Undergraduate Research Experiences for Pre-Service Teacher Candidates: Necessary Conditions for Productive Projects

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Abstract: Institutions of higher education have increasingly motivated faculty to involve undergraduates in their research. These can be excellent opportunities for education researchers interested in working with pre-service teacher candidates (PSTCs). This article demonstrates the necessary conditions required for successful research experiences and includes two sample projects involving PSTCs.

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Introduction

Since the early 2000's, institutions of higher education have increasingly motivated their faculty to provide research experiences to undergraduate students. Beginning in STEM disciplines and expanding to all areas of research, these opportunities are exciting potentials for undergraduates to grow and can also further faculty research and teaching goals. Teacher educators work with pre-service teacher candidates as their primary body of students, most of whom are near the beginning of their careers with limited or emerging field experience in classrooms. Thus, for education researchers, we can find it difficult to think about how to involved our undergraduate students in our research projects. This paper reflects on one teacher educator who successfully involves undergraduates in high-level research and reveals a particular set of necessary conditions for teacher education faculty who would like to complete research with their pre-service teacher candidates. After sharing these, the article provides two sample research projects completed with undergraduates; thus, this paper is coauthored by an educational researcher and two undergraduate teacher candidates.

The article begins with a review of the emergence of involving undergraduates in research and what benefits are clearly known. Next, the benefits to the unique considerations of education research are detailed, out of which emerges a suggested set of "necessary conditions." These conditions are intended to be useful for teacher educators who would like to try the experience for the first time and for the many who have already involved undergraduates in their research projects but would like to reflect on their prior experiences. In the section that follows, two example projects are shared. The first is an action research project in the researcher's teacher education classroom that scaffolds the learning of instructional delivery practices with the use of improv theatre. The second is a media analysis project using critical discourse analysis that reveals understandings about national news coverage of mathematics education. The two projects differ in method and sub-discipline of education research, demonstrating the breadth of possibilities for involving undergraduates. After the project descriptions, the students' reflections complement the lead author's reflections on the productivity of undergraduate education research.

Undergraduates in research: From STEM to all disciplines, including education

There is much research and activity in undergraduate research experiences, including organizations that support this across institutions of higher education. Beginning with the early research, Russell et al. (2007) provide both the key benefits and suggestions for best practices. They note that undergraduate STEM majors who were involved with research projects, and especially ones funded by the National Science Foundation and other funding bodies, had an increased interest in pursuing a STEM career as well as plans for a PhD in STEM. Moreover, students benefited when they "became involved in the culture of research" and mentors should "combine enthusiasm with interpersonal, organizational, and research skills" (p. 549).

Over time the American Association of Colleges and Universities (AACU) has developed their set of "high impact practices" for institutions to include, with undergraduate research as a prominent item on the list. Currently, they specify how this must be much broader than research occurring in the science labs: "The goal is to

involve students with actively contested questions, empirical observation, cutting-edge technologies, and the sense of excitement that comes from working to answer important questions" (AACU, 2022, n.p.). The AACU supports and publishes research in leveraging the most out of undergraduate research, e.g., with Brownell & Swaner (2010).

Since these earlier studies many articles declare the benefits and best practices of undergraduate research. One of these, Fischer et al. (2021) provides an excellent review of what is known from among these contributions and explicitly moves the conversations about best practices in undergraduate research beyond STEM fields. As researchers across disciplines (two in STEM, one in performing arts, and one in social sciences), they review much of the literature's suggestions of the benefits: including gaining experience in the techniques of research, appreciating the discipline of study much more deeply, working on project teams, greater retention in their major and postgraduate pursuits in the discipline. They also note that these benefits occur across student identity and are especially beneficial for those underrepresented in academic disciplines: women, BIPOC, and lower socioeconomic status students specifically.

