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Determinants of student engagement in undergraduate research at the University of Kentucky

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Introduction

Undergraduate research is defined as "an inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline" (CUR 2015).

The Kentucky Council on Postsecondary Education's *Stronger By Degrees: A Plan to Promote a More Educated and Prosperous Kentucky, 2016-2021 Strategic Agenda for Postsecondary and Adult Education* indicates undergraduate research promotion as a strategy for achieving a primary policy objective. (Council on Postsecondary Education, 2016)

> "Policy Objective 10: Increase basic, applied, and translational research to create new knowledge, accelerate innovation, and promote economic growth
>
> > Strategy 10.4. Increase opportunities for undergraduate students to conduct or assist in research."

The University of Kentucky 2015-2020 Strategic Plan also includes undergraduate research in its list of strategic initiatives to support the undergraduate education objective. (University of Kentucky, 2015)

> "Strategic Initiative 3: Enrich students' undergraduate education through transformational experiences of self-discovery and learning.
>
> > Action Step 1: Integrate high-impact practices such as undergraduate research, education abroad, service learning, and experiential learning programs throughout academic curricula and majors."

Completion of this action step at UK will require institutional policies to support and incentivize the efforts of directly mentoring undergraduate students in research and other high impact practices.

There are challenges to providing research opportunities to undergraduates, however, and those programs that indicate a less than optimal level of current engagement will need effective policies and procedures to overcome the specific challenges. It is not clear why some students choose to engage, while others do not, given the same access to opportunities. This capstone aids the development of policies by examining the factors that affect a student's choice to engage in research as an undergraduate, and recommending strategies to increase the number of students who make that choice.

Opportunities for engagement in undergraduate research at the University of Kentucky

UK is similar to most other institutions of higher education in that we offer many undergraduate research opportunities as a whole, but they are found in individual departments with variable levels of support, and it is difficult to find information about them. I present here a list of programs and opportunities that I am aware of, but it should not be taken as a complete list.

Undergraduate students at UK often access research experiences through informal apprenticeship arrangements with a faculty mentor after becoming incentivized by a compelling research anecdote mentioned in class. The student may volunteer their time, or the faculty mentor may have research grant funding available to pay the student.

The NSF EPSCoR Research Experience For Undergraduates program provides grant funding to faculty willing to provide summer research engagements and mentoring to undergraduates.

The UK Office of Undergraduate Research facilitates research engagement through several funding, presentation, and student-faculty matching initiatives; and coordinates efforts with the UK Center for Academic Resources and Enrichment Services to disseminate information to minority students.

The Society for the Promotion of Undergraduate Research (SPUR), facilitated by the Office of Undergraduate Research, helps to match students with research mentors and holds educational colloquia.

At least two UK departments offer research opportunities to their students through coursework (curriculum embedded research). The Biology Department offers a Freshman Seminar course, BIO 199, Research Experience in Biology. The Psychology Department offers four senior level courses: PSY430, Research in Personality; PSY 440, Research in Social Psychology; PSY 495, Senior Thesis Seminar; and PSY 496, Senior Thesis Research.

Challenges to undergraduate research engagement at the University of Kentucky

Although there are compelling reasons to provide research opportunities to undergraduates, faculty and administration at UK have noted considerable challenges to doing so.

1.) One issue is that there is no quantitative measure of the level of demand or current engagement in undergraduate research broadly at UK. Undergraduates are not commonly required to enroll in a specific course to participate in research, and often engage through informal arrangements with a faculty mentor. Therefore, the university has no systematic way of identifying or counting them. The lack of data concerning this issue leads to a dependence on qualitative statements that are not likely to influence budgetary decisions.

2.) The budget for undergraduate research is no trivial matter though. The costs of research are high compared with traditional coursework in the same discipline. These costs come from increased faculty time commitment to mentor students one on one, administrative oversight, purchases of research equipment (especially in the STEM areas), and purchases of supplies and consumables needed to conduct experimental research.

3.) Another challenge to undergraduate research engagement is the current lack of structural faculty incentive. Although mentoring undergraduates in research is often personally rewarding for faculty, they often do not receive institutional support or recognition for these activities in their distribution of effort contracts.

