Agenda

- Overview of Educational Research
- Developing a good research problem
- Answering your research question through educational research
- An example of a project
An Introduction to Educational Research

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Definition

- Educational research refers to a variety of methods in which individuals evaluate different aspects of education including but not limited to: student learning, teaching methods, teacher training, and classroom dynamics.

Wikipedia
Education – a “Soft” Science

- **Hard sciences**
  - Natural sciences: physics, chemistry, biology, computer science
  - Scientific, rigorous, experimental, mathematical, objective

- **Soft sciences**
  - Social sciences: history, sociology, psychology, education
  - Informal, messy, qualitative, interpretive, subjective

By implication, less good
Educational Research is Hard

- Educational researcher David Berliner wrote,
  - “But the important distinction is really not between the hard and the soft sciences. Rather, it is between the hard and the easy sciences. Easy-to-do science is what those in physics, chemistry, geology, and some other fields do. Hard-to-do science is what the social scientists do and, in particular, it is what we educational researchers do.”

Why Education Research is Hard

• A given pedagogical approach may work:
  ◦ with one student or group of students but not another,
  ◦ with one curricular topic but not another,
  ◦ with the same student(s) and same content in one situation but not another.

• The challenge is that many interacting factors can influence learning, teaching, and education.
Different Research Traditions

- Historical
- Philosophical
- Mixed Methods
- Experimental
- Ethnographic
- Correlational
- Evaluative
- Survey
- Descriptive
- Narrative
- Action Research
Two Broad Categories

- **Quantitative research**
  - uses numerical data and statistical/computational methods of analysis to measure the incidence of some phenomenon, determine how factors relate to one another, or explore cause-effect relationships

- **Qualitative research**
  - uses descriptive information (interviews, observations) to develop a rich, detailed understanding or interpretation of a particular phenomenon or experience

Comparing Quant and Qual

- **Quantitative**
  - Positivist
  - Researcher objective
  - Deductive
  - Research design determined in advance
  - Large sample
  - Numerical methods and relatively efficient analyses
  - Goal to generalize to broader population

- **Qualitative**
  - Constructivist
  - Researcher subjective
  - Inductive
  - Research design may emerge during study
  - Small sample
  - Descriptive methods and time-consuming analyses
  - Goal to understand specific situation
Research Process

1. Identify a broad research problem
2. Review relevant literature
3. Identify a specific question or problem to investigate
4. Determine a research methodology
5. Collect data
6. Analyze and present results
7. Interpret results and report findings
Quantitative methods are used when the questions relate to causality, the comparison of groups, or the relationship of two or more variables.

Qualitative methods are used when the questions relate describing, exploring, or seeking to understand a particular phenomenon or lived experience.
Common Quantitative Methods

- **Experimental/quasi-experimental research**
  - Test whether a particular intervention affects outcomes for a group of learners

- **Correlational research**
  - Examine the relationships between variables when intervention is not possible

- **Survey research**
  - Describe the characteristics of a population by sampling the group
Experiments

- True experiments, with random assignments of subjects, are the “gold standard” of quantitative designs.
  - Quasi-experiments, using intact groups, are often used in educational research.

- Example research question:
  - Do students given visual depictions of sorting algorithms perform better on an algorithms test than students who do not receive visual depictions?

Independent variable – what is manipulated, in this case, the presence or absence of visual depictions of sorting algorithms

Dependent variable – the outcome that is being measured, in this case, performance on an algorithms test
Correlational Research

- Correlational designs are used to assess the relationship between two or more variables when the variables cannot be manipulated or controlled.
  - Correlation ≠ Causation
- Example research question:
  - Are students' attitudes towards computer science related to their gender, age, and number of computer science courses previously taken?
Survey Research

- Survey research is used to characterize a population by gathering information about a sample of that population.