Fischer et al. (2021) also contribute a very helpful taxonomy for "high-impact" projects involving undergraduates because the undergraduate research experience can be rather varied:

> Student immersion into a disciplinary problem with a research mentor lends itself to a highly engaging-learning experience. However, mentors do not always know how to fit the work that needs to be done on their own research to the skills and knowledge of students who want to get involved. The actual tasks assigned to a student will vary across disciplines and even students with prior research experience may not be well prepared to fit into a new project. In addition to a wide range of possible tasks is variability in the level of autonomy afforded to the student. Looking holistically, undergraduates experience inconsistency in the range of opportunities and skills gained from undergraduate research. Thus, what is missing from prior studies of undergraduate research as a +IP is a clear delineation of the components and dimensions of the research experience and what make it high impact. (p. 89)

Their taxonomy includes the following indicators: "Originality of research; Systematic disciplinary inquiry; Evaluated research process work; Activities emphasize research; Required project; Mentoring" (p. 91). Each component is detailed with examples and further guidelines. For example, for originality of research, the authors push research mentors to consider research questions for which both the mentor and the student do not know the answer. As another example, the required project suggests that mentors define target projects for the undergraduate, such as presentations at research conferences or publications. Their taxonomy's elements provided inspiration as I developed my own necessary conditions for productive education research involving pre-service teacher candidates.

Along with the research, several institutes and organizations work across institutions of higher education to support undergraduate research experiences. One of these is the Council on Undergraduate Research whose board members are comprised of academic leaders across US colleges and universities. Their mission supports and promotes "high-quality mentored undergraduate research, scholarship, and creative inquiry" (CUR,

2021). They provide consultations for universities to promote undergraduate research, professional development for research mentors, and recognition for institutions that are good at providing high impact undergraduate research experiences. CUR includes divisions associated with academic disciplines, including a division specifically for Education. One Education Division activity is providing small funding for mentor-student research collaboratives as well as awards for mentor-student projects. The Division's biannual newsletters, located on their website, prove inspirational reading to see the types of projects education researchers have enacted with their undergraduate students.

Each institution promotes undergraduate research experiences differently and it is important to note how the examples described in this article relate to the particular context, specifically Kutztown University. This regional public university has embraced the call for undergraduate research for several years. We have one faculty member who coordinates the Undergraduate Research and Creativity program for the university. The program disseminates research opportunities for our undergraduates and holds an annual conference for undergraduates to share their research and creative projects. The program works closely with the university's Office of Grants and Supported Projects, who annually run the KU BEARS (Kutztown University Bringing Experiences About Research in Summer) grant opportunity. The KU BEARS program is a competitive grant opportunity for faculty summer research. Faculty can apply for up to $2000 and all funds for the grant are to be used to pay a salary stipend for undergraduates involved in research. Faculty members select the undergraduates they want to work with for the summer. Additionally, the undergraduates involved in the project are offered free on campus housing for the duration of the summer project.

Necessary Conditions for PSTC Research

Taking together what is known about undergraduate research experiences, the researcher sought to adapt these as a set of necessary conditions for a successful experience involving pre-service teacher candidates. These grew out of the general literature on undergraduate research experiences but specifically target the unique circumstances that our undergraduates are pre-service teacher candidates. The five tenets developed are: Pre-service teacher prior knowledge; Faculty motivation; Pre-service teacher responsibilities; Rigorous methodology; and Satisfying finding." Each of these is described as follows, relating them to the literature and practices of undergraduate research more generally.

Pre-service teacher prior knowledge

Because undergraduates are pre-service teachers, it becomes important to develop projects that relate to prior experiential knowledge and carefully negotiate their research responsibilities with their career experience. For example, it may be hard to find a way to involve undergraduates in any projects related to empirical study of teachers because they are only beginning to have classroom teaching experiences. As another example, when involving an undergraduate in a project that studies the researcher's own classroom practices and its effects on the students, this should only occur when the undergraduate student has already completed the course that is being studied. Most important to this consideration, the researcher must identify projects that the undergraduate has experience with and knowledge about,

perhaps to complement that of the lead researcher. This may relate to an interest or activity that the student has significantly more knowledge about than the teacher educator. This balances what the mentor and student bring to the table and increases motivation to work and learn together mutually.

Faculty motivation

Furthering the motivation for the faculty mentor, they need to feel confident and excited about how to relate the student's prior knowledge to an area of inquiry within their own educational research sub-domain. A handful of possibilities exist. One is research that can improve our teaching. Thus, an opportunity to relate the student's prior knowledge to an action research project in your own teaching might be a good approach. Another option is to think about previous publications and areas of inquiry as they relate to the student's interest: How can this merge into a definable project? This necessary condition relates to Fischer et al's tenet of "originality of research:" Faculty mentors will be highly motivated when they define a project whose area of inquiry is relevant to their own work and the answers to research questions posed are not yet known by the faculty member.