Literature Review

Benefits of undergraduate research

Studies show that the quality of student learning is improved by engagement in research (Bradforth et. al 2015, Gafney 2010, Hunter et. al 2007, Kardash 2000, Kuh et. al 2006, Lopatto 2007, Linn, et. al 2015). A University of Delaware study finds that students perceive increased learning outcomes from research engagement as compared to traditional coursework (Ward et.al 2002). They specifically indicate increases in technical skill, ability to act independently, insight into graduate study and career possibilities, understanding of the value of teamwork, ability to think creatively, self-confidence, and communication skills. Engagement in educationally purposeful activities, such as undergraduate research, is also shown to increase first-year GPA, especially among students with lower pre-college achievement levels. (Kuh, et. al, 2006)

Undergraduate research is also shown to increase student retention rates, especially among sophomores, minorities, and "at risk" students (Jones et. al 2010, Kuh, et.al 2007, Gregerman et al. 1998). The first generation college student cohort falls into this "at risk" population and may therefore experience a positive retention impact from undergraduate research engagement. The University of Kentucky attracts many of these first generation students from around the state and identifies them as a valuable opportunity to facilitate workforce development and promote innovation in Kentucky.

Recruitment officers and faculty at universities throughout the country are reporting an increasing demand for undergraduate research opportunities, and that access to undergraduate research is an important factor behind recruitment success (Hoke and Gentile 2008, Conrad et al. 2009, Lopatto 2007).

Student engagement in undergraduate research activities is associated with an increased probability of continuing to graduate programs (Alexander et al. 2000, Dahlberg et al. 2008). By increasing the desire for graduate study among our undergraduate population, the UK undergraduate curriculum serves as an incubator for highly qualified students applying to our graduate programs.

Variables that may impact a student's choice to engage in research

Academic ability

Hu and Kuh, 2002, find that academic preparation has a positive impact on engagement in general, although they do not look specifically at undergraduate research as a form of engagement. The study also finds that the relationship between student engagement and institutional culture is complex, and proposes that institutional culture changes hold the greatest power for improving student engagement outcomes.

Commonly used indicators of student ability include ACT, SAT, and high school GPA. ACT and SAT scores have been criticized as poor predictors of student success, and many are promoting the transition to alternative admissions requirements among higher education institutions. (Hiss and Franks, 2014) Hiss reports that high school GPA is more predictive of success, and recommends optional testing policies that will make admissions more attainable to minority and underprivileged students who have done well in high school.

A regression analysis of student success at UK uses high school readiness index, which combines high school GPA and composite ACT score to create a single variable, weighted for GPA with a slight correction for ACT. (Rudick et. al, 2015) They find that readiness index is more predictive of retention and persistence than either of the single variables alone, particularly in predicting at the time of a student's admission to UK.

Demographics and socioeconomic status

College and university programs that support undergraduate research show widely varying degrees of minority representation, due to the various program mandates and foci. (Russell et. al 2005) Without the advantage of a structured program to incentivize research engagement and remove barriers to access; minority, first generation, and low income students are at a disadvantage concerning engagement in high impact practices due to information asymmetry and lower educational aspirations. (Kuh et. al 2006) Underrepresented minority students are more likely to participate in a structured program of engagement than through informal methods, such as the traditional apprenticeship method of undergraduate research. (Chang et. al 2014)

Information asymmetry impacts student choice concerning which school to attend, whether or not to continue to graduate school, and may also impact their choice to engage in many high impact practices. (Hoxby and Avery, 2013) Programs structured to ensure the elimination of information asymmetry, are shown to improve equity of school choice and diversify the student body. (Hoxby and Turner, 2013) The Expanding College Opportunities Project, an intervention developed by Hoxby and Turner to eliminate information asymmetry, increased the number of college applications and increased the likelihood of admission to a "peer" college by 78% among low-income high-achievers. It is possible that low-income students at UK are subject to information asymmetry effects related to opportunities for engagement in high impact practices, such as undergraduate research.

The UK student success regression analysis mentioned above also finds that an important predictor of student success, particularly when the prediction is made at the beginning of the first fall semester, is financial unmet need. (Rudick et. al, 2015) The unmet need variable is taken from FAFSA applications and is the sum of the expected family contribution and financial aid package, subtracted from the total cost of attendance at UK. Socioeconomic status may affect a student's engagement in high impact practices if they must spend more time working for pay, leaving less time to engage in extracurricular activities.

