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Exploring Variance in Undergraduate Research Participation: A Quantitative and Qualitative Investigation among Students with Differing Levels of Involvement

Dr. Andrew Olewnik, University at Buffalo, The State University of New York

Andrew Olewnik is an Assistant Professor in the Department of Engineering Education at the University at Buffalo. His research includes undergraduate engineering education with focus on engineering design, problem-based learning, co-curricular involvement and its impact on professional formation, and the role of reflection practices in supporting engineering undergraduates as they transition from student to professional.

Dr. Monica Lynn Miles, University at Buffalo, The State University of New York

Monica L. Miles, Ph.D. is an Assistant Professor of Engineering Education at the University at Buffalo in the School of Engineering and applied sciences. Dr. Miles considers herself a scholar-mother-activist-entrepreneur where all her identities work in harmony as she reshapes her community. She is a critical scholar who seeks transformative solutions to cultivate liberated and environmentally just environments for Black people, and other minoritized individuals. She believes in fostering racial solidarity and finding her own path in the movement.

Hasan Asif, University at Buffalo, The State University of New York

Hasan Asif, is a graduate from the University at Buffalo in Data Science, possesses a keen interest in data transformation and gaining insights from data, includes expertise in setting up statistical tests, transforming data, and creating visualizations. He has demonstrated his skills by architecting systems to analyze the longitudinal participation of students throughout their studies.

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Introduction

This research paper concerns undergraduate research, a high impact experience [1] that allows students to get involved [2] in meaningful ways in their campus community (and beyond). Understanding the navigation and impact of undergraduate research experiences for STEM students is limited and primarily derived from Research Experiences for Undergraduate (REU) programs [3]. There is a recognized need for research that more broadly explores undergraduate research experiences [3] considering their potential impact on individual students, institutions, and the engineering disciplines.

For individual students, there are potential benefits in the form of professional competency development, persistence, self-efficacy, and GPA [3], [4], [5], [6], [7], [8], [9], [10], [11]. For institutions (especially R1 institutions like the one where this study was sited) the development of a research pipeline built from evidence-based interventions could be beneficial to research output and overall standing. For the engineering discipline, advancement of the field is dependent on mentoring and developing the next generation of research scholars.

However, it can be difficult to study undergraduate navigation of research experiences because those experiences often occur as co-curricular engagements. As such, there are limited academic records and student artifacts that might be explored to advance our understanding of the undergraduate research experience. This exploratory study sought to provide some insights through exploration of data that resulted from a professional development survey (PDS) instituted at an R1 institution in the Northeast United States. Through the PDS, undergraduate students reported annually their experiences in a variety of co-curriculars, including undergraduate research.

We were particularly interested in understanding what, if any, differences there were among three student groups, those who never participated in research (G1, N = 700), those who participated during their first year but did not continue (G2, N = 31), and those who participated in their-first year and continued in subsequent years (G3, N = 20). We considered two fundamental questions:

1) What differences, if any, are there among these three groups on traditional academic measures (high school GPA, SAT scores, undergraduate GPA)?

2) What differences, if any, are there among students in G2 and G3 as reflected in their PDS responses?

To investigate these questions, we analyzed a cohort of student PDS data from 2015-2018, inclusive. More details regarding the data set are provided in the Methods section. First, a brief review of the literature related to undergraduate research is provided.

The Potential Educative Value of Undergraduate Research
According to a consensus study from the National Academy of Sciences, Engineering, and Medicine, there is robust evidence demonstrating that involvement in undergraduate research improves retention within STEM fields, including for under-represented populations [3]. Engaging in undergraduate research (UR) can be an integral academic pursuit for students to complete their engineering degrees. Scholarship accentuates the positive impact of undergraduate research such as involvement in various student outcomes, encompassing perceived advancements in academic skills and a deepened understanding of engineering and research processes [10], [11]. For example, studies have comprehensively explored the multifaceted benefits of undergraduate research (see [12], [13], [14]). Seymour and colleagues inclusive review synthesizes findings from numerous studies, emphasizing the positive influence of UR on students' interest in STEM majors, career readiness, research acumen, critical thinking, disciplinary expertise, comprehension of the research process, insight into scientific methodologies, and enhanced self-efficacy and self-confidence in research capabilities [13]. The undergraduate research experience, as described by the authors, is a "powerful affective, behavioral, and personal discovery experience whose dimensions have profound significance for their emergent adult identity and sense of direction" (p. 531).