Rigorous methodology

As the review of research on undergraduate research experiences revealed, students have varied experiences and some literature suggests that undergraduates working on NSF or other large-scale funding body leads to better outcomes. One interpretation of this conclusion is that the project has better outcomes for students when it is legitimate, high-level research. A project's methodology should be something that the mentor has experience and training using and is able to train an undergraduate to be responsible for specific components of its execution. Many times, undergraduates come into a research experience with their background knowledge of the term "research" in the colloquial, as if they are going to research a topic and bring together some ideas that they learned into an essay or presentation. Mentors should not fall prey to this expectation, merely thinking of their collaborative projects as simply a literature review. In suggesting a rigorous methodology, this comes in quite a variety of forms for education research, not limited to empirical studies using quantitative or qualitative methods, but also the inclusion of projects that use rigorous policy analysis methods, philosophical or theoretical methods, etc.

Pre-service teacher candidate responsibilities

A typical education research project includes, roughly speaking, a problem statement, a conceptual framework, literature review, a methodology, data and analysis, and conclusion. These vary according to sub-discipline and methodology, they are a bit different for conceptual projects, but there are a variety of components to any research project. The faculty mentor needs to determine what are reasonable responsibilities to delegate to the undergraduate student given the timeframe of the project and their background knowledge. For example, limited timing may allow an undergraduate to only complete the literature review. A rigorous literature review requires training to locate peer-reviewed resources, use multiple keywords to exhaust all literature, write annotated bibliographies, and turn these into a narrative literature review for use in a manuscript. Another area of responsibility

could be coding data. To do so, the undergraduate needs to complete ethics in human research training (if applicable to the data collected) and be trained by the mentor on coding methods. Whether or not a student is involved in one or multiple steps of the project, they should be taught the full scope of the project, so they see how their responsibilities fit into the whole project.

Satisfying findings

The final necessary condition for successful projects is less something that can be determined in advance but something that should follow if all other parts are in place. To acculturate undergraduates most effectively to research life, the project needs to come to satisfying research findings. The joy of discovering something that is of mutual interest to the faculty and student will be especially memorable for the student and will validate the experience and challenging work. A satisfying finding could either bring together questions posed by the research project and its data, could fill holes in the existing literature, and, in my view the most exciting, could address conceptual issues related to the theoretical framework. With strong motivation and a rigorous methodology, the goal of a satisfying finding can be set up to sustain the project. In my experience, the mentor sees the satisfaction first and should elaborate on its development and resolution a few different ways to make sure it is clear for the student.

Two examples of education research involving pre-service teachers

With these necessary conditions for inviting undergraduates into the world of education research at hand, next are two examples of research projects that were completed at our university's summer undergraduate research program. David Mohamad worked on the first, an action research project for my Principles of Teaching class that used improv theatre to develop best practices in instructional delivery. Another undergraduate at my institution participated in this project but was unable to contribute to providing reflections for this article. Michael Mistler worked with me on the second project that used critical discourse analysis to understand the national news media coverage of mathematics education policy. To share more details on each project, we offer a very abbreviated version of each project including references to existing literature and write with a narrative, active voice to describe how the project emerged.

For the improv theatre project, the initial problem of practice was to develop new interventions for teaching students how to best deliver instruction in the classroom. Mark explained how there was an idea about "teaching as performing" and David came to the project team with a lot of experience in improv theatre. We set about focusing on Mark's teaching intervention on how to use improv to improve my teaching practices. The project team identified several resources related to teaching as a performative activity, including Rubin's (1995) comprehensive exposition on teaching as performance and Pineau's (2004) consideration of the metaphor's problems. With this more refined focus, the most relevant literature for our project became Falter's (2015) feminist critique of the teaching of performance metaphor. She declared that, when left untroubled, the metaphor lent itself to the gendered nature of teachers as the inferior, the feminine, following the "script" of explicit curriculum that society has handed to them. Our project team found hope in the opportunity of using improv as a rejection of this scripting of teaching.