Major field of study

Research experiences for undergraduates have historically been offered primarily in the science and medicine disciplines, but are now becoming more popular across all disciplines, especially as a way to show increased student learning outcomes through application of knowledge and critical thinking. The reason that science programs have been more successful with this high impact practice traditionally is due to the strong support from funding agencies, such as the National Science Foundation, to develop undergraduate research curriculum and programs with the intention of diversifying the research scientist population. (Kuh, 2008)

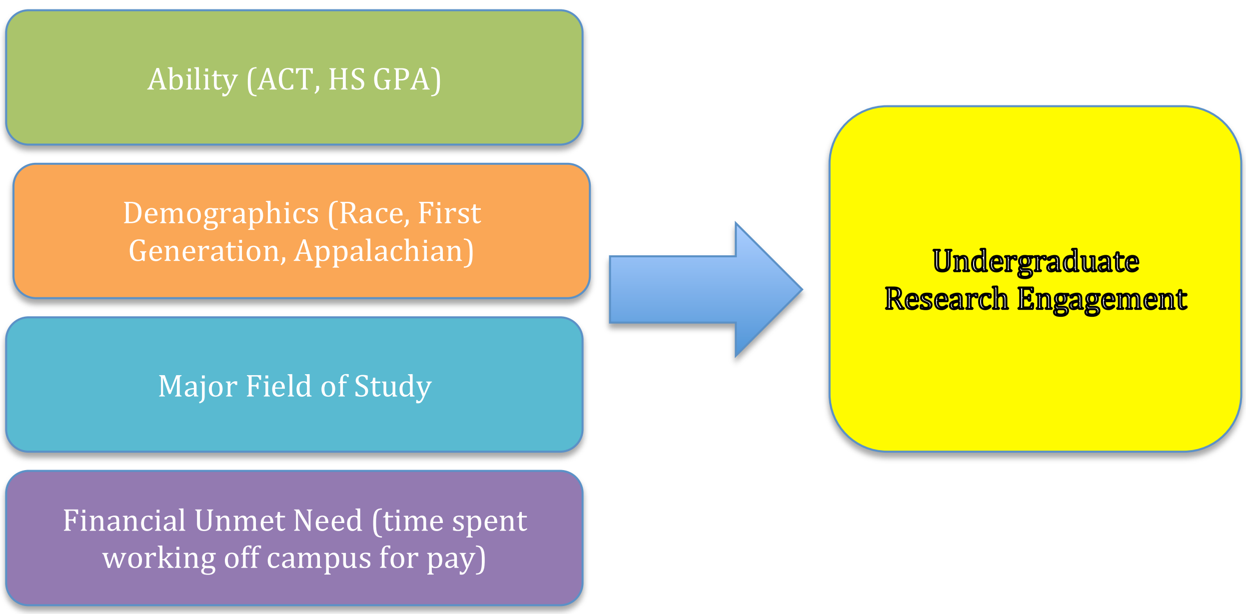
One example of a structural emphasis on undergraduate research in a non-science field is found at the Music History program of California State University, Sacramento. The program implemented a new curricular design to support undergraduate research in 2014 by creating a new senior capstone research course, and scaffolding research preparatory education throughout the program's other courses.

This was made possible by direct support for undergraduate research initiatives through the program's College of Arts and Letters. (Frankenbach, 2016)

Research design

This capstone analyzes the factors that affect an individual student's choice to engage in undergraduate research at UK, and estimates which factors have the greatest impact. Understanding the factors impacting a student's choice to engage will aid in the development of effective policies to increase engagement at UK. Four groups of variables are included in this analysis: student ability, demographics, major field of study, and financial unmet need. (fig. 1)

Figure 1: Research design



Data sources

Although UK does not currently collect comprehensive data specific to students involved in undergraduate research, our students do participate in the National Survey on Student Engagement (NSSE), which asks about research participation. The survey is presented to all UK first year and Senior students, and provides data from those who choose to respond. The 2015 NSSE survey responses were collected from 2,030 students, representing a 17% response rate from the freshman class (n=895), and a 23% response rate from the senior class (n=1,135). Of the freshman students responding, 66% were female and 97% were full time students. Of the senior students responding, 57% were female and 90% were full time students.

The survey asks one question specific to participation in research, “Which of the following have you done or do you plan to do before you graduate?” One of the categories under this question is “Work with a faculty member on a research project”. The choices for the response to this question are “Done or in progress”, “Plan to do”, “Do not plan to do”, or “Have not decided”. (figure 2, from NSSE website)

Figure 2: NSSE survey question #11

Which of the following have you done or do you plan to do before you graduate?

