

PubHub: A Web-Based Compendium to Catalyze Undergraduate Research Publication

Rebecca Ligrani, Irena Gorski, Sarah Ritter, and Khanjan Mehta

Council on Engaged Scholarship

Humanitarian Engineering and Social Entrepreneurship (HESE) Program

School of Engineering Design, Technology, and Professional Programs, College of Engineering

Penn State University

State College, PA, USA

Correspondence: khanjan@psu.edu

Abstract— Research publication and presentation provides undergraduate students with invaluable benefits including career preparation and increased confidence. At the same time, it provides the scientific community with better-prepared professionals while contributing to the larger knowledge base. Since opportunities and resources for undergraduate research are growing, larger numbers of students are now engaged in formal disciplinary research and creative inquiry across disciplines. However, only a few students disseminate their research findings in scholarly forums like refereed journals and conference proceedings. Barriers to undergraduate research publication include lack of faculty time to devote to mentoring students in writing, limited institutional funding for undergraduate research, and student's unfamiliarity with the publication process. This article describes PubHub, an online compendium of 50+ learning modules across five categories to assist students through the publication and presentation processes. A pilot assessment of PubHub amongst students and faculty members indicates its usability. While resources like PubHub cannot increase funding for undergraduate researchers or shorten the timescale of the peer-review process, they can lower barriers and democratize the publication process, while refocusing faculty time on intellectual aspects of research rather than the scholarly writing process by providing students the knowledge and specific insights they need in a just-in-time manner.

Keywords—*scholarly writing; undergraduate publication; undergraduate research*

I. INTRODUCTION

Undergraduate research is widely accepted as an essential component of rigorous academic education [1][2]. Benefits of undergraduate research include enhanced learning, critical thinking development, career preparation, cultivation of an innovation-oriented culture, and higher student retention [1][3][4]. Universities are thrusting undergraduate research forward as a tool to support and create more research-based careers in the emergent knowledge economy [1][5].

Engineering programs are enhancing their students' competitiveness in the job and graduate school markets by embedding undergraduate research into their academic culture. Furthermore, undergraduate research is becoming a critical component of the student-centered narrative of universities. While undergraduate research is widely recognized as a high-impact practice and offers a wide array of benefits, publishing research findings in peer-reviewed journals and conference proceedings is a significant learning and professional development opportunity in itself. A survey of the literature presents the following reasons why undergraduates should disseminate their research (ranging from scientific articles to creative works):

1. **Engaged academic participation:**
 - a) Publication is the pinnacle of participation in the professional academic culture, and provides students with a window into a professional career as a researcher [6].
 - b) Sharing research experiences and evidence-based practices can help undergraduate students find mentors and collaborators, and advance their field forward [7].
2. **Professional development:**
 - a) Publications enhance undergraduate students' competitiveness in graduate school applications and the job market [1][8].
 - b) Students develop skills such as communication, persistence, creativity, judgment, and organization [9].
 - c) Students gain greater autonomy and self-efficacy [10].
 - d) Students are exposed to networking opportunities at conferences and workshops which may lead to new resources and collaborations.
3. **Publication is an expected part of research:**
 - a) Making research public completes the research cycle [10].
 - b) There is an ethical imperative to publish and make knowledge public, especially when the

research is supported by taxpayer dollars (i.e. agencies like the NSF, NIH, and USAID).

- c) The publication process brings with it an inherent quality control mechanism that strengthens research [6].

4. **Institutional gains:**

- a) Undergraduate students can help faculty members and institutions increase their research productivity. As opposed to graduate students who are typically financially supported by faculty members, undergraduate students are often engaged by way of course credit or relatively lower wages.
- b) Undergraduate research publication aligns with student-centered institutional missions and can be used to draw high-performing students to elite institutions.
- c) A greater volume of publications enhances the visibility and status of institutions, and is a particularly important measure for research universities.

