Barriers to Transformative Learning in Undergraduate Research: Helping Student Researchers to Embrace the Hurdles

SARAH B. LOVERN
Concordia University Wisconsin

Abstract

Data shows that undergraduate research is a high impact practice utilized as an essential part of many college campuses (Sternquist et al., 2018). Within the last decade, much of this influence on student success is beginning to be attributed to transformative learning. Transformative learning involves the student in more than just learning about problems. It causes the individual to undergo significant phases of reassessment and growth that challenges old assumptions and takes the student towards higher-level thinking processes and new directions (Mezirow, 1978). However, this is not an automatic transformation that occurs when a student first engages in an innovative research project. Many students falter when first exposed to the need to move up Bloom's taxonomy from simply memorizing facts or concepts to applying them in the research setting. Therefore, undergraduate research mentors are challenged to not only teach the skills of the discipline, but also help students increase metacognition to aid in the transformative process. With this dual responsibility, several pitfalls in the process can be found including: 1) Time constraints on faculty and student engagement in the research process, 2) Ill-prepared students lacking foundational knowledge as well as fundamental skills, and 3) An increase in students' participating in research only to fulfill an admission requirement for graduate programs. These three aspects are discussed in terms of why they exist for the student population and how mentors can help the students embrace these hurdles in an effort to gain greater understanding of why the research is beneficial to their development as an undergraduate student and a lifelong learner. This includes recognizing and identifying learning bottlenecks (Middendorf & Shopkow, 2018), overcoming student resistance, and developing a welcoming research culture that recognizes students come from a variety of frames of reference (Taylor, 2008). Mentors must help students to acknowledge how the frame of reference is unique for everyone on a team, even in disciplines which are traditionally believed as completely objective. Practical guidance for mentors to overcome the three major barriers mentioned above is provided to increase transformative learning growth of student researchers.

Keywords: transformative learning, culture, undergraduate research, bottleneck, threshold concept, mentor

Introduction

The high impact practice of undergraduate research is a high-impact strategy used by many institutions of higher learning (Sternquist et al., 2018). Additionally, more and more focus on transformative learning and its impact on student achievement that has occurred over the last decade. Transformative learning changes from the traditional focus of the student simply encountering and solving a problem. Transformative learning shifts the focus towards higher-level thinking via significant phases of reassessment where the student continually reassesses old assumptions and must apply new ideas or techniques to the curriculum (Mezirow, 1978). Undergraduate research has been shown to increase satisfaction of learners and retention of specific research skills (Lopatto, 2004), but can it also improve transformative learning? Since the retention of STEM undergraduate majors throughout U.S. colleges and universities is quite poor compared with other majors, Wilson et al. (2012) developed a model that incorporates undergraduate research to increase retention. This model involved three tiers: traditional strategies involving support via academic advising and early intervention is the first tier in the model, an integrated undergraduate research experience, and faculty mentoring. Mentoring and research opportunities combined to help students become metacognitively aware and allowed students to outperform colleagues not participating in the program (Wilson, 2012). Possibly more noteworthy is that participants in the program developed constructive strategies for enhancing their higher-order thinking skills which helped with scientific understanding and improved performance in coursework (Wilson et al., 2012). Both the development of self-examination skills and increased mastery of discipline-specific competencies can be considered transformative learning. Therefore, this study strongly confirms that transformative learning can be achieved via undergraduate research.

However, it is not an automatic transformation that occurs when a student first engages in an innovative research project. Many students find comfort in memorizing simple facts or concepts and being quizzed or tested on this information. It is when they are challenged to think critically or apply this basic material in new scenarios, such as undergraduate research, that many formerly-successful students falter. A hesitation to advance upward on Bloom's taxonomy is a common attribute of the beginning research student. Therefore, undergraduate research mentors are tasked to not only teach the discipline-based techniques and modes of inquiry, but also help students increase metacognition to aid in the transformative learning process. With this dual responsibility, several pitfalls in the process can be found including: 1) Limited time available for faculty and student engagement in the research process, 2) Ill-prepared students lacking in foundational knowledge who struggle to complete basic tasks, let alone move to cognitive expertise of the subject matter and the process occurring, and 3) An increase in students' desire to participate in research solely as a pre-requisite for graduate programs or as part of a capstone course. Fortunately, each of these three areas can be remedied to allow for transformative learning to occur and greatly impact the success of each student. Below is a discussion of these obstacles along with why each exists and how mentors can help embrace these hurdles in an effort to gain greater understanding of why the research is beneficial to their development as an undergraduate student and a lifelong learner.