	Done or in progress	Plan to do	Do not plan to do	Have not decided
Participate in an internship, co-op, field experience, student teaching, or clinical placement	○	○	○	○
Hold a formal leadership role in a student organization or group	○	○	○	○
Participate in a learning community or some other formal program where groups of students take two or more classes together	○	○	○	○
Participate in a study abroad program	○	○	○	○
Work with a faculty member on a research project	○	○	○	○
Complete a culminating senior experience (capstone course, senior project or thesis, comprehensive exam, portfolio, etc.)	○	○	○	○

Of the 763 UK freshmen responding to the question, 10% report having done research or are in progress, while 42% plan to do research and the remainder do not plan to or have not decided. Of the 983 UK seniors responding, 29% report having done research or are in progress, while only 16% plan to before graduation. The senior responses also indicate that 43% do not plan to do research and only 12% are still undecided. This shift from greater proportions planning to engage or undecided in the freshman year, to greater proportions successfully engaged or having decided not to engage by the senior year, is expected as a result of a student having had more time decide, and more exposure to opportunities.

The survey results are subject to selection bias and variable interpretation of the definition of “research”. Not withstanding these caveats, the NSSE survey results are currently the most comprehensive data available to identify undergraduate researchers across the diverse areas at UK.

NSSE produces several standard reports for each participating college or university, including comparison reports with similar participating institutions’ results (University of Kentucky IRAA). Significantly more freshmen at UK indicate that they are participating in research than the freshmen at other KY schools, or those at comparison schools with Carnegie classification as research university with very high activity (RU/VH). Likewise, significantly more UK Seniors report research participation than those at other KY schools, but nearly the same rate of participation is found among other RU/VH comparators. (Table 1)

Table 1. Comparison of research engagement responses between UK and similar schools

		UK		Kentucky		RU/VH	
		frequency	proportion	frequency	proportion	frequency	proportion
Work with a faculty member on a research project	Freshmen responding “Done or in progress”	70	10%	151	7%*	431	6%***
	Seniors responding “Done or in progress”	285	29%	723	22%***	2,159	30%

(p<0.05* , p<0.01**, p<0.001***)

Other NSSE survey responses provide self-reported student characteristics variables for this analysis including, class, major field of study, time spent working off campus for pay, and demographics including first generation and race.

The data set also includes institution reported variables, three of which are used in this study, Appalachian (based on county of permanent residence), high school GPA, and composite ACT score.

The UK office of Institutional Research provided the matched institutional and NSSE individual student data for this analysis after removing all student identifiers.

Variables

Two dummy variables for student class were created to analyze the freshmen and senior students separately. Freshmen are coded as "class1" and seniors are coded as "class4".

Dependent variables

There are two dependent variables used in this analysis.

The first dependent variable, "research", is the student's reported interest in research engagement, although not yet actively participating. The ordinal variable responses are ranked as 1 for "do not plan to do", 2 for "have not decided", and 3 for "plan to do".

The second dependent variable, "res yes", is a dummy variable indicating if the student reported "have done or are in progress" (1) vs. any other response to the same question (0).

Explanatory variables

Explanatory variables are included to assess the relationship of research engagement with individual student characteristics of academic ability, demographics, major field of study, and financial unmet need. A cross table of calculated correlations between all explanatory variables may be found in appendix A.

Two continuous variables for student academic ability were taken from the institution reported data, high school GPA and composite ACT score. (Table 2) High school GPA is more likely to capture dimensions of long-term student ability and college readiness, as well as "grit", but are not standardized across school systems. The composite ACT scores are standardized, and therefore more comparable between students. However, ACT tests ability at only a moment in time when the test is taken, and a student could have a particularly good or bad day, potentially reducing the ability of ACT scores to predict outcomes. This study utilizes both measures to capture a more complete picture of student ability. I hypothesize that increased student ability will relate to increased engagement in research, as the high achieving students are more likely to seek extracurricular academic engagement, and are more likely to be invited to participate by a faculty mentor.

Table 2. Hypotheses on student academic ability

Independent variables	Definition	Hypothesis
hs gpa	High School GPA (not scaled to 4.0) from UK reported data	Increased GPA will relate to increased research engagement
act	UK reported student composite ACT score	Increased ACT score will relate to increased research engagement

Student demographics variables were taken from self-reported demographics responses to NSSE survey questions. (Table 3) A dummy variable was created for each demographic group of students indicating that they identify as first generation, Black, Asian, or Hispanic. An additional dummy variable was taken from UK reported data of Appalachian students based on county of permanent residence. (Appendix B) I hypothesize that, due to information asymmetry about research opportunities, minority, first generation, and Appalachian students will engage in research less than their peers.