Moreover, several studies on UR show a positive correlation with higher GPAs [6], [8], [9], [15], [16] and sustained pursuit of engineering majors [17]. This collective body of research underscores the transformative impact of undergraduate research on students' academic, personal, and professional trajectories. Research experiences can encompass both Undergraduate Research Experiences (UREs) and Course-based Undergraduate Research Experiences (CUREs; [18]). UREs involve individual students working in faculty research laboratories with one-on-one mentoring, typically spanning one or more semesters, although the activities and mentoring styles may vary. Due to limited capacity, UREs are often competitive and have selection criteria such as grades, test scores, and previous experience or performance based in a class [19].

In contrast, CUREs have a structured curriculum and are open to a broader range of students, placing higher demands on mentors to guide multiple students [18]. Duration is a critical factor in both UREs and CUREs, influencing outcomes significantly [18]. UREs and CUREs differ in selectivity, duration, setting, mentoring approaches, and associated costs. Notably, Burt and colleagues [19] delve into outcomes associated with participation in UREs, focusing specifically on engineering undergraduate students. Their research underscores the significance of sociocultural perspectives on learning within UREs, emphasizing the role of faculty supervisors in mediating students' participation and learning of research methodologies. The study suggests that URE participation not only fosters a sense of belonging and confidence in research abilities but significantly contributes to retention in engineering pathways.

Furthermore, the study by Rodríguez Amaya and colleagues [20] investigates the impact of UREs on engineering students, particularly those from minority backgrounds. Exploring student characteristics and their influence on UREs, the study identifies classification and ethnicity as statistically significant predictors. Despite a small sample size, the findings emphasize the need for high-impact UREs, mentorship relationships, and efforts to address student misconceptions, particularly among underrepresented groups. Faculty mentoring emerges as a crucial factor in enhancing students' attitudes and engagement in STEM disciplines, addressing the broader concern of retaining underrepresented students in STEM globally.

The integration of undergraduate research experiences, whether in traditional UREs or CUREs, has a profound impact on students' academic, personal, and professional development, especially within the dynamic landscape of engineering disciplines. The differentiated nature of these experiences, coupled with the valuable insights from Burt and colleagues [19] and Rodríguez Amaya [20] and colleagues, highlights the need for structured programs, faculty mentorship, and targeted efforts to promote inclusive engagement in undergraduate research, ensuring the continued success and diversity within STEM education.

It is crucial to highlight the distinction between "research experiences" and "research lab experiences," [19]. Existing scholarship often conflates these terms, and for clarity, "research experiences" are acknowledged to be broader in scope than experiences specifically within a "research lab" [19]. The term "research experiences" encompasses a range of activities, including reading scientific literature, contributing to the design of research projects, working towards significant findings, and delivering oral and written presentations of the results [19].

On the other hand, research conducted within a laboratory is typically confined to hands-on experiments and the subsequent writing of lab reports. The scholars pressed that this distinction is crucial to avoid conflating the broader research experience with the specific activities carried out in a research laboratory setting [19]. Such insights underscore the importance of recognizing that research experiences can encompass various activities beyond traditional lab work, contributing to a more comprehensive understanding of the research landscape that undergraduates navigate.

Methods

The approach used in this study employed quantitative and qualitative research methods applied to an institutional data set, comprising a professional development survey and complementary data for each student (e.g., high school GPA, SAT scores). These data were deidentified prior to being provided to the research team, thus through consultation with the IRB office, this study was considered a records review and not qualified as human subject research (i.e., was exempted from a formal review process). In this section, the PDS survey and data used in this study are briefly described, along with details of the quantitative and qualitative methods applied to the data.