Area 1: Time Constraints on Faculty and Students

The expectation of faculty to excel in the classroom, perform unique scholarship, and find time for service has become an even more daunting task in the last several decades (Jacobs & Winslow, 2004; Townsend & Rosser, 2007). Therefore, the balance of giving their time to students and completing an ever-lengthening list of tasks becomes difficult to achieve. While involving undergraduates in research projects is extremely beneficial to the students, the investment in time, and often financial resources, is much more risky for the faculty member. As the investigator, a tremendous amount of time is committed to the student in training discipline-specific techniques, helping develop critical thinking skills, and simply checking the work for accuracy. The return on investment for the instructor's specific scholarship project is quite minimal. So, the push and pull of obligation in other areas with the desire to help the student succeed is not to be negated or ignored. How can a professor successfully fulfill the needs of his or her own scholarship and give a beneficial experience to the student?

The first area of focus for faculty mentors that is often ignored, even by very effective researchers, is to invest time outside of the project to personally know the student researcher. Whether the institution's student population is highly-diverse or rather uniform, each student possesses a variety of specific strengths, weaknesses, and cultural complexities. Each of these characteristics may help or hinder the student's ability to perform specific tasks. Understanding these characteristics takes time over the first few weeks of the project, but the emotional investment will show the student that each person is a member of the research group and an intricate part of the team.

The work of Erez & Gati (2004) can help the mentor better understand the need of students to be seen as individuals within the team. They developed a multi-level model of cultural characteristics which is dynamic and therefore always changing. This model includes levels of cultural importance including global, national, organizational, group, and individual (Erez & Gati, 2004). Conducting research with a student or multiple students would be considered group culture. In this model, each level will impact another, so clear expectations and expressing team-level values such as shared learning orientation, interpersonal trust, and support are crucial to developing a positive research culture (Erez & Gati, 2004). There are various ways that research mentors can build community. This starts with communication by clearly stating expectations of the student and reciprocating by listening to the student as well. Students have been shown to be experiencing more stress than the generations before them and this is exhibited in widespread increases in university counselling service referrals (Macaskill, 2012). The mentor should build community by listening to concerns of the student outside of the research project that occur both in and out of the classroom. The instructor must also provide specific training for the jobs the student will be expected to perform and give praise and admiration for small student successes along the way. These small investments in time will help develop and cultivate a strong group culture for success.

A second area of focus for a research mentor under time constraints is to specifically focus on particular areas of Douglas' Research wheel (Douglas, 2013). This wheel is a tool that categorizes research into four broad categories (Creative, Community, Applied, and Scholarship)

with 18 subcategories including diverse activities such as data collection, service enterprise, invention, or service. In graduate school, students acquire the skills necessary to accomplish many areas of the wheel at one time. For example, a graduate student may conduct a literature review, data collection, communication of the lab results to community groups, create new equipment, and conduct a simulation. However, graduate students are further along in their careers and often fully-immersed in their projects. That will not be the case at the undergraduate level, so it is inappropriate to assume the student is capable of accomplishing such a tremendous workload at the same time as juggling classes, extracurricular activities, and often another job. Therefore, a research mentor should focus an undergraduate towards not only one of the four major categories on Douglas's research wheel but towards one of the individual activities. A thorough literature review is a great activity to undertake, but difficult for an undergraduate to accomplish by simply being sent to the library to conduct. Instead of sending the beginner off in search of what literature is available, start by giving the student a landmark paper in the field or a recent manuscript of importance. Additionally, the mentor must make sure to teach that student how to read a discipline-specific document. Each discipline approaches knowledge and research in somewhat unique ways (Middendorf & Shopkow, 2018). Often research experts are unaware of discipline-specific nuances because they have used them for decades. Mentors must take the time to reflect on their own practices to be able to successfully teach these skills to the undergraduate scholar.

After the student has been exposed to an example of successful research, the mentor should focus that student's project in only one of Douglas's 18 activity areas (Douglas, 2013). If a student is conducting experimentation, keep the project narrow and focused at the beginning. Having an experiment that has too many options for the student may lead the student astray and waste time. The research mentor is the expert and can ensure that the research conducted is new and innovative as the mentor has knowledge of current literature. Then, the mentor can continue to provide additional relevant research papers as the research progresses. After some results have been accomplished and the student has a comfortable understanding of the project, this is the time to have the student go back and dive deeper into the literature themselves.

Area 2: Ill-Prepared Students Lacking in Foundational Knowledge

Threshold concepts is a theory that certain particularly-difficult concepts are critical to understanding a discipline (Middendorf & Shopkow, 2018). If a student researcher failed to grasp specific concepts taught in the coursework, this will impede his or her progress in that course and further hamper transformational learning via undergraduate research. Additionally, learning bottlenecks are parts of the curriculum in which students fail to grasp material even if they are diligently trying, prepared for class, and aided by instructors that have thoroughly presented the discipline-specific content (Middendorf & Shopkow, 2018). These bottlenecks, which occur across virtually every course regardless of discipline, will also appear in undergraduate research. Again, if a student lacks basic foundational knowledge, application of that knowledge is impossible. Therefore, through clear communication with the student, the mentor must find the learning bottlenecks that have occurred with each individual research student. Only after identified can these learning bottlenecks be remedied and transformative learning be afforded the opportunity to occur.

