a group of students working together came to the consensus conclusion that,

> *"The problem with the Phelps County food system is a deficit in availability. This is due to the poor distribution, low local production, and* ***high number of citizens not taking advantage of SNAP and similar financial assistance****."*

Through interviews with local stakeholders, the students noted the availability of government assistance supporting access to food (i.e., WIC – women-infant-and children – and SNAP – supplemental nutrition assistance programs – resources are available in Phelps County). The students also noted that individuals in the community were disinclined to avail themselves of these resources, in part, because of a strong sense of independence/self-reliance and a general distrust of government. As reported previously, many parents in underserved rural communities, such as the Ozark mountains of south central Missouri, view the Federal government and some state government with distrust [41]. Prior qualitative research on individuals living in the Ozark region succinctly captured this sense of self-reliance in the following quote, "The difference between town and country is this: In town others do for you. In the country you do for yourself," [42, p. 67]. Collectively, the results collected by the students and the prior literature highlight an important tentative conclusion, namely that "free food" provided by the government may not be a suitable approach to support food availability in the region, and (re)design of the Phelps

County food system should explore alternative approaches to enhancing availability (i.e., perhaps distribution through food pantries and/or providing opportunities to self-produce food such as through community gardens and/or additional hunting/fishing take/catch limits).

Second, we note that one student reported learning that,

> *"**Chefs, they do take steps to reduce waste. And I was kind of surprised by that**. But they said it's all about the money. They don't want to over produce, and then have to throw food away because that's money they're throwing away."*

This observation by a student in particularly important to the area of food loss and waste (FLW), and this example highlights one of the advantages of a qualitative approach to research as compared to a quantitative approach to research. For example, a quantitative approach may ask individuals to rank order from most to least important a predetermined list of reasons for FLW. In contrast, a qualitative approach may invite a diverse sample of individuals to share stories that help to define the terms food, loss, and waste, and help to unearth unexpected reasons for FLW. A practical comparison of quantitative and qualitative approaches to FLW includes the "Inglorious Fruits and Vegetables" campaign in Europe [43].

In Europe, produce (i.e., fruits and vegetables) that fails to achieve basic minimum aesthetic quality controls at the farm gate is not considered "food". Thus, when these "non-food materials" are diverted to facilities built for waste to energy production (i.e., anaerobic digestors), there is not a quantitative impact on FLW measurements. In the US, "ugly vegetables" and "ugly fruit" are still considered "food". The FLW hierarchy promoted by the US Department of Agriculture (USDA), the US Food and Drug Administration (FDA), and the US Environmental Protection Agency (EPA) recommends that all food be offered for human consumption, then for animal consumption, then for composting, and only finally for anerobic digestion [44]. Thus, an "ugly apple" in Europe would not be characterized as food and would be immediately sent to an anaerobic digestor. In the US, an "ugly apple" that was not purchased at a store would be considered wasted when it was sent to compost. While quantitative measures of FLW may miss this important distinction, a qualitative approach – eliciting stories with rich detail – would make clear that regulations providing a definition of "food" are partially responsible for how society compares FLW between Europe and the US.

In the case of the quote provided by this student, in the Ozark region – with a sense of self-reliance noted above – the issue of FLW is connected to financial responsibility. This is important to note because "more expensive items" may be less susceptible to FLW as compared to "less expensive items". Future quantitative research could explore this tentative conclusion because the qualitative research unearthed an important understanding of the local, lived experience regarding FLW.

The addition of qualitative research methods from nursing to support traditional quantitative engineering methods is an important tool for modern environmental engineering. For example, the ABET program criteria for environmental engineering and similarly named programs states that, "the curriculum must include … calculus-based physics, chemistry (including stoichiometry, equilibrium, and kinetics), earth sciences, biological sciences, and fluid mechanics

… hands-on laboratory experiments, and analysis and interpretation of the resulting data in more than one major environmental engineering focus area, e.g., air, water, land, environmental health…" [45]. These criteria – focused on foundational math and science, engineering applications of math and science, and experimentation are areas where environmental engineers historically have tremendous strength in teaching using a variety of pedagogies. The ABET program criteria also include, "… design of environmental engineering systems that includes considerations of risk, uncertainty, sustainability, life-cycle principles, and environmental impacts…" [45]. Again, environmental engineers historically have tremendous strength in teaching design.

