“During my month long experience, I faced setbacks and overcame them with the help of faculty and students I would have otherwise never met. I can honestly say that I have gained a great appreciation for the work they do, and I hope that they learned from me at least as much as I learned from them. This program is excellent because it proves that when people get together, problems get solved.” – Engineering student Zach Evetts

Background and Research Framework
More than a decade ago, the Boyer Commission’s report on reinventing undergraduate education highlighted the importance of interdisciplinary inquiry, stating that “collaborative learning experiences provide alternative means to share...the skills of analysis, evaluation, and synthesis [that] will become the hallmarks of a good education, just as absorption of a body of knowledge once was” (Boyer Commission on Educating Undergraduates in the Research University, 1998, p. 11). In 2003, the National Research Council built on the work in the Boyer Commission’s report and other researchers to suggest that interdisciplinary education is “in the best interests of both undergraduates and their professors” (p. 22) and should be “developed and reinforced so that interdisciplinary thinking and work become second nature” (p. 2-3).

Research shows that student engagement is one of the best predictors of success in college. The benefits of student engagement
include critical thinking, openness to diversity, openness to challenge, psychosocial development and identity formation, post-occupational status and income, growth in leadership abilities, growth in job-related skills, and moral and ethical development (Miller & Butler, 2011). Additionally, educational practices that foster student engagement are the best practices touted in educational literature: student faculty contact, reciprocity and cooperation among students, active learning, prompt feedback, time-on-task, high expectations, and respect for diverse talents and ways of knowing (Chickering & Gamson, 1987). In short, the faculty-student activities that occur naturally in the research environment lead to student engagement, and student engagement results in a litany of desirable academic skills and aptitudes necessary for college success. It is clear that UR opportunities can be a key component in developing students who graduate and enter the adult world well prepared for their futures.

The Vision
In 2004, a group of College of Science and Mathematics faculty at Midwestern State University (MSU) believed that a certain kind of magic was inherent in research when faculty and students work together toward a common goal and that research could be used as a tool to engage undergraduate students in their own learning. UGROW (Undergraduate Research Opportunities and Summer Workshop) was born. Figure 1 illustrates the interdisciplinary evolution of UGROW.
UGROW started with five students from the Biology and Chemistry departments. At its beginnings UGROW focused on promoting and nurturing interdisciplinary research endeavors for students within the College of Science and Mathematics. However, some faculty members were talking about expanding the opportunities to students from other colleges to provide an environment conducive to “out of the box” thinking and innovation. It was only when Dr. Patti Hamilton, Dean of the Graduate School, made Brandon Smith, Assistant Professor of Theatre, aware of UGROW that faculty and students alike embraced the idea of an interdisciplinary program across our campus. The story below narrates the journey traveled by faculty and students as they followed the intuitive vision that interdisciplinary research between the arts and the natural sciences is exciting and opens new worlds. To assist others considering this journey or in the midst of this journey, the UGROW model and corresponding recommendations are presented.

The Bandersnatch Project
As with other institutions, at Midwestern State University, UR initiatives began in the natural sciences (Fritzman & Gibson, 2008; Young, 2008) and then expanded to include the arts. However, it was a research project between fine arts and engineering students and faculty that became a catalyst for university-wide efforts to institutionalize UR from one college to across the university.

Although numerous meaningful UGROW research projects have been completed over the past eight years, the Bandersnatch project united theater students and faculty with engineering students and faculty in an interdisciplinary research endeavor. The resulting original play, Bandersnatch, featuring huge mystical creatures designed by the engineering school, captured the hearts and imaginations of the MSU community and won awards nationwide. The UGROW model made this possible.

Watch:
http://www.youtube.com/watch?v=_q4L_hDUbZU&feature=plcp

Theater Faculty Perspective
Brandon Smith, a faculty member from the theater department, describes the Bandersnatch project this way:
“As educators, we often tout engagement and the benefits of a liberal arts education to our students, but how many of us actually venture across campus and participate in scholarly work outside of our own discipline? This was my first experience with UR and cross-disciplinary collaboration while producing a play. The idea started as a pet project between graduate school friends. Josh Blann and I wrote it without much consideration of an actual production, and therefore let our imaginations create a ridiculously complex fantasy world populated with giant monsters, ghouls, and birds the size of men. Then the manuscript sat in a drawer for a year. The problem was that our imaginations had created things that neither of us had the skill or funds to realize in the real world. We wanted mechanisms, robotics, giants, and spectacle that would transport the audience. It was only when the Dean of the Graduate School, Dr. Patti Hamilton, heard of our project and suggested approaching the engineering school for assistance that our dreams began to be realized.”