Professional development survey (PDS) and complementary data overview

The PDS survey was implemented by the institution from 2015 through 2021. Though referred to as a survey, the institutional intent was to simultaneously capture data that helped to understand the nature of student co-curricular experiences and establish a reflection portal that enabled and encouraged students to reflect on their experiences outside the classroom [21]. Conducted annually, all engineering undergraduate students were asked to self-report and reflect on their co-curricular experiences from the prior year (i.e., students who completed the survey in fall 2020 would be reporting about activities that occurred between fall 2019 and summer 2020, inclusive). The experiences included: technical work (e.g., internship), non-technical work (e.g., grocery store clerk), undergraduate research, student clubs/organizations, makerspace/engineering project micro-credential program, community service, and study abroad.

By responding to the PDS, students self-reported data for each experience type, indicating the semesters in which they participated. As part of documenting their experience, students were asked to respond to two open response prompts: *Please explain your primary project by considering the following: situation or task (the task/problem you were presented with), action (what did you do), result (what did you accomplish), impact (how did this help the overall project); What was the nature of your research experience? Please include the overall scope of the project and your individual responsibilities.* Finally, they also indicated the types of professional competencies that that believed they had used/developed/improved. A more complete discussion of the PDS survey can be found in [21], [22]. In this study, we focused on the open responses from students.

Additional data about the students provided by the institution included gender (Man or Woman) and Race/Ethnicity (White, Asian, Black or African American, International/Non-Resident Alien, Hispanic/Latino, Unknown, Two or more races, American Indian or Alaska Native), high school GPA, SAT scores, and term GPAs. In this study, we considered the GPA and SAT scores.

The data considered in this study represents a cohort of students who were admitted in the fall 2015. Focus was on the undergraduate research experiences reported in that first year. Three groups were considered from this cohort: Group 1 (G1, N = 700) comprises students who never reported participation in undergraduate research at any point during their undergraduate careers (fall 2015- summer 2018), Group 2 (G2, N = 31) comprises students who reported participating in undergraduate research in 2015-16 but did not return to research in the next year, and Group 3 (G3, N = 20) comprises students who participated in research in 2015-16 and continued participating in the following year (2016-17).

Quantitative analysis

To answer the first research question, we used various descriptive and inferential statistics. Descriptive analysis, encompassing mean, standard deviation, and minimum, was conducted on traditional educational performance metrics, such as high school GPA (HSGPA), SAT scores, and Term GPAs for various academic terms. Box plots are utilized to visually represent the distribution of these metrics within each group.

Subsequently, Analysis of Variance (ANOVA) was employed to test for overall group differences on academic measures. Post hoc pairwise comparisons were performed using the Tukey Honestly Significant Difference (HSD) test to identify specific group variations. This methodological approach, integrating descriptive analysis, visualization, ANOVA, and Tukey HSD tests, facilitated a comprehensive examination of the potential association between research involvement and academic performance indicators among student groups. It is important to note that while these analyses dive to comprehend the correlations from academic success and students text responses, establishing inference requires further discussion and consideration of potential confounding factors.

Qualitative analysis
To address the second research question, we employed attribute coding as a methodological approach [23]. Attribute coding utilizes binary coding to signify the presence or absence of specific attributes and involves systematically documenting the inherent characteristics of all student responses for subsequent analysis. Here, attributes encompassing aspects of the research experience such as impact, action, learning, etc. Coding was conducted to analyze 58 responses from individuals in G2 (left research) and G3 (continued research). From G2, there are a total of 31 students, but responses were received from only 28 students. Within G3, there are a total of 20 students. These students were expected to provide responses once in AY 2015-16 and once in AY 2016-17. However, we obtained responses from only 16 of 20 students for the first year of research (AY 2015-16) and 14 responses for the second year of research (AY 2016-17). Of these 30 responses 24 came from the same students. Both sets of responses were included in the analysis.