Although publication is acknowledged as an important aspect of a comprehensive education and professional experience, there are still a number of barriers faced by students and faculty. Common barriers include:

1. **Limited time:**

- a) Faculty often lack the time and effort required to guide students through the publication process [6].
- b) The publication process may extend beyond a student's graduation and students lose funding or course credit incentives [11].

2. **Little institutional support:**

- a) Most faculty receive little to no incentive to mentor undergraduate students through publication as opposed to other work that will help them gain promotion and tenure.
- b) If a faculty member leaves an institution, there is often no infrastructure to continue to support their undergraduate students through the publication process, letting manuscripts come to a halt [10].

3. **Lack of preparation:**

- a) Most undergraduate students lack an understanding of the publication process, such as how to find a relevant journal and how to interact with editors and reviewers.
- b) Few students receive training in research writing (e.g. presenting ideas in precise terms with correct citations, evidence, and arguments).
- c) Students conducting research for the first time spend most of their effort on orienting themselves to the research process and are given little to no introduction to interpreting and publishing results [12].

To address some of these challenges, an online compendium of resources that guides students through the publication and presentation processes was developed. PubHub (www.sites.psu.edu/pubhub) is aimed at lowering barriers of limited time and lack of preparation in a just-in-time manner, with the ultimate goal of enabling more undergraduate student-led refereed articles to be published. This article describes the benefits of undergraduate publication and presentation and the motivations for creating PubHub. The user-centered and iterative design process employed to identify relevant topics, gather content, and present PubHub is described. Lastly, several use cases on how PubHub's learning modules can be integrated into courses and research group operations are presented, followed by a culminating discussion on faculty and student perceptions of this resource.

II. SITUATION AND MOTIVATION

A. *The Call for Undergraduate Research*

Undergraduate research is strongly encouraged in higher education, particularly in the STEM fields, and has demonstrated success in increasing students' desires to pursue graduate degrees and research careers [1][4]. Attention from national organizations, institutions, and across the academic literature demonstrates the prominence of undergraduate research today. Between 2010 and 2015, 253 articles discussing undergraduate research in the sciences were published [13]. Additionally, the National Science Foundation (NSF) and the National Science Board incorporated research and education at higher institutions into their most recent strategic visions [14][15]. Substantial financial resources are being directed towards undergraduate research, for example, the 666 NSF funded Research Experiences for Undergraduates sites in 2016 [16].

B. *Problem Statement*

Regardless of how students engage in research, communicating results remains an important part of the research cycle. Positive outcomes for students who publish or present research include increased self-confidence, better communication skills, acclimation to disciplinary culture, enhanced employability, and greater autonomy [10]. The Boyer Commission on Educating Undergraduates in the Research University—which offered prescriptions for research universities to address deficiencies in undergraduate education—included a recommendation that research training require training in effective communication [16]. Rather than categorizing publication as a supplementary step for undergraduate research, it could become a normative expectation for undergraduate researchers.

C. *Existing Online Writing Resources*

Some universities host free, open online writing centers. For example, the Purdue Online Writing Lab (OWL), created by Purdue University, is a popular academic writing website. Purdue OWL includes information about general writing practices, research writing and citations, subject-specific writing, job search writing, and information catered to English

language learners. Additionally, the University of North Carolina Writing Center has a comprehensive archive of stylistic and compositional resources, as well as a collection of field-specific pages. Both websites are text-based, with examples as the prime teaching tool. Online resources hosted by non-university entities include online style guides (e.g. Chicago and Oxford), websites devoted to demystifying the publication process, and sites that provide advice and templates for designing conference posters and slide presentations (e.g. colinpurrington.com and makesigns.com). Most of the content is focused on general writing or technical writing, but not on research writing with the specific purpose of publishing in an academic forum: this is the gap that PubHub was designed to fill. See Table 1 for a description of specific barriers to undergraduate publication and how PubHub addresses those barriers.

D. Genesis of PubHub

Students, faculty, and departments require institutional support to embed research dissemination into undergraduate students' scholarship. Support includes raising awareness about student publication and its alignment with university missions, creating policies that require or reward dissemination, assisting faculty with curricula design and pedagogy, and rewarding supportive faculty with recognition and promotion and tenure opportunities [10].