“The play picks up where Lewis Carol’s poem, “Jabberwocky,” leaves off. A young man returns home from a deadly hunt with a monster head as his trophy, but rather than finding a community made safer through his actions, our protagonist returns to discover that his father has been killed and a more dangerous enemy is attacking his small village. Soon his girlfriend is “Bander-snatched” and whisked away to an unknown location and thus begins a whimsical adventure that involves a huge Jub-Jub bird, zany villagers, puppet children, a blind swordsmen, a reanimated Jabberwock corpse, and an unexpected reconciliation with a long-lost family member. It’s an epic romp through a comic world of imagination, and it demands
some creative modes of storytelling to pull it off. That’s where the MSU McCoy School of Engineering came in to aid with the creation of the complex puppets, intricate mechanical prosthetics, and robotic creatures.”

“The collaboration started small. Dr. Sheldon Wang, Chair of the McCoy School of Engineering, agreed to allow me to present my idea to his Mechanisms class. About this same time Dr. Magaly Rincon-Zachary, Director of UGROW, went out on a limb and let Theatre do a late entry into the summer research program. The presentation to the Mechanisms class quickly morphed into a design project that was incorporated into the curriculum.”

Professor Smith continued with the project description: “The project was simple: take the design criteria given and develop a prototype for one of the creatures in the play. The results were amazing. Popsicle sticks and wire became large hands, wire was bent and soldered into a peacock’s tail, and a large bird emerged from a series of carefully placed dowels. It seems like a logical progression to engage experts on campus to collaborate on research, but how many of us do so regularly? Inclusion of people and ideas from other disciplines was exciting, and one could almost feel the energy behind the project building as more and more people on campus became involved.”

“Not only did students and faculty outside the project end up collaborating in a meaningful way, but the theatre and engineering students were often able to do the same for research projects in areas they might otherwise never get to work. It is a truly magical experience to see students from totally different backgrounds and fields work together to solve problems. You see them not only develop confidence and clearer communication and analytical skills, but also a healthy respect for the work of others and a spirit of collegiality and community. The same can be said for the faculty involved.”

“It is so easy to get caught up in our own work, to put on blinders, and toil alone in an office. Then we are surprised to learn that the same behavior is often mirrored by students. How can we expect them to have a spirit of discovery if we won’t venture across campus and look for ways to collaborate with our colleagues? If I had not been encouraged by a wonderful mentor to branch out and work across disciplines I would have missed what has been the most significant event in my career thus far. I have never worked harder on a project, nor have I had more satisfaction or pride for my students than I did while working on Bandersnatch. It began as pure fantasy, something that seemed impossible to realize, and grew into something meaningful and rewarding to everyone who worked on it.”

Theater Students’ Perspectives
Students were likewise energized by the Bandersnatch project. Kelcie Bush, theater student, described her experience this way:

“Bandersnatch was an incredible opportunity for MSU Theatre. As a student of the theater, I never thought that I’d get a chance to work on a show as unique as ‘Bander,’ especially at my age! It was a collaboration feat of astounding proportions, and anyone who knows anything about what it takes to pull together a play would agree. I was there at some of the very first preliminary ‘monster discussions’ for the show when we met with a taxidermist and looked at pictures of exotic creatures. Now looking back to those first meetings, I’m really impressed by how the show developed and grew into the technical feat that it was. I was placed on team ‘Jub-Jub’, one of the bird characters in the play. Our job was to build her, and give her life. I remember staring at a few line drawings and then drawing patterns
for rattan pieces by hand... trying to create this creature. It was a labor of love, and I think I can speak for everyone when I say that we became quite attached to these characters. Although I'm an actor, I also have an emphasis in costuming, and I was given the job to experiment with different ways to 'skin' these puppets. Many pairs of ripped and dyed pantyhose later, we had completed the task. I took part in the UGROW program in 2011, and I was exposed to different principles of science I never knew existed. I absolutely loved teaching these scientists about my art through Bandersnatch because they were earnestly interested in our work. It was also wonderful getting to work as an actor on this fresh script. The play changed along with the actors, we truly made Bandersnatch completely ours.”