But where environmental engineers may especially draw value in collaborating with nurses is in the areas of defining and exploring the values of the public versus the values of individual people in the areas of risk, uncertainty, sustainability, life-cycle principles, and environmental justice. As we noted previously, nurses are unique among the healthcare professions in that a nursing patient may be an individual, a family, a population, or a community [46]. Thus, nurses understand how to "build up" to the concept of "public health" by considering the person-centering preferences of individuals. One way that nurses accomplish this is through the use of qualitative research. While quantitative research methodology and analyses – dealing with measurable phenomena – are well known to environmental engineers, the application of qualitative research methodology and analyses – including collecting and studying narratives – is perhaps less familiar to environmental engineers. The results of this current study suggest that students of environmental engineering are open to instruction about qualitative research methods.

Conclusion

Previously, we reported on efforts to revamp an existing course to focus on the (re)design of local food systems [21]. In the current study, we specifically highlight the role of qualitative research methodology that emphasizes students of engineering learning techniques from instructors of nursing. The results of this work support two important conclusions, namely: 1) students of environmental engineering are open to instruction from nurses about how to perform qualitative research; and 2) students of environmental engineering demonstrated how to use these methods to uncover improved understanding of the lived experience of community stakeholders as part of this class. The results of this study support the conclusion that qualitative research methodology is an essential skill of the nurse+engineer interface, which has benefit for addressing the challenging problems of food system sustainability.

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Appendix A. Slides used to teach qualitative methods.

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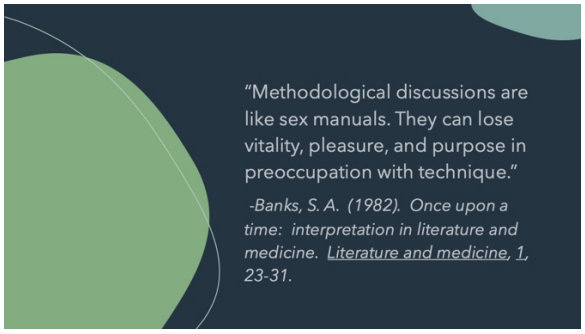

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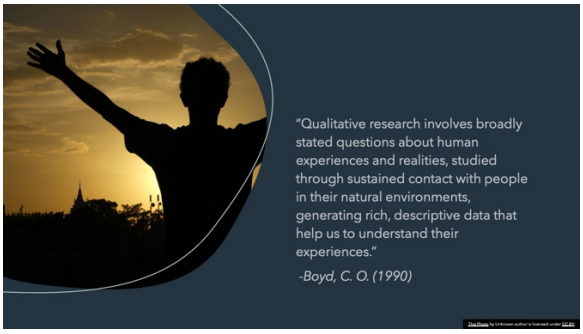

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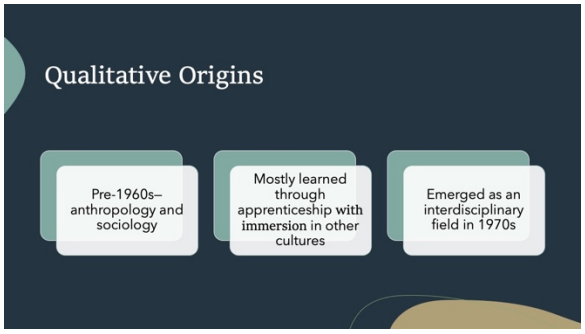