At Penn State, the Humanitarian Engineering and Social Entrepreneurship (HESE) program creates a normative culture of publication, which results in 20-30 publications per year. The vast majority of the articles have undergraduate students as the lead authors [7]. The course instructor, and the senior author on this article, partnered with undergraduate students to create web-based modules to facilitate HESE students' research and publication journey. At the same time, the Penn State Council on Engaged Scholarship (CoES) was looking for ways to scale engaged teaching and learning and community engagement across Penn State. Through conversations with faculty and students at Penn State, the need for expanded resources for students to publish and present their research was validated.

The PubHub team, composed of faculty, staff, and students, first developed a typology of categories and subtopics relevant to research and publication. Two focus groups with undergraduate researchers and faculty members were used to identify relevant topics for modules. The structure and format of modules originally made for HESE students were used as benchmarks, and publication in peer-reviewed journals and conference proceedings was established as the ultimate goal. The target audience was identified as undergraduate students to ensure that the modules had adequate depth and breadth, with the realization that graduate students could benefit from PubHub as well. Intensive scholarly and gray literature searches were conducted to

TABLE 1. HOW PUBHUB ADDRESSES BARRIERS TO PUBLICATION

Group	Barrier	How PubHub Addresses the Barrier
Students	Publication and presentations remain "expert" knowledge, difficult for undergraduate students to access.	Comprehensive modules about all aspects of publication and presentations that are freely available online.
	Undergraduate students have not yet developed proper time-management and manuscript timeline skills.	Modules addressing how to plan and execute a manuscript, how to maintain one's momentum while writing, and how to edit a manuscript.
	Difficulty finding research opportunities that can result in publication.	Modules about how to write research proposals, find research opportunities that are advertised, and apply for fellowships and grants.
	Students do not know how to network with professionals and researchers.	Modules that show students how to market their research at conferences and create a research brand.
	Little to no training in scholarly writing (e.g. being succinct, using specific citation styles, developing strong arguments backed by evidence).	Modules with comprehensive writing instruction, and information on how to navigate specific instructions to authors.
	Confusion about how to communicate research results, especially to people outside of their field.	Modules about audience, how to present a results and discussion section, and how to tell a story in an article and presentation.
	Undergraduate researchers do not know that publishing is an option.	Videos about the benefits of undergraduate publication and where to go for help (e.g. ask librarians, graduate students).
	If a student graduates, they do not have resources to help them publish.	PubHub is freely available so that even students who are not affiliated with an institution can access and use it.
Faculty	Cannot devote enough time to mentoring students through publication.	PubHub provides instruction on the mechanics of writing and publication so that faculty can devote their time to the intellectual aspects of their work.
	Difficulty finding students committed to publication and with appropriate writing skills.	

ensure that the modules are comprehensive and relevant to students across all disciplines. During a beta launch period, the website was shared with over 100 faculty and staff at Penn State for their suggestions and critiques. Appropriate improvements were made based on their feedback, including the addition of several new requested modules (e.g. “Creating Your Research Niche” and “Writing a Research Proposal”).

The final website includes a total of 53 modules across five categories (see Table 2). The home page features two videos: one that features university administrators who support undergraduate publication and PubHub as a resource, and one with students that highlights the variety of research that students can perform. The website also contains a page titled “Penn State Spotlights” that features five video testimonials. The five videos each address a different theme:

1. What undergraduate research is like at a Penn State Commonwealth campus.
2. How undergraduate research enhances teaching and learning.
3. Why undergraduate research matters to students, faculty, and college deans.
4. How the University Libraries can support

undergraduate research and publication.