Another theatre student, Sterling Biegert, elaborated:
“Bandersnatch was one of the best experiences of my life and even though I am still young, I truly believe it will hold that position until the day I die. Going into UGROW for the summer was interesting. Everyone had high energy and big dreams for this project we knew almost nothing about. We had our inspirations (War Horse, Lion King the Musical, Lewis Carroll’s “Jabberwocky” poem, etc.), our director’s vision, and our determined ambitions. I think what made this process so unique was the opportunity to build it from the ground up. We were very lucky to have a director like Brandon Smith who knew what he wanted but allowed us to make our own discoveries to get there. Every detail was personalized by someone in the cast or crew. There was no right or wrong way. Never once were we forced to go down a set path someone had already paved the way for. We made our way through our own metaphorical "Ungles," tripped and fell a few times, but ultimately we got to explore completely new territory. We were adventurers as well as innovators. There is no way we could have made it through without the amazing teamwork and impeccable guidance we had. Through the UGROW and the rehearsal process, I think we all knew we had created something quite unique. However, having worked on it for so long, we got lost in all the hard work and fun we were having. There were definitely times when we would become too accustomed to what we created and perhaps even took it for granted. It was not until we performed in front of an audience for the first time that we realized how rare and special an opportunity we had.”

Engineering Faculty Perspective
Dale McDonald, assistant professor of engineering, felt that UGROW and the Bandersnatch project broadened his research interests and revitalized his career:

“The collaboration between the Department of Theatre and the McCoy School of Engineering at Midwestern State University on the production of Bandersnatch was a beautiful demonstration of UR involving fine arts and engineering science.” This may be interpreted as a perfectly natural result of inquiry based learning (Boyer Commission on Educating Undergraduates in the Research University, 1998 pp. 19-21). Such research and scholarly endeavor with a strong mentorship component has the potential for transformative change in the educational experience of the undergraduate participants (Zydney et al., 2002). To prospective faculty mentors, participation may seem as “service” or “just another duty” with limited ability to advance their own interests. However, faculty mentors may reap benefits as well, perhaps re-shaping the course of one’s research trajectory and emphases; branching out into fields where one was not formally trained. The literature supports this idea that faculty may re-direct their own interests as a product of such interdisciplinary efforts (Young, 2008).

“As a new assistant professor, my research agenda involved investigating open problems within a well-defined sub-discipline of mechanical engineering; dynamic systems and control. However, once I began participating in the UGROW program, my research trajectory was thrust into new, rewarding areas. Each year, the interaction with students and faculty from my discipline
and other disciplines gave me the knowledge and confidence to explore areas beyond traditional borders of mechanical engineering. Seeing young scholars pursuing knowledge in areas that were at first unfamiliar to them inspired me to do the same. Exposure to other disciplines motivated me to branch out to the field of population dynamics, both theoretical and applied, and explore issues such as government regulation and taxation of nature resource systems (e.g., the commercial fishing industry). I realized that exploration of unfamiliar areas was possible, was rewarding, and was, indeed, revitalizing. Participating in several UGROW experiences and observing the multidisciplinary student-faculty research efforts led to three measurable achievements: 1) development of the MSU population dynamics laboratory, 2) collaboration with an undergraduate investigator that led to a peer-reviewed publication that I presented at an international conference (McDonald & Falade, 2012) and 3) my own publication of a separate refereed journal article that was inspired by my UGROW experiences (McDonald, 2012).”

“The structure of the UGROW program that facilitated my growth is also what made the Bandersnatch collaboration possible. My observation and student feedback suggest that this structure is a key component of UGROW’s success.”

Engineering Student Perspective
As Brandon Smith, director of Bandersnatch stated, “Three young engineers emerged as leaders from that mechanisms class, and they decided to sign on to participate in summer research. One of them, Zach Evetts, was already enrolled in UGROW, but Cody Bates and Rip Martin were just as interested in being part of the process. Initially, they all planned to put in a month over the summer. None of us had a clue that the work would soon lead to the scholarships, awards, and nearly a year of collaboration. As part of the UGROW summer project, the engineering students worked side-by-side with about 20 theatre majors in the summer of 2011. During this time the students applied scientific method to hypothesize and test new processes of fabrication and storytelling. Theatre and engineering students collaborated daily and were able to play off of one another’s strengths to quickly overcome obstacles that would have stymied them on their own.”

Engineering student Zach Evetts expressed his appreciation for the UGROW experience in the following words:

“I can say with all certainty that my participation in the UGROW program is one of the most valuable experiences that I have had. UGROW allowed me the opportunity to work towards a set goal in an interdisciplinary environment and to discover my own method for solving problems. Basically, I not only got to work hard, but I was also given the opportunity to learn based solely on how my curiosity drove me. During my month long experience, I faced setbacks and overcame them with the help of faculty and students I would have otherwise never met. I can honestly say that I have gained a great appreciation for the work they do, and I hope that they learned from me at least as much as I learned from them. This program is excellent because it proves that when people get together, problems get solved.”