- Example research question:
  - What programming languages are most commonly used by computer science teachers in introductory courses at the high school and college levels in the U.S.?
Common Qualitative Methods

- **Grounded theory**
  - Derive an understanding of a phenomenon by examining the experiences of people who have experiences the phenomenon

- **Ethnography**
  - Study the behavior, beliefs, and language of a group of people who share a culture

- **Phenomenology**
  - Examine the lived experiences of people to gain an understanding of them
Grounded Theory

- Grounded theory is qualitative procedure that is used to generate a theory or explanation of some phenomenon that is grounded in the experiences of the participants.

- Example research question:
  - How do peer interactions influence the learning of students in computer science laboratories?
Ethnography

- Ethnographic designs, originally developed in anthropology, are used to describe and analyze a group of people that shares a culture (i.e., behaviors, beliefs, language).

- Example research question:
  - How do high school computer science teachers conceptualize the discipline of computer science?
Phenomenology

- Phenomenology is a method in which human experiences are examined through the description of people’s lived experiences.

- Example research question:
  - What is the experience of high school computer science teachers in their first year of teaching?
Combinations of Methods

- **Mixed methods**
  - The use of both quantitative and qualitative methods in one study. Methods can be used concurrently or sequentially depending on the aims of the study.

- **Action research**
  - Systematic investigations by teachers, often involving mixed methods, to address practical problems in the classroom or school.
Choosing Your Methods

- Match your approach to your research question.
- Consider your audience (e.g., policymakers tend to prefer quantitative data).
- Do what you are comfortable with based on your own background and training.
Research Ethics

- Get approval from your local IRB to do research with human subjects.
- Follow the ethical guidelines of professional associations such as ACM, APA, and AERA.
- Collect, manage, and report data according to ethical standards.
Educational Research

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Research Problem

Subject area

1. Topic
2. Educational Issue
3. Evidence for the Issue
4. Deficiencies in the Evidence
5. What Remedying the Deficiencies Will Do for Select Audiences

- Subject area: Educational Issue
- Evidence from the literature
- Evidence from practical experiences
- In this body of evidence, what is missing?
- What do we need to know more about?
- How will addressing what we need to know help:
  - Researchers
  - Educators
  - Policy makers
  - Individuals such as those in the study

Creswell (2012). Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research, 4e. Pearson Education
Identifying a Topic

- Can you study the problem?
  - Is there a possibility of empirical investigation?
  - Do you have access to the research site?
  - Do you have the time, resources, and skills to carry out the research?

- Should you study the problem?
  - Does it advance knowledge?
  - Does it contribute to practice?

- Will your study replicate a past study but examine different participants and different research sites?

Creswell (2012). Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research, 4e. Pearson Education
Identifying a Topic

- Narrow and focused topics
  - Broad topics are problematic

- Researchable and non-researchable topics
  - Researchable topics...
    - Can be investigated empirically
    - Have theoretical or practical significance

- Non-researchable topics
  - Cannot be resolved through the collection and analysis of data
  - Address “should” questions

Good Research Problem

- The problem is clearly stated
- The problem will contribute significantly to the body of knowledge
- It will lead to further research
- The problem is researchable (empirically investigates, i.e. data can be collected)
- The problem is suitable (interests you, suits your research skills)
- The problem is ethical (no potential risks to the participants)

Six Guiding Principles [1]:
Committee on Scientific Principles for Education Research

- Pose significant questions that can be answered empirically
- Link research to relevant theory
- Use methods that permit direct investigation of the question
- Provide a coherent and explicit chain of reasoning
- Replicate and generalize across studies
- Disclose research to encourage professional scrutiny and critique

The question [2]

- Figure out what the question is (really)
  - What do you REALLY want to know
  - Can it be feasibly investigated

Decide what sort of evidence would satisfy you
  Better, a reasonable, skeptical colleague
  What does a sufficient answer look like?
    What sorts of evidence would not convince you?
    What would a counter-example/contradiction look like?

Developing the evidence [2]

- What technique or methods would produce that evidence?
  - Quantitative: does it happen
  - Qualitative: why or how does it happen

Don’t think about developing a proof for something. Think about gathering evidence for something.