5. The different “flavors” of research students can engage in.

E. Module Design

Each module was designed to be used as a just-in-time resource, meaning it can be used individually when a student needs that particular information. PubHub is not meant to replace coursework to systematically improve writing skills, but rather provide specific directed information when it is needed by students. Each module begins with a summary of the significance of the information presented and learning objectives for the module. It then provides the content, using examples, tables, and images as often as appropriate. For example, the module that explains what a conference is contains [nine](#) images and a video to familiarize students with various conference sessions and venues before they even attend one. The modules conclude with an optional, self-grading quiz that the student can take to assess his or her understanding of the material. Additionally, every module can be downloaded as a PDF file for easy printing and emailing. Figure 2 shows a typical learning module, with the introduction, content, and quiz at the end of the module.

TABLE 2. PUBHUB CATEGORIES AND MODULES

Publication Process	Preparing Manuscripts	Stronger Writing	Conference Central	Find an Opportunity
<ol style="list-style-type: none"> 1. Diverse Publication Forums 2. The Journey of a Manuscript 3. The Peer-Review Process 4. Selecting a Scholarly Journal 5. Avoiding Plagiarism 6. Collaborative Writing Strategies 7. Authorship Issues 8. Responding to Reviewers 9. Messy Journal Issues 10. Keeping Your Sanity 	<ol style="list-style-type: none"> 1. Manuscript Frameworks 2. Speed-Reading Academic Articles 3. Writing a Strong Abstract 4. Writing an Engaging Introduction 5. Writing a Strong Conclusion 6. Managing Citations 7. Reviewing the Literature 8. Writing a Literature Review 9. Storytelling in Articles 10. Tempering Your Results and Discussion 11. Common Charts and Graphs 12. Integrating Strong Visuals 13. Using Completing Statistics 14. Editing Your Manuscript 	<ol style="list-style-type: none"> 1. Writing a Killer Paragraph 2. Style: Voice and Point of View 3. Writing Direct, Active, and Clear Sentences 4. Choosing Direct and Accurate Words 5. Making Smooth Transitions 6. Using the Correct Tenses 7. The Art of Paraphrasing 8. Punctuation Nation 9. Commas and Apostrophes 10. There, Their, or They're? Common Mix-Ups 11. Words and Phrases to Avoid 12. Using Abbreviations: Acronyms and Units 13. Using Numbers in Your Articles 14. Choosing Correct Pronouns 15. Latin Words in Scholarly Writing 	<ol style="list-style-type: none"> 1. What is a Conference? 2. Making the Most of a Conference 3. Understanding Your Audience 4. Storytelling in a Presentation 5. Preparing Your Presentation 6. Delivering Your Talk 7. Designing a Poster 8. Presenting a Poster 9. Poster Templates 10. Posters: The Good and The Bad 	<ol style="list-style-type: none"> 1. Get Going @ PSU! 2. Writing a Research Proposal 3. Writing a Competitive Research Fellowship or Grant Application 4. Creating Your Research Brand