As the teaching intervention developed, David presented several improv theatre game options for Mark to relate to the professional standards of teaching. As one example, one goal we have as teacher educators is to develop our candidates' ability to use active question and discussion in their classrooms. This requires the ability to ask good questions spontaneously and to have the mindset of "ask questions" rather than "tell answers" both in whole class, small group, and individual settings. To develop this mindset and habit, our project team identified the improv theatre game called "Questions Only" in which a pair of players tells a story by asking only questions. Although the types of questions used in the classroom are different than the game's questions, playing the game pushed the teacher candidates into a mindset and habit of asking questions more frequently.

Several additional improv theatre games were related to effective teaching practices. Extending their work beyond the summer project, my undergraduate student researchers attended class during the academic year to help facilitate these games. This was especially useful because of David's experience with improv theatre. In the following summer, the project team coded the data from the classroom and discovered several significant findings. First, the teaching intervention developed the teacher candidate's confidence in front of a classroom and with a range of teaching practices. Second, the intervention over time developed in candidates a sense of the performativity of teaching and, excitingly, qualitative data was coded to reveal a striking finding: participants felt more that teaching was spontaneous and unscripted, thus the teaching intervention appeared to engage directly through the conceptual question's posed by Falter's (2015) feminist critique of teaching as performance. The research findings, especially this last moment that engaged with theory, were a memorable highlight for the project team. These research findings were incredibly helpful for Mark's teaching practice, and he continues to refine these tools for use in my classroom.

The second research project was completed by Mark and Michael. As a secondary mathematics teacher candidate, Michael expressed a significant interest in knowing more about the politics of mathematics education and had prior experience in the performing arts and news media. Mark considered how this might integrate with his own research trajectory in mathematics policy analysis, e.g., Wolfmeyer (2013). He knew that mathematics education topics were increasingly being covered on national news networks and with some interesting discussions that would advance Michael's understanding of mathematics teaching. So, we selected this coverage as our unit of analysis and drew upon rigorous methodological examples that use critical discourse analysis methods to explicate meaning from news events. Our literature review included several newer pieces on news media coverage of mathematics education such as Abtahi & Barwell (2019) and Andersson et al (2021). These and other contributions outside of mathematics education, e.g., Goldstein (2010), generated a concise methodology using both frame and content analysis for the news events we identified.

An initial, interesting finding set us on a satisfying path early on. We realized that in selecting events from among the last 6 years (2015-2021), mathematics education was a topic covered inequitably across national news networks. We only identified a small number of news stories about mathematics education on CNN and MSNBC programs but several on Fox News. As we worked through both frame and

media analysis, we developed other striking findings. Although the news coverage contained the topic of mathematics education, other points beyond mathematics education seemed to be the priority. For example, one news media story spent more time discussing racial politics than it did mathematics teaching and learning. We do not suggest that racial politics has nothing to do with mathematics teaching, it certainly does! Our analysis of the news media indicated that racial politics, in favor of a continuation of things "as they are" and dismissal of advancements of equity, were the primary goals of the coverage rather than a discussion about mathematics classrooms.

Our primary conclusion, another satisfying result, was that mathematics education typically covered in national news stories advanced controversial policy discourses broader than mathematics education. In other words, we viewed the coverage of mathematics education as a tool for advancing particular ideologies, usually related to continued systems of power and oppression. As one clear example, we located a 2018 mathematics news event that ended up discussing at length the concept of meritocracy. As teacher educator and teacher candidate, we both knew well that public education functions in the mythology of meritocracy by providing a false sense of equal opportunity for all when we know that opportunity gaps (Milner, 2020) exist in public education. One counter-discourse that often appears in conversation suggests that meritocracy does function and everyone, regardless of their race, has equal opportunity even when the data does not support that conclusion. These conversations, as it did in the 2018 news event, go even further with declarations like "saying that meritocracy is embedded in societal racism" is a racist concept itself. Most recently, this twist on the concept of meritocracy appears also in the 2021 Pennsylvania House Bill No. 1532 (still in active legislation at the time of manuscript publication), also known as PA's Anti-CRT bill. One of their defined "racist concepts" that should be banned from teaching in higher education includes that "Meritocracy or merit-based systems are either racist or sexist." For Michael and Mark, our striking finding was seeing how the mathematics education news coverage three years prior had advanced a political discourse that now shows up directly in active legislative documents in our home state. More generally, during the data coding process we engaged in significant discussions about policies and practices of mathematics teaching including anti-racist pedagogies, traditional versus reform teaching, and detracking mathematics classrooms. Through the coding process Michael deepened both his understanding of mathematics pedagogies and the policy discourse landscape of public education.