A three stage, collaborative coding process was used by the authors. During the analysis process, the researchers did not know which group the responses came from. The coding process commenced with the main coder analyzing 10 randomly selected participant responses. At the conclusion of this stage, the coders collaboratively reviewed and revised the initial attribute codes. In the second stage, the primary coder extended the attribute coding to the remaining 44 responses. Toward ensuring interrater reliability, in the third stage the second and third coder were each randomly assigned 10 participants to analyze, inclusive of four common participants. The coders then conducted a review to ensure that the outcomes across all coders were similar. Attributes were considered based on the prompts and through the collaborative review process. The final set of attributes and a detailed description of each is provided in Table 1.

Table 1. Attribute codes

Code	Definition	Example
Impact	focus on impact of student work (experiment, test) in broader or narrow range. It is not impact of res on their self	• *This helped further the knowledge about this material* • *This conclusion will help to narrow down the options for solutions to making batteries longer lasting.* • *Findings to be used for future projects*
Perceived Learning	self-reflection of value or knowledge gained during the research experience	• *I am still in the middle of learning to code, and coding, neural networks* • *Learned about the anatomy and physiology of the lung and its cilia*
Nature of research	descriptions that suggest proximity to the core research work (e.g., performing experiments to get new results) • No (not described or suggested) • Support role (actions suggest more that they are supporting research) • Yes (actions suggest a direct role in research)	• *Tested the molds to find stresses and strains* • *Designed an experimental procedure for the synthesis of uniquely nano-structured silicon-germanium anode material for lithium-ion batteries.* • *I conducted experiments for each modality first separately. I analysed the data using the mat lab program*

Task	represent the worked they were assigned or things they broadly doing during the research. It includes the role and responsibility; it's the scenario or context for their involvement • Non-specific with respect to projects or objectives/goals • Specific about objectives • Objectives or goals can be inferred	• *I conducted experiments to test a triple modality system* • *This research program involved the study of nonthermal plasma*
Action	specific description of activities or things they did within the broader task • Vague or generic description of actions "I did research" • Specific actions or activities that fit the context ("I developed an experiment") and/or mention of specific tools or skills that they applied	• *Rendered and refined computer-aided design (CAD) drawings of these skulls using Avizo, MeshLab, Geomagic, Strand7* • *developing software to learn about chemistry in a quicker, and more efficient way* • *during the time that I served as communications lead, included antenna design, FCC licensing, testing work, and recruitment*

Findings

In this section, findings from analysis of the PDS data are presented. First, quantitative findings are presented to answer the first research question: What differences, if any, are there among these three groups on traditional academic measures (high school GPA, SAT scores, undergraduate GPA)? Then, qualitative findings are presented to answer the second research question: What differences, if any, are there among students in G2 and G3 as reflected in their PDS responses?

Quantitative findings

Descriptive statistics (mean and standard deviation) for the three groups are shown in Table 2. Corresponding box plots are shown in Figures 1 and 2. Statistics and box plots are shown for traditional academic measures of high school GPA (HSGPA), SAT scores, and undergraduate GPAs for relevant. Based on these statistics, the three groups can be characterized as follows. G1 (no research experiences) had the lowest average HSGPA, SAT, and term GPAs, and has the highest variability on these measures. G3 (continued with research after first year) had the highest average HSGPA, SAT, and term GPAs, and the least variability. G2 (left research after first year) lies between G1 and G3 in terms of average and variability on all measures.

The outcomes of the one-way ANOVA (Table 2) indicate a statistically significant difference among groups (G1, G2, G3) for six out of eight academic measures (HSPGA, SAT, GPA 16 SP, GPA 16 F, GPA 17 F, GPA 18 F). The Tukey Honestly Significant Difference (HSD) post hoc tests (Table 3) further support these distinctions, highlighting significant pairwise differences among the groups in various academic variables identified through ANOVA.