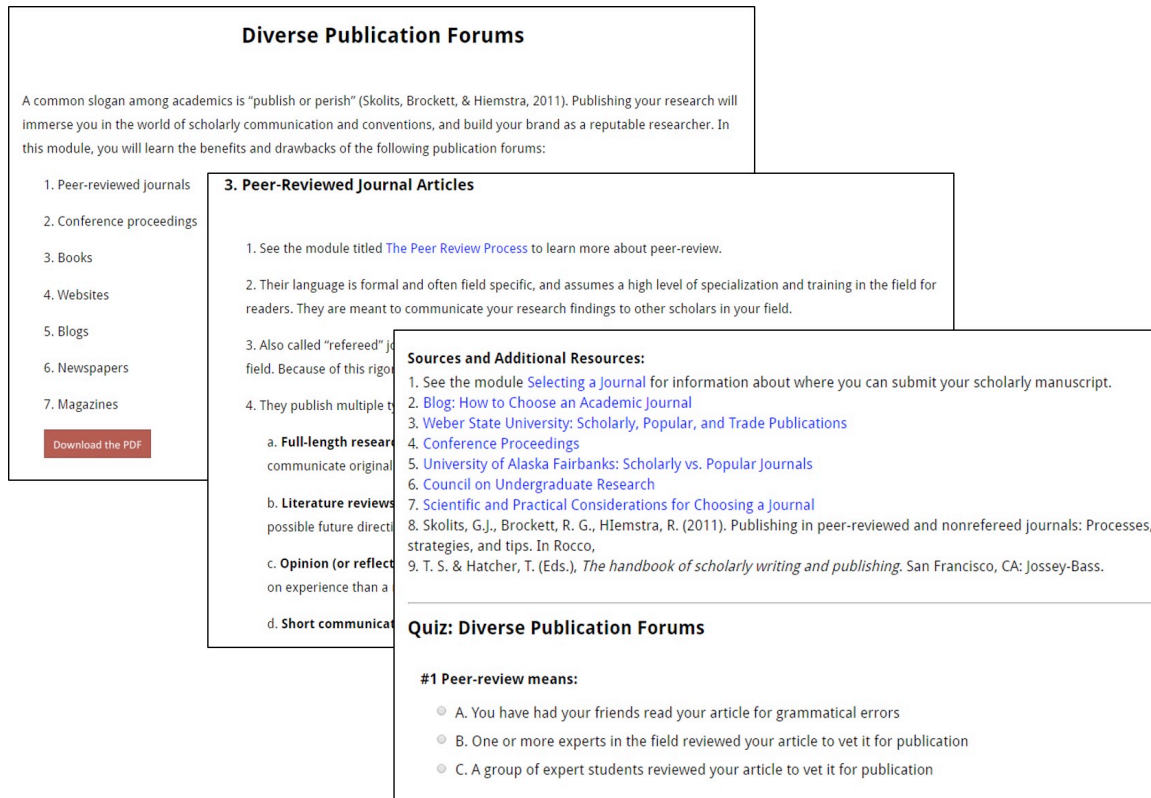


Fig. 2. PubHub website design showing introductory material (top), module content (middle), and module sources and quiz (bottom).

F. PubHub Framework

An adapted online computer-based training approach, also known as online courseware, was used to structure PubHub. Online courseware presents self-paced learning modules to students to interact with and complete. Upon completion, there is usually a post-test for students to assess their understanding of the material and revisit any concepts that need further instruction [17]. As such, each PubHub module (except five) concludes with an instant feedback quiz, providing comprehension benchmarks for students as they progress through the modules. The modules present information via video, images, and text to make them an accessible and engaging experience for students. Another significant aspect of PubHub is the plethora of additional resources—including scholarly articles, university writing centers, and videos—to which users are connected. All sources are cited and linked, which gives credit where it is due and familiarizes students with the scope of information about writing and publication that is available online and in libraries.

G. PubHub Use Cases

To integrate a resource into the normative culture of a group, pathways need to be defined and marketed to potential users. In the case of PubHub, universities need to establish a culture where undergraduate students are expected, or at least encouraged, to publish their research. There are four primary

pathways where one can establish the normative use of PubHub. First, faculty can direct their undergraduate researchers to use PubHub independently while they write a manuscript or prepare a presentation. Second, faculty can use particular modules in their classrooms to instruct students on scholarly writing and presentation conventions, especially those courses where students are required to conduct research. Third, PubHub modules can be incorporated into Research Experiences for Undergraduate workshops and instructional sessions. Fourth, writing tutors can integrate modules into their tutoring sessions.

III. ASSESSMENT

A. Methods

A preliminary assessment of PubHub was performed to understand its helpfulness for faculty and students and how it could be improved. Online qualitative questionnaires and a focus group were conducted to assess Penn State faculty and **students'** perceived utility of PubHub as well as its capacity to lower barriers to undergraduate research dissemination. Participants were purposely selected due to their involvement with undergraduate research. The research team invited students who they knew conducted research **and** faculty who posted research opportunities on Penn State's undergraduate research website to participate. The selected faculty and students were all invited to participate in a focus group, and those who could not attend were provided the questionnaire.

The researchers conducted one faculty focus group and received five completed questionnaires from faculty, and six completed questionnaires from students. Overall, there was a 24.3% faculty response rate and a 61.5% student response rate.