Watch:
http://www.youtube.com/watch?v=_Xbqz3mfw3s&feature=plcp

Outcomes
What are the benefits to students who are involved in UR? The Boyer Report (Boyer Commission on Educating Undergraduates in the Research University, 1998, p. 11) states that the expected outcomes should be development of “the skills of analysis, evaluation, and synthesis.” To address this issue, evidence of these three skills will be juxtaposed against the natural progression of undergraduate theatre and engineering students working towards a common goal, culminating in the theatrical presentation of Bandersnatch.
• **Analysis:** The analytical and practical application of kinematics played a fundamental role in the project. Engineering students used their knowledge of mechanisms, ergonomics, and production value to design the giant, moveable costumes and the intricate puppets.

• **Synthesis:** The theater students were charged with defining the context and meaning that would convey the appropriate emotion and meaning to the audience. The knowledge, creativity, and expertise of the theater students provided a filter to inform and focus the efficiency of the engineering design. The development and practice of the skill of synthesis resulted in a collaborative, interdisciplinary process that affected both parties.

• **Evaluation:** In the context of the Bandersnatch project, evaluation required that seemingly disparate disciplines transfer information, ideas, and inspiration. Engineering students had to work with the global philosophy of their peers in theater; theater students had to assimilate engineered solutions into a dramatic production that fostered and preserved the intent of the production. The final evaluation measured the end product against the desired intent of the production and communication of the desired effect to the audience, and both groups were deeply involved in this evaluative activity.

However, quantifiable performance measures are often useful to measure benefits—in this case, those realized by the undergraduate theatre and engineering participants. Evidence which supports this is provided by the reception to the Bandersnatch production. Engineering students were recognized by the Kennedy Center American College Theater Festival (KCACTF) Region VI with the top award in their area of design, the Allied Design and Technology Award. This special award included an invitation to present their work at the national convention of the United States Institute of Theatre Technology in California. The McCoy School of Engineering was recognized at the state level of KCACTF for excellence in Meritorious Achievement. The theater students as well as the production itself were honored by becoming one of six plays selected from the states of Arkansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas to perform at the Region VI Festival and, subsequently, earned the “Distinguished Production of a New Work award” at the Kennedy Center for the Performing Arts national convention in Washington, DC. Finally, the theatre faculty member, Brandon Smith, was honored as a Distinguished Director for 2011. It is doubtful that these nation-wide honors would have been received if the project had not been through the fires of rigorous analysis, synthesis, and evaluation. Additionally, the project became a vehicle for learning and campus-wide involvement in UR. It built relationships that will last a lifetime.

To date, 70 undergraduate students have participated in UGROW summer workshops including nine students in the Fine Arts College. Since students show such a positive response to the UGROW experience, students across MSU campus inquire about the program and how they can participate. Thus, the program has extended beyond the STEM disciplines and the arts to social and applied sciences and humanities.

Based upon the testimonials and evidence in the preceding narrative and the supporting literature, it is felt that the potential for transformative change in the educational experience of the undergraduate participants is fostered by the UGROW construct. Specifically noteworthy is the broader impact that firsthand witness of the results may inspire faculty to contemplate and, if appropriate, alter and expand their own research directions, as experienced by Dr. McDonald, which is reinforced by the literature (Young, 2008). When researchers in the sciences partner with researchers in the arts, the narrow boundaries that are often experienced in the sciences (Schantz, 2008) can be expanded. At the same time, the expansive scope of projects in the arts and
humans can benefit from the segmentation and compartmentalization brought in by the sciences.

The UGROW Model
The UGROW Model evolved from one year to the next as lessons were learned through trial and error. Each year, UGROW faculty met to discuss how the program could be improved. Each year, the summer workshop was fine-tuned. The timeline of events below is accurate as of this date; however, the model maintains a pragmatic flexibility to allow change easily and naturally, when necessary.