Get some Feedback

- Groups of 3, 4 minutes per person

- Describe:
  - Your question
  - What evidence would satisfy you?
    - Or not satisfy you
  - What techniques or methods will you use?
A bit more about evidence

Difficulty in Gathering or Analyzing

Strength of Evidence
What have others asked?
Where can I publish it?

- Many thanks to the CE 21 project PIs who generously provided (sample) research questions for this workshop.
  - Let’s just get an idea, the rest are in the slides for your later viewing.

- Computing Education Research Venues
  - Conferences: Practitioner and Education Research
  - Journals
A funded CE 21 project...

1. Does the **number and diversity of CPS students taking** at least the foundation course for the CTE InfoTech increase?

2. In schools that **offer** Taste of Computing, does the number and diversity of students who, having completed the new foundation course for CTE InfoTech, **enroll and completes subsequent years** of CTE InfoTech increase?

3. In schools that **offer** Taste of Computing, are students who complete at least the foundation course for the CTE InfoTech **inspired to pursue further studies**?

4. Does the **number and diversity of CPS teachers** prepared to **offer** the Taste of Computing foundation course for the CTE InfoTech increase?
A funded CE 21 project

- How do different learning-theory informed PD [professional development] options for teaching computing initiate and support teacher implementation of curriculum, and student performance, motivation, and ownership, in various school contexts?

- What is the relationship between professional development experiences and teacher use of SGD [Scalable Game Design] materials?

- How do the different models of professional development relate to different types of mediation for students using the SGD [Scalable Game Design] materials?
A funded CE 21 Project

- Do teachers learn computer science using the examples +practice model?

- Do teachers become more efficient at programming tasks after using examples+practice?

- How do we apply and adapt instructional design practices for computer science?
A funded CE 21 project

- Does using computational music remixing within a formal CS learning environment increase African American student engagement in Computer Science?
A funded CE 21 project

- Can a mix of in-person and online professional development prepare instructors to adopt/adapt curriculum and methods successful in Dr. Simon’s UCSD Computer Science Principles (CSE3) course?

- What pedagogical content knowledge/methods materials and curriculum are effective in supporting the training of CS Principles instructors?

- How do needs and motivations of four target instructor audiences differ (in-service and pre-service instructors; with and without computing backgrounds)?

- Which elements: community building, mentoring, and/or peer support – are most critical to developing and sustaining new computing instructors at the high school level?

- How do attitudes and experiences change among underrepresented audiences taking CS Principles (both secondary students and those training to become teachers of this course)?
Computer Education Conferences

- Education Research
  - ICER: International Computing Education Research

- Practitioner
  - SIGCSE
  - ITiCSE: NOT just technology
Computing education, as a research discipline, is the study of how people come to understand computational processes and devices, and how to improve that understanding. As computation becomes ubiquitous in our world, understanding of computing in order to design, structure, maintain, and utilize these technologies becomes increasingly important – both for the technology professional, but also for the technologically literate citizen. The research study of how the understanding of computation develops, and how to improve that understanding, is critically important for the technology-dependent societies in which we live.

Learning and Instruction both areas of interest
Computing Education Research employs methodologies from many fields, amongst them psychology, education, anthropology and statistics. As a consequence, research is frequently characterised by a diversity of methodological approaches; these may be applied directly, or may be combined and modified to suit the particular cross-disciplinary questions that we ask.
ICER 2011 (a subset)

- Choosing Computing:
  - Deciding to major in computer science
  - How CS majors select a specialization
  - CS Majors’ Self-Efficacy Perceptions in CS1: Results in Light of Social Cognitive Theory

- Collaborative Learning:
  - Peer Instruction: Do Students Really Learn from Peer Discussion in Computing?
  - PeerWise: Exploring Conflicting Efficacy Studies

- Informal Learning
  - Students’ Perceptions of the Differences Between Formal and Informal Learning.
  - ScriptABLE: Supporting Informal Learning with Cases.
ICER 2011 con’t