Faculty were asked questions about their experiences engaging undergraduate students in their research and the challenges they faced in supporting undergraduate student publication. They were then asked to provide their opinion on PubHub and whether or not they would recommend it to their students. Students were asked whether they have published and/or presented their research and the benefits if afforded them, and if they would use PubHub or not and why.

B. Methodological Limitations

The perspectives presented in this research are a pilot assessment of the perceived usefulness of PubHub for undergraduate students. Sampling bias may have skewed the student responses since the research team purposefully selected students whom they had connections with and whom knew about publication and presentation. The low response rate could be attributed to invitations being sent out towards the end of the academic year when students and faculty are busy wrapping up their semesters. Because of this, some students and faculty declined participation altogether or did not complete the questionnaire that was sent to them.

Further limiting the pilot evaluation of PubHub is the lack of comparison of PubHub to other online writing resources. This would have enabled the researchers to more strongly gauge the contribution of PubHub to the field of student publication. Future research could compare the user interface and content between PubHub and other resources to better crystallize how PubHub fills a niche in the field.

Future investigation of PubHub should also include a larger sample size of students with varying degrees of familiarity with publication and presentation. Additionally, incorporating students from fields outside of STEM, as well as non-native English speakers and international students, will provide a more holistic perspective of its application to all undergraduate students.

IV. RESULTS AND DISCUSSION

A. Results from Student Questionnaires

Students found research opportunities by individually seeking out opportunities posted online and emailing professors whose research they were interested in. One student joined the HESE program where research is embedded into the design. Students were motivated to do research for a variety of reasons including strengthening graduate school applications, completing a requirement for their Honors degree, and wanting to pursue research since a young age. The students each secured funding through various channels including the faculty's department, a grant, or the University Honors College. In most cases, students were involved in all aspects of the project—from the literature review, to research design and experimentation, to data analysis. Four out of the

six students have published their research, and the two who have not intend to do so soon.

The students brought up multiple challenges to publishing and presenting their research. The dominant theme was that there was little to no support to help them effectively communicate their research through writing and presentations. Aspects of this challenge included revising manuscripts and incorporating reviewer comments, and telling a story through an article or poster.

Despite these challenges, students benefitted from publishing and presenting their research. They reported increased confidence, improved writing and presentation skills, more competitive graduate school applications, and increased networking opportunities. The student-identified benefits mirror the benefits discussed in the literature [1][8][9].

The students who had already published their research validated the significance of the information that is shared on PubHub. One student explained, "It seems a lot of this content is things I've picked up on my own going through the process..." Another student expressed, "...it provides well thought out yet simple steps that you need to understand to be published/present." Again, "It is a great source to utilize.... it definitely gives you a step forward for the career path of research. It is great for pub/presentation." One student explained that the information on PubHub is available through English classes and Librarians; a valid observation, but housing comprehensive information in one place that is easily accessible at the exact time a student needs it makes PubHub a unique resource. Lastly, one student who has not yet published explained that she will use PubHub as she writes her manuscript and inform her laboratory partner about it as well: "Looking through the website, it appears to be very helpful, and I am most likely going to use it for my paper as I prepare it for publication." The combined responses from students indicate the need for a resource like PubHub and the receptiveness of students to such assistance.

B. Results from Faculty Questionnaires and Focus Group

Faculty self-reported barriers to undergraduate publication and presentation are:

1. Students lack background knowledge about research methods.
2. Students are not present long enough to see the research to completion (due to the student entering the lab as a junior or senior, transferring between campuses, lack of time to commit each semester, or because the projects are long-term).
3. Faculty are overcommitted and cannot devote enough time to mentoring students through publication.
4. Undergraduate publication does not count towards promotion and tenure.
5. Students do not fully realize the benefits of publishing and presenting.
6. Difficulty in recruiting students that are qualified and committed to pursuing publishable research.