- October-March: Students apply to the program and are selected on the basis of major and overall GPA, classification and essays. Students and mentors each receive a $1,000 summer stipend. Students also receive a $1,000 scholarship for the following academic year to support their research.
- February: Students and UGROW faculty members meet together during which time the professors present their ideas or questions that need to be answered through experimental, field, applied, creative, or theoretical research.
- May: During the first week of the summer UGROW experience, faculty members conduct a variety of workshops using a hands-on approach to introduce students to best practices and to specific techniques used in different disciplines, such as MATLAB, statistical tests, bioinformatics, engineering mechanisms, data recording and analysis, storytelling and writing. Each student chooses a research project in an area of interest. The research is led by the faculty member who presented the idea or question (see above).
- Throughout June: For four weeks, UGROW students experience the authenticity of research in faculties’ laboratories and workspaces, in a highly interdisciplinary environment. Students work on projects with their mentors and meet weekly as a group during which time they openly discuss their progress, challenges, pitfalls, “aha” moments, and occasional frustrations. These meetings provide a venue for students to ask questions, offer suggestions, and brainstorm. UGROW helps defray the cost of laboratory consumables, poster printing, and student attendance at professional meetings.
- End of June: The summer program ends with a student symposium and a social gathering.
- September through April: During the following academic year, students continue working on their projects if necessary. They then prepare posters and oral presentations to present at the MSU Scholarship Colloquium and at professional meetings.

Other UGROW Student Contributions to Their Disciplines
Central to any discipline is the dissemination of data, creative works, applications, etc. UGROW students have engaged in disseminating their work. Results from UGROW projects have been published in peer-reviewed journals or presented at professional conferences. For instance, in Shipley et al. (2012), the second author provided preliminary data during UGROW 2005. Likewise, in Shao et al. (2009), the second author synthesized compounds during UGROW 2007 that subsequently she characterized during the school year. Jacob Staples, a computer science student, participated in UGROW 2008. His project involved creating a method to detect corners in digital images. His work was accepted for publication in the proceedings for the 21st International Conference on Computer Applications in Industry and Engineering (Staples & Hood, 2008). A list containing examples of recent
oral and poster presentations is too long and outside the scope of this paper. However, we offer a few titles from oral and poster presentations to give the reader an idea of the research diversity and breath UGROW students produce (Thomas, Panchoo, & Rincón-Zachary, 2006; Mitchell & Shipley, 2009; Corbette, Porter, & Shipley, 2012; Falade & McDonald, 2012; Ochoa & Masuoka, 2012; Willeby & Price, 2013).

Recommendations
David DeVries (2001) concludes his essay, “Undergraduate Research in the Humanities: An Oxymoron?,” by discussing the importance of models for collaboration across disciplinary boundaries in UR and the importance of sharing these models. In this spirit, based on the Bandersnatch project and seven years of UGROW experience, we offer the following recommendations to those wanting to explore multidisciplinary partnerships and UR in the arts and humanities.

• Solicit commitment to research and collaboration. Start with a small, dedicated group. Seek mentors. Plan for success then celebrate and promote it when it happens. In a review of a study by the American Council on Education, Malachowski and Webster (2008) found that “leadership matters, because it is clear that someone (or a group of people) must take ownership of the change process” (p. 46).

• Explore/make/find connections among disciplines. Venture outside of your department and your college. Think beyond the traditional approaches to your research areas. As Blackmer (2008) states, “Our students don’t want to learn about meaning, they want to make it and they no longer abide by the rules that divide disciplines” (p. 8).

• Model the spirit of discovery and collaboration for your students. It will do them good and it will be good for you, too.

• Demonstrate to students that we learn together and from each other. Students learn from faculty, faculty learn from students, students learn from students, and faculty learn from faculty.

• Give students ownership of their work. Students appreciate the “opportunity to build it from the ground up” and “to make [their] own discoveries” (Sterling Biegert, MSU student).

• Build in regular opportunities to share and provide feedback. This will provide motivation to keep moving forward (even when presented with obstacles); a chance to evaluate the strengths and weaknesses of others’ work; opportunities to put concepts into words and speak knowledgeably and intelligently about research; and fresh insights and perspectives.

• Be open to new experiences and directions for research. Opportunities for this will inevitably arise. It is our job to recognize them.

• Announce your research interests and projects to students inside and outside of your field constantly. Students will approach new challenges fearlessly if they know they exist.

• Have fun!

In the plenary presentation at the 2008 Council on Undergraduate Research National Conference, Jennifer Blackmer (2008) stated, “The world is certainly changing, our identities as teachers, scholars and mentors are changing...performing arts and the weird, creative people that populate them offer new models of research and learning to any field” (p. 12). This statement is particularly poignant in light of the developments surrounding the career shift by engineering professor Dr. McDonald. The first-hand witness of a dynamic collaboration between the arts and engineering convinced these investigators that the narrow limits of formal academic training need not fully define career and research paths. Following the lead of those “weird, creative people,” exciting areas of exploration lie ahead in many disciplines if one believes it is possible.
Works Cited