Table 2. Descriptive statistics for each student group and ANOVA results

	G1 (no research)		G2 (left research)		G3 (cont. research)		F stats	P-value
	M	**SD**	**M**	**SD**	**M**	**SD**		
HSGPA	90.43	6.27	93.91	4.45	95.62	4.11	8.03	**< .001**
SAT	1157.6	151.47	1224.5	169.92	1256.8	131.69	5.15	**.006**
GPA 16 SP	3.13	0.54	3.34	0.6	3.49	0.49	5.71	**.003**
GPA16 F	2.91	0.66	3.1	0.61	3.32	0.55	4.01	**.008**
GPA 17 SP	3.1	0.57	3.15	0.63	3.35	0.53	1.92	.137
GPA 17 F	3.02	0.62	3.2	0.59	3.37	0.64	3.84	**.022**
GPA 18 SP	3.22	0.578	3.37	0.53	3.43	0.71	1.74	.163
GPA 18 F	3.24	0.59	3.56	0.35	3.65	0.31	6.69	**.001**

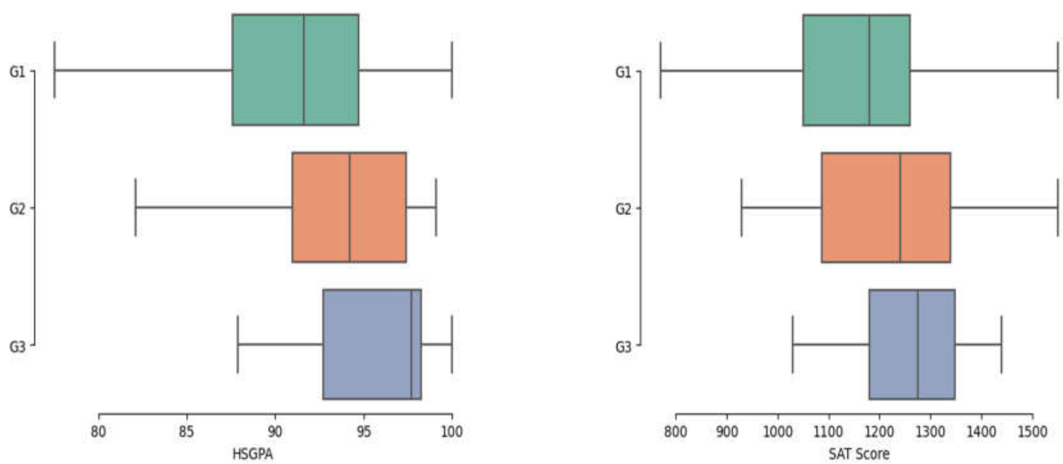

Figure 1. Box plots for HSGPA and SAT

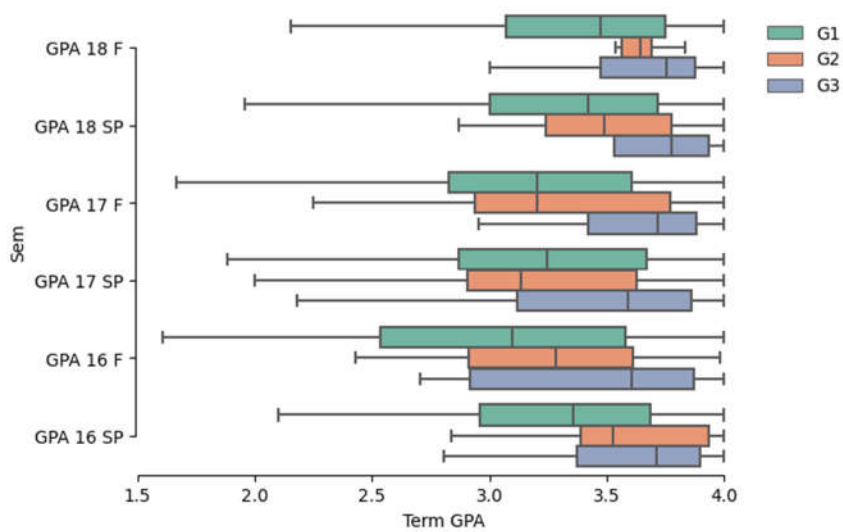

Figure 2. Box plots for undergraduate GPA

The Tukey Honestly Significant Difference (HSD) post hoc tests uncovered significant pairwise differences among the groups (Table 3). All variables identified through ANOVA exhibited at least one meaningful pairwise difference. Specifically, students who continue research (G3) showed a significant difference compared to those who did not pursue research (G1) across all academic measures. Additionally, a significant difference emerged between the group of students who left research (G2) and who continue research (G3), specifically in the variables of HSGPA and GPA 18 F.

Table 3. Posthoc significance pairwise comparison results

Variable	Group 1	Group 2	Mean diff	P-adj
HSGPA	G3	G2	-1.71	0.68
	G3	G1	-5.19	**0.004**
	G2	G1	-3.47	**0.021**
SAT	G3	G2	-32.32	0.79
	G3	G1	-99.25	**0.028**
	G2	G1	-66.92	0.10
GPA 16 SP	G3	G2	-0.14	0.62
	G3	G1	-0.35	**0.013**
	G2	G1	-0.20	0.12
GPA 16 F	G3	G2	-0.21	0.47
	G3	G1	-0.41	**0.017**
	G2	G1	-0.19	0.25
GPA 17 SP	G3	G2	-0.20	0.44
	G3	G1	-0.25	0.12
	G2	G1	-0.05	0.87
GPA 17 F	G3	G2	-0.17	0.63
	G3	G1	-0.35	**0.026**
	G2	G1	-0.17	0.36
GPA 18 SP	G3	G2	-0.06	0.93
	G3	G1	-0.20	0.27
	G2	G1	-0.14	0.46
GPA 18 F	G3	G2	-0.09	0.87
	G3	G1	-0.41	**0.014**
	G2	G1	-0.31	**0.023**

Qualitative findings

In this section findings from the qualitative analysis are presented. First, to characterize the nature of the responses between G2 and G3, there was a notable difference in the length of responses. For G2 (students who left research) the mean response length was 293.81 words with a standard deviation of 211.68 words. For G3 (students who continued research) the mean response was 685.4 words with a standard deviation of 720.4 words.