The reported barriers to undergraduate publication and presentation echo the findings from other studies [6][11][12]. Upon viewing PubHub, faculty reported that they would recommend parts of the website to their students. The “Stronger Writing” category was most widely discussed, likely because it applies to publications in all disciplines. Suggestions for improvement included better guidance on how to use PubHub, and a system whereby students receive personalized module recommendations based on their information needs. Faculty at Penn State are already showing PubHub to students in their classes and laboratories.

When recruiting undergraduate researchers, faculty seek students that are motivated (regardless of their GPA) and have field-specific skills, especially the completion of pre-requisite courses. More student training and a centralized clearinghouse for undergraduate students to advertise their qualifications and interests would reportedly help faculty recruit higher quality researchers. In addition to PubHub as a resource, faculty emphasized the need for financial assistance from the University and better promotion of undergraduate research opportunities. Many of the faculty voiced concern that there is little University infrastructure for them to find qualified undergraduate researchers, thereby limiting the potential for publishable research to arise.

C. Transferability of Results

The results of this research indicate that students who wish to publish research require guidance about the publication process and academic writing conventions. Furthermore, faculty are receptive to outside resources to direct their student researchers towards. Readers of this research that identify with the challenges posed in student publication can use PubHub in their own work. Even more, PubHub is not limited to the Engineering field and can be used by faculty and students in all disciplines. The wide applicability of PubHub makes this research transferable to academicians and their students across myriad geographies and disciplines.

D. Limitations of PubHub

Although identified by faculty and students as a useful resource, PubHub can be improved upon. Faculty noted that PubHub hosts a cumbersome amount of information with little instruction on how to navigate the modules. Faculty also voiced concern that PubHub is less applicable to students that present or perform creative works. Students thought that some of the information on PubHub duplicates what they learn in the classroom.

V. CONCLUSION

Publication is an important pedagogical and professional experience for students, placing them as contributors to the frontier of their field and providing tangible benefits for themselves, their mentors, and their institution. The overarching purpose of PubHub is to help undergraduate researchers get their work published in scholarly journals and to present at academic and practitioner conferences. Students who have accessed PubHub confirm its timeliness and

usefulness. Faculty see PubHub as an instructive resource for their undergraduate researchers and would like to see additional resources from their institution such as financial assistance to pay for undergraduate researchers and research supplies, and infrastructure for them to recruit highly qualified students for their research projects. The purpose of this research was to gauge the appropriateness and usefulness of PubHub for faculty and students. This investigation revealed the receptiveness of faculty and students to publication-related resources, and indicates the many gaps yet to be filled to make undergraduate publication a normative part of undergraduate education. The results of this research are transferable to students and faculty across institutions and disciplines, and expanded use and investigation of PubHub will better crystallize its niche in student research publication.

ACKNOWLEDGEMENT

The researchers would like to thank the Schreyer Institute for Teaching Excellence for their support of PubHub. Thanks to Sara Warnquist, Arianna DeReus, and Siri Maley for help developing and editing PubHub, and to John Meier and Rebecca Miller at PSU Libraries for ongoing advice about PubHub. Thanks to all the faculty, staff, and students who provided their input to make PubHub stronger.