After identifying threshold concepts necessary for the student project and the potential bottlenecks of these knowledge areas, the mentor should focus the student on very specific tasks and ensure that the necessary threshold concepts are taught to the student once again. As addressed in area 1, student weaknesses and strengths can be identified when an environment of open and positive discourse is developed. The skill set of the student researcher is built by allowing him or her to complete small tasks with success. The researcher must dedicate time away from the student-mentor interaction to prioritize what tasks can be taught that will allow the student to gain independence and also be most valuable for the mentor to further the research project.

Once small skills are taught and repeated, larger tasks can be performed. As this continues, having the student keep a diary of the research process (and not just a log of data collection) can be extremely useful (Wallin, 2017). Begin by using specific prompts such as, "What was the most important thing you realized this week?" or "What was the greatest challenge this week?" (Wallin et al., 2016). These small diary entries allow for communication to deepen and will provide insight to the thought-processes of the student, helping to identify if a threshold concept is understood or if a bottleneck has appeared. These diaries will also augment the transformative learning process bringing the student back to personal understanding of key concepts, having the individual think about the process and why tasks were performed, and how the results will impact the next steps in the project.

Area 3: Students Participating in Research Solely as a Pre-Requisite for Graduate Programs or Capstone Courses

Again, the mentor must remember that all students come with individual worldviews that have developed over their lifetime. Returning to the work of Erez & Gati (2004), every individual has a dynamic cultural frame of reference including many levels. Before a mentor can develop the teamwork aspect of the group culture level, the attributes of each individual must be considered. Why wouldn't an undergraduate appreciate a faculty member gifting time to work with a student on a project? Three aspects may play into the cultural perspective of the student: 1. This requirement appears to be of the same value as any other pre-requisite such as number of credit hours obtained or a minimum GPA. 2. This is yet another hurdle placed in the way of the student that prevents a degree, and therefore, career and paycheck, from being achieved. 3. Research has nothing to do with the future career itself.

These three ideas seem fairly naïve to an academic but may be deeply entrenched within the student's worldview and culture. What individual involved in any sort of education hasn't heard that "those who can do, those who can't teach?" This maddening phrase, adapted from the George Bernard Shaw play, *Man and Superman*, has become commonplace amongst frustrated students. And, while completely absurd, misconceptions are extremely hard to remove from the brain. Unlearning what is already believed is often more difficult than learning new information (Angelo, 1993). So, a student may perceive conducting research with a professor, not as an opportunity, but an obligation to work with someone not actually doing work of any real significance. Hands-on undergraduate research is a great way to remedy this fallacy. Showing the student why the work has been important to other research, how scientists actually

communicate with one another via peer-reviewed manuscripts and presentations, and how the student will be actively engaged in the process will help alleviate this initial delusional state.

This particular student is really the best opportunity for the mentor to develop transformative learning. Fostering transformative learning must be deliberate and conscious (Taylor, 2008), so the mentor must work with the student to explain why participating in research is a necessity. Many undergraduate research students are in their third or fourth year of college and have entered the cognitive level to understand that their learning is strengthened by moving up Bloom's taxonomy. As well as setting specific expectations, the mentor should teach the student about the learning process. A mentor may even take the time to explain the importance of Bloom's taxonomy to learning or why graduate programs need students to use critical thinking. If a student can understand that being required to undertake research is not meant as a barrier to success, but instead, meant to grow one's ability to learn, the student may put forth more effort and achieve greater comprehension.

Conclusion

Practical guidance based in research from a variety of fields has been provided pertaining to three common pitfalls found by mentors when undertaking undergraduate research. Tremendous time constraints impact the capacity of the mentor and student to interact. Researchers must ensure that the project given to the student is well-defined and attainable to the undergraduate. The mentor must also construct a work environment that recognizes personal individuality and constraints in student preparedness. Lastly, the initial interactions between mentor and student need to address the significance of the research to the student as a mechanism for the growth of the student. Habits and misconceptions can be a barrier to learning (Angelo, 1993) and should be acknowledge and addressed so they can be overcome by the student researcher.

This metacognitive contemplation will set the stage for the beginning of the transformative process via undergraduate research. Being aware of these hurdles and understanding how to overcome each will increase transformative learning growth of the student researcher. This will allow for deeper understanding and increased retention via the research experience, strengthening the process and outcome of the research itself, and therefore benefiting both mentor and student. When a student is motivated, provided the resources, and given the knowledge to explore classroom concepts at a deeper level, he or she can become a lifelong learner in a rapidly changing world (Christie et al., 2015). Undergraduate research provides this experience and allows for an excellent opportunity for a transformative educational experience.

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Author's Note: Sarah B. Lovern is an Associate Professor in the Department of Science at Concordia University Wisconsin.