Overall, this suggests that students who continued with research provided more details about their experiences in responding to the prompts compared with their peers who left research after the first-year. However, we also note a relatively high level of variability in the response length.

Attribute coding revealed some important differences among these two groups along five attributes: action, impact, nature of research experience, collaboration, and perceived learning. Each of these is considered here.

Action: Within both groups, a notable contrast in the articulation of actions emerged, particularly evident among students who left research after the first-year (G2). A substantial majority in this category provided vague descriptions of their actions, with the highest percentage falling into the group of students who did mention actions but offered only brief descriptions. Examples of such responses include statements like *"I manage and help build and research about a sat"* and *"running simulations and helping out with the experiments."* In contrast, approximately 50% of students who continued with research presented detailed and specific accounts of their actions. Their narratives delved into the intricacies of the tasks performed, as evident in statements such as *"conducting cell culture, taking images with a microscope of the cells, an in-depth literature search, and fabricating a fluidic device using stereolithography 3D printing. I created a fluidic device through stereolithography 3D printing to aid in the differentiation of adipose-derived stem cells into a certain endothelial cell type in the eye. I created many different prototypes testing different factors of the device for optimization"* and *"using the microscope, understanding ImageJ, Excel, and cell culturing... The summer project included sectioning 50 blocks, analyzing the lungs in over 150 slides, and taking descriptive notes/sketches of the section. This required reading the structure of the lungs, the histology of the respiratory system, the histology of the muscle/connective tissue and the histology of the tumor cells."* Conversely, among students who continued and conducted research in 2016-17, there was a tendency to poorly articulate their actions in their next reflection cycle, with approximately half providing vague descriptions such as *"Designed and constructed a prototype wing and tested" and "One example is a software test."* We note that after participating in research for a second year, only six of the 20 students continued in research for a third year.