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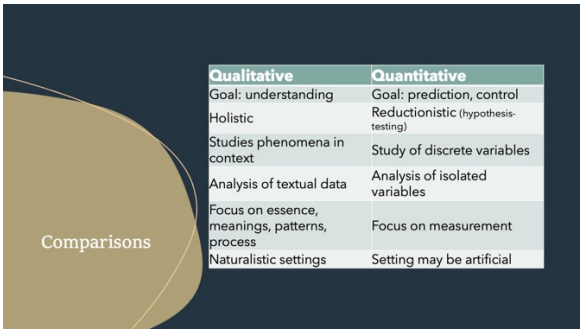

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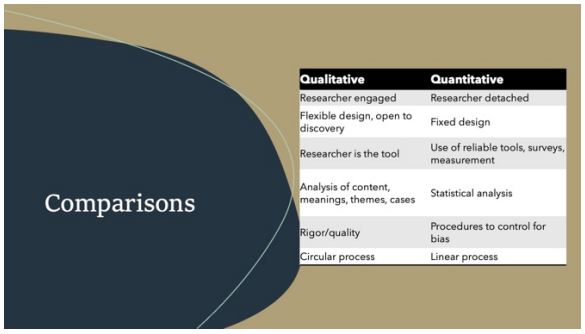

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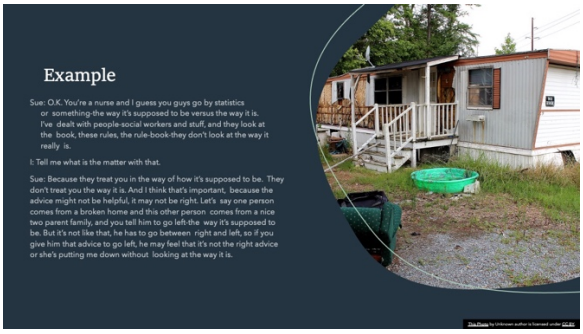

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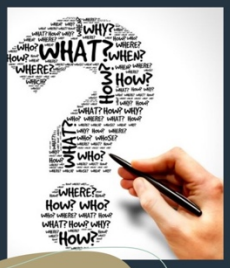
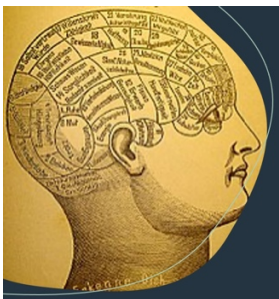


Differences

- Use of theoretical framework?
- Research questions/lines of inquiry
- Sample size
- Data collection procedures
- Analytic procedures
- Description of findings
- Ethical considerations
- Computer programs for data management
- Questions of rigor/quality

10



Sampling in Qualitative Studies

- Sample sizes are usually small
- Often rely on samples of convenience
- Sampling unit may be individuals, families, nursing units, episodes, etc
- Sample size often determined during a study
- Considerations include purpose, scope, design *(longitudinal design)*, and practical issues

11

Qualitative Approaches

- Grounded theory
- Ethnographic
- Participatory action research
- Case study design
- Husserlian phenomenology
- Interpretive phenomenology
- Narrative analysis
- Historical research

12

Generating Data

- Interview data
- Diaries
- Use of pictures and drawings
- Videotaping
- Documents
- Participant observations and field notes
- E-mail responses

13

Interviewing

Survey interviewing

- Conducted as a stimulus-response exchange
- Interview executed in a uniform manner
- Interviewing techniques standardized, forced choice
- Power rests with the researcher to define questions and legitimate answers
- Stories dismissed as untidy and unscientific

Qualitative Interviewing

- Conducted as a dialogue, following the lead of the interviewee
- Listening is methodologically crucial
- Conversation emerges without preset limits for what counts as a legitimate response
- Stories are encouraged and indispensable for understanding

14

Analyzing Qualitative Data For

- Themes
- Basic social process
- Meanings
- Patterns
- Variations
- Paradigm cases

15

Purpose of the Study

- ...was to explore the experiential meanings that constituted parents' understanding of raising Generation Z pre-teen children (eight to 12 years old) living in rural communities.