Table 1 further indicates the ways that these two projects correspond to the necessary conditions for involving pre-service teacher candidates in education research.

Table 1: *Two examples of projects with necessary conditions*

	Improv and Instructional Delivery	Mathematics Ed in the National News
PSTC prior knowledge	-experience in improv theatre	-experience in performing arts, film, and media
Faculty motivation	-integrates feminist and performance theories into teaching -action research to improve classroom instruction	-continues project of national mathematics ed policy studies
Rigorous methodology	-classroom action research including IRB	-critical discourse analysis
PSTC responsibilities	-literature review -intervention development -enactment of protocol -transcribing -coding of data	-literature review -development of methodology -transcribing -coding of data
Satisfying finding	-improv reveals the performative yet spontaneous nature of teaching -use of improv increases ability to deliver instruction -disrupting gendered expectations of teaching profession	-coverage of mathematics ed in the news is not consistent across news platforms -coverage is less about math, more about politics -coverage uses mathematics ed to advance other policy discourses to continue systems of power and oppression

Student Reflections and Conclusion

Throughout the process, Mark made clear to both David and Mark that the research must accord with the necessary conditions. To continue their experience, Mark invited each to contribute their own reflections in this article and asked that they write through these reflections using the language of the necessary conditions.

From David: From my research experiences, I now aim to become a professor later in life. The project we worked on taught me the rigorous methodology involved in action-based research and I will now be better prepared in completing projects like it in the future. I learned how to appropriately obtain data from students and how to effectively look at it when compiled. Although the results we obtained were not exactly what I expected, they were very satisfying to find. In many ways teaching is a performance art. The purpose of this research was to examine Danielson's Framework of Teaching and to see how effective the students took in the information, mostly by connecting my background in improv theatre, and see how well the students were able to perform as teachers in the classroom as a result. Specifically, to my own goals as a future teacher and researcher, I strengthened my

observational skills in research and my performance skills in teaching, especially since I was unaware of Danielson's Framework before the research. This allowed me to gain a deeper understanding my junior year when I was using the framework myself.

From Michael: One of the main things I grew to appreciate was the rigorous methodologies that researchers must use. Before this project, I thought research was conducted in the manner most 10th graders "research" a topic for a paper. However, now I understand that research is about identifying a problem, looking at previous publications to identify a strategy to solve the problem, developing your method, and retrieving the data. Now I can describe what research is and be able to read publications accurately. Second, I grew as an educator, and this relates specifically to our project's focus and my prior knowledge. With my background in news media and interest in politics, I was excited to dig into an investigation about how mathematics education was covered. Our satisfying finding was surprising, it caused me to now know that sometimes people's views about education stem from these news networks. Our job as educators is to properly inform and advocate for the best possible education for our students. This research project has encouraged me to be a voice that uses ideas created by researchers. Therefore, this project has easily exceeded my expectations because I now have a new educator purpose.

David and Michael's reflections provide a glimpse into the possibilities for other education researchers to harness the excitement and productivity of undergraduate research experiences. We encourage education researchers to involve undergraduates in their research projects and to consider these necessary conditions as a starting point. For those who have done this before, we invite you to reimagine your work using these necessary conditions. The possibilities of research topics are endless given the broad range of interests that teacher candidates have and to which education researchers can connect research topics. If done with attention to rigor, successful projects will lead to a deepening of knowledge about teaching in the short term, the deeper appreciation of education research in the short and long term as a means for teacher development, and for the development of more education researchers in the long term. Whether an undergraduate pursues research full time later or prioritizes teaching for most of their career, clearly their approach to teaching will be much more research-minded in practice and that they will use action research methods to deepen practice. Further research, as longitudinal studies, can codify the specifics of these long-term effects of undergraduate research experiences in education. This approach and others are necessary future projects to fully explore the ways that undergraduate research experiences are a good fit for pursuit by teacher education faculty.

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