Impact of Work: An evident discrepancy in the discussion of the impact of work surfaced, particularly among students who left research after the first year. Approximately 60% of this cohort either completely omitted any mention of the impact of their work or inadequately addressed it. Examples, such as *"Talked about before but UBNL is also research. I researched new sat components... I manage and help build and research about a sat"* and *"Collaborated with PhD students to investigate the gas-phase synthesis and applications of nanomaterials in the lab. Designed an experimental procedure for the synthesis of uniquely nano-structured silicon-germanium anode material for lithium-ion batteries,"* lack explicit discussions on the broader impact of their research efforts. This potentially demonstrates a limited awareness of the broader significance of their work. Few students who left research after the first year provided explicit description of the impact, like *"The impact of what I did helped the Science team learn* *what we needed so we can develop better, more accurate tests with more advanced equipment (which we now know what equipment we need) to find the precise focal lengths of the lenses."*

In contrast, 70% of students who continued with research, whether broadly or specifically, reported the impact of their work, either in the present or future. For instance, one student explicitly mentioned, *"We were able to realize that adding just a little garlic doesn't have that much effect on the bacteria, but when a lot is added, they die."* Another student utilized experiment results to guide development, stating, *"Once I managed to get good data after adjusting the experiment set up, my team and I started putting two modalities together."* This contrast with students who left research might suggest a more heightened awareness and articulation of the impact of research among students who continued with their research endeavors.

Nature of Research: A substantial portion (60%) who left research after the first year, did not explicitly mention or highlight any direct involvement in core research activities. In these instances, students describe their tasks but evidence of the research context is not provided. Only 10% engaged in core research activities, while the remaining 30% described a supporting role, participating in regular lab work and assisting ongoing research efforts. For example:

In contrast, among the group of students who continued with research (AY 2015-16), 50% described being involved in support roles within a research context. This involvement is evidenced by statements such as *"helped edit doctoral candidate project," "responsible for charging and discharging the batteries," "using the microscope, understanding ImageJ, Excel, and cell culturing," and "managing a group of students by assigning them tasks and mentoring them."* Additionally, 25% of continuing students (AY 2015-16) described engagement in core research activities, demonstrating a more direct contribution. Quotes illustrating such involvement include *"performed tests and utilized microscopy to observe beat and waveform," "designing, creating, and testing a communications system,"* and *"I conducted experiments to test a triple modality system."* This breakdown underscores the varying degrees of research involvement among students, with some actively participating in research tasks while others providing support through diverse activities. Second-year responses among students who continued research in AY 2016-17 describing involvement in core research activities reduced to 15%. The majority of responses described a support role.

Collaboration: Collaboration emerged as a significant theme; 55% of students who left research described some form of collaborative effort during their research endeavors. Expressions like *"I did research for a professor," "Collaborated with PhD students," and "I assisted"* strongly indicate collaborative engagement. Similarly, among students who continued their research activities, 60% were involved in collaborative efforts, either within a group or with a professor. However, a noteworthy contrast arises for students who continued research during the 2016-17 period, as only 30% of them worked in collaboration with a professor or graduate student. This suggests a tendency towards more isolated research pursuits within this specific subgroup, with a lower proportion engaging in collaborative efforts with academic mentors or peers.

Perceived learning: Perceived learning was more prominently emphasized among students who continued research. Among students who continued research 50% of the 2015-16 responses and 60% of the 2016-17 responses explicitly mentioned their perceived learning. Supporting quotes include statements such *as "I have learned enough," "Learned about the anatomy and physiology," "The research experience was a learning experience," and "This experience allowed me to gain a lot of COM theory and management skills."* In contrast, only 18% of students who left research explicitly mentioned perceived learning stemming from their involvement. This discrepancy highlights a distinct emphasis on learning and personal development among students who chose to continue their research activities.