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Theme 2: Parenting stress and demands

Subtheme 3: **Financial constraints**

- Some families struggled to meet their basic needs
- Lost jobs
- Lost cars
- Lost savings

17

Cat (mother 3)

Cat explained: "Stuff like doctor's appointments right now are really hard because we have to drive my husband to work for the day to have access to the car. Stuff like their [pre-teen] dentist appointment schedules have fallen behind because I end up just canceling the kids' appointments. I also haven't signed the kids up for extracurricular activities because transportation is such an issue."

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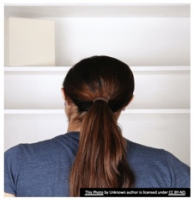
Cat (mother 3)

Cat disclosed: "I don't know how we would get by if my husband did not steal food from work. We would be for real hungry."



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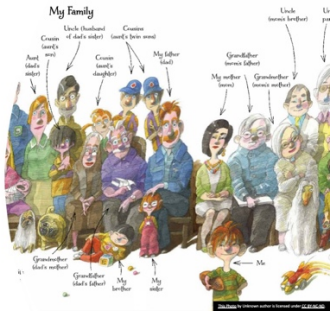
Theme 1: Parents' everyday concerns in caring for their pre-teen children

- Subtheme 6: **Family legacy**
  - Interactions with their own parents
  - Personal childhood experiences, good and bad



20

Greg (father 7)

Greg described how sexual abuse shaped his concerns for his pre-teen daughter: " I am overprotective [of my daughter]. I do not want my daughter to ever experience sexual abuse.... I don't let my daughter go out anywhere. When I was a kid, I would've already been all over the neighborhood by myself, but I don't let my daughter out of the backyard by herself. I've been very picky about which friends I let spend the night."

21

Analytic Process: No cookbook

22

Ethical Considerations

- IRB approval
- Voluntary participation
- Informed, ongoing consent
- Maintaining confidentiality
- Use of pseudonyms in reports
- Disguising/omitting identifying information
- Findings remain faithful to participants' experience

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Rigor/quality

- Research design is spelled out and is consistent
- Does the study address research questions?
- Measures to assure quality of data
- Procedures to minimize researcher bias
- Consensual validation
- Audit trail
- Journaling

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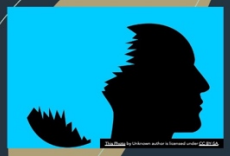

Is reader's understanding enhanced?

"Qualitative interpretations illuminate and often provide a vicarious experience by making the familiar more familiar (eliciting the often-cited shock of recognition), making the familiar strange, and/or by revealing what is hidden."

-Sandelowski, 1995, p. 372

25

An African Proverb

"The lion's story will never be told as long as it is the hunter who tells it."

26

Developing Interview Guides: Some Basics

- IG functions as a flexible guide to open up a conversation
- Includes broad, open-ended questions to guide the conversation
- Probes included to ensure that details are elicited (e.g., context, changes over time, what person felt, thought, did)
- IG seeks detailed stories, not generalities

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MORE BASICS

- Questions may come from clinical experience and literature
- Avoid health care jargon, use lay language
- Avoid closed ended questions
- Questions organized chronologically
- Researcher validates understanding during interview: "You felt really undermined.
- Researcher seeks clarification: "I'm confused

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Excellent Probes

- Tell me more.
- What do you mean?
- Give me an example.
- If I had been a spider on the wall, what would I have seen?
- What do you think the (nurse vs patient, parent vs child) was thinking or feeling during that situation?

29

"Remember only this one thing," said Badger. "The stories people tell have a way of taking care of them. If stories come to you, care for them. And learn to give them away where they are needed. Sometimes a person needs a story more than food to stay alive. This is why we put these stories in each other's memory. This is how people care for themselves. One day you will be good storytellers. Never forget these obligations" (Lopez, 1990, p. 48).