CS1:
- What students (should) know about OOP
- Predicting At-Risk Novice Java Programmers Through the Analysis of Online Protocols
- Explaining program code: giving students the answer helps – but only just

Tools and Techniques:
- CAL Programming Tutors that Guide Students in Solving Problems and Help Students Building Skills.
- Personifying Programming Tool Feedback Improves Novice Programmers’ Learning.
- The “Prototype Walkthrough”: A Studio- Based Learning Activity for Human- Computer Interaction Courses.
Previous ICER themes

- Student pre-conceptions of various computing concepts
  - Large-scale, multi-institutional studies of students real-world experiences and understandings of various computing concepts

- Surveys of what CS ed research has been done

- Analysis of value of tools (both supporting teachers and supporting students)

- Student (and instructor) perceptions/self-theories (learning computing, of outsiders re: computing, of students)

- Gender issues

- Tools: Faded worked examples, programming language supports, etc.
Papers may present work at different scales, from classroom-based empirical studies through evaluative comparisons of pedagogic approaches across institutions or countries and of different types from the practical to the theoretical.

The Journal is not dedicated to any single research orientation. Studies based on qualitative data, such as case studies, historical analysis and theoretical, analytical or philosophical material, are equally highly regarded as studies based on quantitative data and experimental methods. It is expected that all papers should inform the reader of the methods and goals of the research; present and contextualise results, and draw clear conclusions.
Papers published in TOCE take a scholarly approach to teaching and learning, establish a clear connection to student learning, and appeal to a broad audience interested in computing education: instructors, researchers, curriculum designers, and administrators.

The topics covered by TOCE will range across diverse aspects of computing education including

- traditional computer science, computer engineering, software engineering, information systems, information technology, and informatics;
- emerging aspects of computing; and
- applications of computing to other disciplines, such as computational biology.
Research Designs
Experimental Research Design

- Researcher manipulates the independent variable
  - Experimental and Control groups
- Measure each dependent variable
- Control extraneous variables to remove any rival hypothesis
Examples :: Experimental Research Design

- One group pre-post test

<table>
<thead>
<tr>
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<th>Pretest</th>
<th>Independent Variable</th>
<th>Posttest</th>
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<td>Y₁</td>
<td>X</td>
<td>Y₂</td>
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- Randomized post-test only

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<td></td>
<td>Exp</td>
<td>Y₁</td>
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<td>Y₂</td>
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Examples :: Experimental Research Design

- **Counterbalanced Design**

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<thead>
<tr>
<th>Class A</th>
<th>Topic 1</th>
<th>Topic 2</th>
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<td>Control</td>
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<table>
<thead>
<tr>
<th>Class B</th>
<th>Topic 1</th>
<th>Topic 2</th>
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<tbody>
<tr>
<td>Experimental</td>
<td>Control</td>
<td>Experimental</td>
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</table>

- **A-B-A-B Design**

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<thead>
<tr>
<th>Phase A</th>
<th>Phase B</th>
<th>Phase A</th>
<th>Phase B</th>
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<tbody>
<tr>
<td>Control</td>
<td>Experimental</td>
<td>Control</td>
<td>Experimental</td>
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</table>
Validity: Internal

- Internal validity refers to the degree to which observed differences in the dependent variable are a direct result of manipulation of the independent variable and not some other variable.

- Internal validity is concerned with the confidence with which plausible rival hypothesis can be ruled out as explanations for the results.

Threats to Internal Validity

- History
- Maturation
- Repeated Testing
- Instrumentation
- Selection
- Attrition
- Diffusion
Maintain Internal Validity

- Randomly Assign Participants
- Select homogeneous group of participants
- Use participants as their own control (e.g., A-B-A-B design)
- Control for situational differences (e.g., Counterbalancing)
External Validity

- External validity is the extent to which the results of an experiment can be generalized to people and environmental conditions outside the context of the experiment.

- External validity threats can be divided into two categories:
  - ‘Generalizing to whom’ threats
    - Threats affecting groups to which the study can be generalized
  - ‘Generalizing to what’ threats
    - Threats affecting the settings, conditions, variables, and contexts to which the results can be generalized.