Discussion

The findings of this study shed light on various aspects of undergraduate research participation and its implications for undergraduate research experiences and institutional support structures.

First and foremost, the observation that students who choose to participate in research in the first place and those who continue in research tend to have higher high school GPAs raises questions about the criteria used in selecting students for research opportunities. There may be inherent biases or systemic barriers in the selection process that privilege certain groups of students over others, potentially limiting access to research experiences for those with lower academic performance. Though research environments may be inherently competitive [19], high school or early undergraduate GPAs may be a poor selection criteria, especially in light of the potential positive effect of research participation on GPA [6], [8], [9], [15], [16]. Our finding that there was no significant difference in term GPAs in spring of 2016 (GPA 16 SP) -- and beyond -- among students who left and those who continued with research suggests that UR participation does not negatively affect undergraduate GPA.

In addition to selection processes, the messaging around research within institutions may signal to students that they do not belong, thus serving as a filter by which students opt out in the first place. For example, university honors programs are positioned to recruit high performing (by traditional academic measures) students to participate in research. While this is a positive messaging to those students and aligned with the competitive interests of research institutions, it may have an unintended negative message for other students that deters them from participating. The implication of these quantitative findings relates to messaging and selection about who can participate in research. It may suggest that institutions need to evaluate their messaging around research participation to ensure that students see research as an inclusive potential pathway. Ultimately, the quantitative results lead to a fundamental question for future study. Namely: To what extent are students selected out versus opting out of undergraduate research?

For students who participated but left research after the first year, we might infer from the quantitative findings that concerns over GPA were not the primary driver behind that decision. The qualitative analysis provides several other possible drivers and two aspects of student reflection stood out.

First, the responses reveal a spectrum of interpretations regarding what constitutes "research" among students. In describing actions, impact, and nature of the research, we observed that students' participation may be near the central research task or take a more peripheral support role. Drawing on the concept of legitimate peripheral participation [24], it is evident that students engage in a range of activities and tasks within research settings, some of which may be peripheral but still contribute meaningfully to the research endeavor. It is essential to recognize and validate the diverse forms of research engagement, including both direct research activities and supportive roles that contribute to the research process. The extent to which students are supported in recognizing their valuable contributions (and thus motivated to continue their involvement) may hinge on the interaction dynamics of the research group with whom they work [19]. Institutions should foster inclusive research environments that recognize and value diverse forms of participation, providing clear pathways for skill development and knowledge acquisition among research participants.

Second, the qualitative analysis highlights the presence of important but often overlooked contributions and learning outcomes among some research participants. Based on the observed underreporting about experiences among students who left research, we are left to wonder if some students leave research because of a perceived lack of learning. Considering the range of valued outcomes associated with research participation reported in the literature [3], [4], [5], [6], [7], [8], [9], [10], [11], it is vital to support students in uncovering and recognizing these potentially hidden aspects of their research participation, ensuring that they are not undervalued or marginalized within the academic community.

Qualitative findings lead us to questions for future research. First, what constitutes research, and to what extent do faculty, graduate student, and undergraduate student definitions overlap? Second, what are the identities of undergraduate researchers and how are those identities constructed and (in-)validated through research experiences?

Conclusion

This exploratory study underscores the need to better understand and support students navigating complex research experiences. Our study is limited by the indirect, self-reported nature of the data, however, our findings our aligned with those reported elsewhere. Institutions can draw insights from reports such as the National Academies Report to inform the development of comprehensive support frameworks that address the diverse needs and challenges faced by research participants. In conclusion, by addressing issues related to selection criteria, support structures, perceptions of research, and hidden contributions, institutions can create more inclusive and enriching research environments that maximize the potential benefits for all students involved.

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