REFERENCES

- [1] The Council on Undergraduate Research. (2011) Council of Undergraduate Research: Learning Through Research. [Online]. http://www.cur.org/about_cur/fact_sheet/
- [2] L. Gaffney, "The role of the research mentor/teacher," *Journal of College Science Teaching*, vol. 34, no. 4, pp. 52-56, 2005.
- [3] John Ishiyama, "Does early participation in undergraduate research benefit social science and humanities students?," *College Student Journal*, vol. 36, no. 3, pp. 380-386, 2002.
- [4] Lida A Beninson, Jessica Koski, Erika Villa, Ronnie Faram, and Sally E O'Connor, "Evaluation of the Research Experiences for Undergraduates (REU) Sites Program," *Council Undergraduate Research Quarterly*, vol. 32, no. 1, pp. 43-48, 2011.
- [5] L. Barker, "Student and faculty perceptions of undergraduate research experiences in computing," *ACM Transactions on Computing Education*, vol. 9, no. 1, p. article 5, 2009.
- [6] J. Jungck, M. Harris, R. Mercuri, and J. Tusin, "Undergraduates: Do research-publish!," *Cell Biology Education*, vol. 3, no. 022-027, pp. 24-46, 2004.
- [7] Rachel Dzombak and Khanjan Mehta, "Scholarly advances in humanitarian engineering and social entrepreneurship: A typology of research publications," *International Journal for Service Learning in Engineering*, pp. 98-116, 2013.
- [8] J R Ferrari, S Weyers, and Stephen F Davis, "Publish that paper--but where? Faculty knowledge and perceptions of undergraduate publications," *College Student Journal*, vol. 36, no. 3, pp. 335-341, 2002.
- [9] Kayla M McCormick, "Skills attained through undergraduate research," *Research Quarterly for Exercise and Sport*, vol. A5, 2014.
- [10] Rachel Spronken-Smith et al., "Completing the Research Cycle: A Framework for Promoting Dissemination of Undergraduate Research and Inquiry," *Teaching and Learning Inquiry: The ISSOTL Journal*, vol. 1, no. 2, pp. 105-118
- [11] L. B. Pacifici and N. Thompson, "What do they expect: A comparison of student expectations and outcomes of undergraduate research experiences," *Journal of College Science Teaching*, vol. 41, no. 1, pp. 54-60, 2011.

- [12] Donna Marie Wing and Dana J Smith, "Undergraduate student- faculty publication outside the baccalaureate curriculum," *Nurse Educator*, vol. 26, no. 6, pp. 256-258, 2001.
- [13] Marcia L Linn, Erin Palmer, Anne Baranger, Elizabeth Gerard, and Elisa Stone, "Undergraduate research experiences: Impacts and opportunities," *Science*, vol. 347, no. 6222, pp. 627-633, Feb 2015.
- [14] Joyce A Kinkead, *Valuing and Supporting Undergraduate Research*. San Francisco: Jossey-Bass, 2003.
- [15] National Science Foundation, "Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014- 2018," 2014.
- [16] National Science Foundation. (2016). National Science Foundation: Where Discovery Begins. [Online]. https://www.nsf.gov/crssprgm/reu/list_result.jsp
- [17] Boyer Commission on Educating Undergraduates in the Research University, "Reinventing undergraduate education: A blueprint for America's research universities." Stony Brook, 1998.
- [18] Linda Harasim, *Learning Theory and Online Technologies*. New York, NY: Routledge, 2012.

ABOUT THE AUTHORS

Rebecca Ligrani is an adult educator with a focus on food systems change. She has an MS in Agricultural, Leadership, and Community Education from Virginia Tech and has worked across the country growing food and organizing communities. She will next apply her skills and expertise in New York City to address hunger and poverty through community education and strategic volunteerism.

Irena Gorski is pursuing an MPH degree at Johns Hopkins Bloomberg School of Public Health to explore passions in sustainable and equitable food systems and their public health implications and further develop her skillset and mindset to improve health around the world.

Sarah Ritter is Assistant Professor of Engineering Design at Penn State University. She teaches both first-year engineering design and Biomedical Engineering senior design, as well as works with students in the Humanitarian Engineering and Social Entrepreneurship program. Sarah received her PhD in Biomedical Engineering from Texas A&M University, where her focus was on the development of minimally-invasive, long-term blood analyte optical monitoring systems, prior to joining the Penn State faculty.

Khanjan Mehta is the Founding Director of the Humanitarian Engineering and Social Entrepreneurship (HESE) Program and Assistant Professor of Engineering Design at Penn State. HESE is an integrated learning, research, and entrepreneurial engagement program focused on developing and commercializing technology-based solutions in low resource settings. In collaboration with his students, Mehta has published over 110 journal articles and refereed conference proceedings with ~50 more in the pipeline. Mehta serves as an Associate Editor for the IEEE Technology and Society Magazine, Contributing Editor for the Engineering 4 Change portal, and a reviewer for a wide array of journals and conferences.