Designing an experiment

- Based on what we’ve discussed so far
  - Propose an experimental research design based upon a hypothetical research question or use a research question from someone in your group. Provide rationale for all the decisions you make. For example, would you need pre-tests? Describe how you would enhance internal and external validity. Also, discuss what sort of instruments and measures would need in your experiment.
What is Causal-Comparative Research

- Used to investigate causal relationships
- To investigate how an identified independent variable affects the dependent variable
- In causal-comparative research the groups are already formed and already differ in terms of the independent variable
- E.g., What is the effect of learning style on student learning?
Comparison to Experimental Research

- **Experimental**
  - Individuals randomly assigned to treatment groups
  - Independent variable manipulated by the researcher

- **Causal comparative**
  - Individuals already in groups before research begins
  - Independent variable not manipulated
    - Cannot
    - Should not
    - Is not

Survey Research

- **Definition and purpose**
  - Survey research involves collecting data to answer questions about people’s opinions on some topic or issue.
  - Surveys product close estimates of what people think or do (at best)
  - A survey is an instrument to collect data that describes characteristics of a population.

Types of Surveys

- Mail surveys (paper or web)
  - Strengths:
    - Require least amount of resources
    - Provides more anonymity
  - Weaknesses:
    - Can produce most nonresponses
    - Researcher lacks control over process

- Telephone interviews
  - Strengths:
    - Produces results quickly
    - Greater interviewer control
  - Weaknesses:
    - Exclusion of individuals, particularly certain populations
    - Need knowledgeable interviewers

- Face-to-face interviews
  - Strengths:
    - Avoids pitfalls of other methods (i.e., reading, no phone)
  - Weaknesses:
    - Higher cost
    - Need good interviewers

Considerations of Survey Research

- Most surveys include one of two types of items.
  - Structured items or closed-ended items for which participants choose among possible responses (e.g., Likert scale).
  - Unstructured items in which participants have freedom of response (e.g., fill-in answer).

- More accurate surveys would involve
  - Every member of population having equal chance of being selected
  - Use of clear, unambiguous questions
  - Everyone responds (or nonrespondents are similar to respondents)

Guidelines to consider when constructing a questionnaire:

- Include the purpose of the study at the top of the instrument.
- Write directions for the respondents.
- Define terms.
- Include only items that relate to the objectives of the study.
- Collect demographic information.
- Avoid leading questions.
- Avoid sensitive questions to which respondents might not answer honestly.
- Organize items from general to specific.
- Have others read your instrument and provide feedback.
- **Pilot test the questionnaire.**

Pilot Testing

- Test on a small number of individuals in the sample
- Ask for written feedback on the questions
- Revise the survey based on the written comments
- Exclude the pilot participants from the final sample for the study

To improve response rate

- Research suggests:
  - E-mail cover letters
  - Follow-up reminders via e-mail
  - Pre-notification with intent of survey
  - Simpler formats
  - Shorter surveys
Find a topic that interests your group. Design a study that utilizes survey methodology. Discuss all aspects of the survey research. Why does survey methodology fit your research? What type of survey will you use (paper, web, telephone, interview)? What types of questions (closed-ended, open-ended)?
Qualitative Research

Know how to listen, and you will benefit even from those who talk badly

- Plutarch
Computer Science Educational Research:
An Equity-Based Research Program in Los Angeles public schools
Set of 3 successive research studies created to study equity issues in computer science education:

1) Reasons for Underrepresentation
2) Studying Exploring Computer Science
3) Examining Quality Teaching
(1) Constructivist Approach to Research
Studying the Reasons for Underrepresentation

California Enrollment and APCS Exam Participation 2004

- White: 39% (Test-takers) 32% (Students)
- Asian: 46% (Test-takers) 11% (Students)
- Latino/a: 46% (Test-takers) 6% (Students)
- African American: 1% (Test-takers) 8% (Students)
Research Design: Studying the Reasons for Underrepresentation

**Question:** Why are so few African American, Latino, and female students studying computer science in high school?

**Strategy of Inquiry:**
- Qualitative case study approach of 3 LA high schools, each with different student population
- Methods: Interviews with students, teachers, counselors, administrators, district officials; engaged in regular classroom observations over 3 years; document analysis
- Role of reflexivity in constructing case studies
- Analyzed qualitative data in grounded approach to generate theories and inductively develop patterns of meaning
- Findings represent different perspectives and understandings of students and educators within a larger sociocultural context.
Findings: Studying the Reasons for Underrepresentation

- What is computer science, anyway?
- Course offerings vary between schools
- Computing courses have no academic home
- Culture of low expectations around computing knowledge
- Little curricular connections with students’ experiences
- Counselors need information
- Teachers need support
- Students have interest!
(2) Participatory/Advocacy Research: Studying Exploring Computer Science
Research Design: Studying Exploring Computer Science

Question: What are the curricular resources, professional development supports, and policies changes needed to broaden participation in computing in a large urban school district?

Strategy of Inquiry:

- Mixed methods study with school district as unit of analysis
- Methods: Longitudinal interviews with teachers, interviews with administrators, classroom observations, professional development participation rates and evaluations, district officials; classroom observations; district and state policy analysis; pre- and post-course quantitative surveys of students and teachers; collection of demographic enrollment data
- Role of advocacy and dialectical role for research team
- Concurrently analyzed mixed method data in order to better understand the problem at hand; ongoing analysis informed the design of the “intervention”
- Findings represent attempt to capture “what works” within the realistic social, economic, and political context of schools
Findings Part I:
Studying Exploring Computer Science

<table>
<thead>
<tr>
<th>Enrollment in New Course</th>
<th>2009-10</th>
<th>2010-11</th>
<th>2011-12</th>
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<tbody>
<tr>
<td># schools</td>
<td>16</td>
<td>16</td>
<td>25</td>
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<tr>
<td># teachers</td>
<td>16</td>
<td>16</td>
<td>29</td>
</tr>
<tr>
<td># classes</td>
<td>17</td>
<td>36</td>
<td>62</td>
</tr>
<tr>
<td># students</td>
<td>306</td>
<td>1377</td>
<td>2049</td>
</tr>
</tbody>
</table>

- 70% Latino/a
- 9% African American
- 40% Females
Findings Part II:
Studying Exploring Computer Science

1) **Curriculum**
   - Common curriculum leads to conversations about teaching and learning; focus on teaching rather than gathering curricular resources or learning new tools.
   - Common curriculum provides cohesive instructional strategy of inquiry to be used in classrooms.
   - Curriculum’s emphasis on concepts, rather than particular programming languages or tools, was important for learning.

2) **Policy**
   - School policies support availability of course, instructor selection, and counseling of students towards course.
   - District policies support institutional structures for course offering.
   - State policies can be garnered to give academic credit to course.

3) **Teacher Support**
   - Ongoing Summer Institutes and quarterly Saturday workshops necessary for learning ECS content, inquiry-based pedagogy, and equity-based teaching practices.
   - Two-year model blends novices and veterans together.
   - These programs should focus on pedagogy from the beginning. This is what makes teaching most effective in classrooms.
   - Tensions between content and pedagogy.
   - Limitations of PD.
   - On-site coaching important opportunity for deepening this PD work.
   - Long-term teacher support programs lead to professional teacher communities that can develop internal leadership and build capacity for sustainability.
(3) Studying Quality Teaching: Pragmatism
Research Design:
Studying Quality Teaching

**Question:** What are the characteristics and instructional practices of effective computer science teachers?

**Strategy of Inquiry:**
- Ethnographic study of 8 classrooms (17 other classrooms have infrequent visits)
- Methods: Longitudinal interviews with teachers, interviews with students, interviews with administrators, regular classroom observations; analysis of student work; student achievement data
- Role of reflexivity around issues of “effective” and “quality”
- Thematic analysis will take place next year
Community of Research Participants