Table 3. Hypotheses on student demographics variables

Independent variables	Definition	Hypothesis
first gen	Dummy variable indicating if student reported that they are a first generation college student	Minority and at risk students engage in research less than their peers
appalachian	Dummy variable indicating if UK recognizes the student as Appalachian, based on county of permanent residence (see appendix B for list of counties)	
black	Dummy variable indicating if student reported that they identify as Black or African American	
asian	Dummy variable indicating if student reported that they identify as Asian	
hispanic	Dummy variable indicating if student reported that they identify as Hispanic or Latino	

A categorical student major field of study variable, "majortype" was created based on NSSE's major categories compiled from student text responses to a question asking for their academic first major, with some specific re-categorizations to account for the author's knowledge of UK programs. (table 5) Two individual programs were reclassified to create their own categories, Biology and Psychology. This was done to control for the effect of existing research courses (curriculum embedded undergraduate research) within these programs. I hypothesize that students in the STEM fields, Biology, and Psychology, engage in research more than their peers in the Arts and Humanities.

Table 4. Hypothesis on Major field of study variables

Independent variables	Definition	Hypothesis
Majortype (1-13)	Categorical student reported academic major, coded into NSSE categories, some majors re-coded by author. (See appendix C for complete list of majors and associated codes)	Students in STEM majors, and in programs with research embedded in the curriculum, will show increased research engagement. (Base = Arts & Humanities majors)

Table 5. Major type codes, category descriptions, and number of students

Majortype code	count	major type category
1	135	Arts & Humanities
2	127	Math & Sciences other than Biology
3	81	Psychology
4	80	Social Sciences other than Psychology
5	206	Business
6	75	Communications, Media, & Public Relations
7	85	Education
8	290	Engineering
9	320	Health Professions
10	29	Social Services Professions
11	47	multidisciplinary, interdisciplinary, undeclared, other
12	68	Agriculture
13	142	Biology

Student unmet need is an important variable for predicting student success as retention and persistence. The NSSE survey data does not provide a direct unmet need variable, but does ask students to indicate the number of hours per week spent working off campus for pay, by selecting category 1-8 among a range of possible hours worked. (Table 6) I use this categorical variable, "work off" as a surrogate of unmet need, and hypothesize that increased unmet need correlates with decreased research engagement, because the student will have less time to engage in research as they spend more time working off campus for pay.

Table 6. Hypotheses on student unmet need variable

Independent variables	Definition	Hypothesis
work off (1-8) category Hours per week 1 0 2 1-5 3 6-10 4 11-15 5 16-20 6 21-25 7 26-30 8 More than 30	Categorical student reported number of hours worked off campus per week.	Students reporting increased hours of off campus work will show decreased engagement in research

Analytical Approach

I use four regression models to test my hypotheses of the effects of individual student characteristics on a student's intention to engage, or successfully engage in research, during their Freshman year, or by their Senior year. (figure 3) Freshmen and Seniors were analyzed separately because freshmen have not had as much time to think about, or engage, in research. Models 1 and 2 look at only the freshman sample, and models 3 and 4 look at only the senior sample. Models 1 and 3 utilize the "research" dependent variable to investigate the student's intention of engaging in undergraduate research among those who have not yet engaged, while models 2 and 4 utilize the "res yes” dependent variable to test the probability of having engaged. Each of the regression models control for student ability, demographics, major field of study, and a surrogate for unmet need.

Figure 3. Description of regression models 1-4

Model 1: research = act + hs gpa + first gen + appalachian + black + asian + hispanic + majortype + work off (if class1)

Model 2: res yes = act + hs gpa + first gen + appalachian + black + asian + hispanic + majortype + work off (if class1)

Model 3: research = act + hs gpa + first gen + appalachian + black + asian + hispanic + majortype + work off (if class4)

Model 4: res yes = act + hs gpa + first gen + appalachian + black + asian + hispanic + majortype + work off (if class4)

Results

Summary statistics

The following summary statistics were found for each of the independent variable groups among 2,030 UK students responding to the NSSE survey in 2015. I include the values for the same groups among the entire UK student body in the same year for comparison (n=30,720, student data reported to the Council on Post Secondary Education in the fall of 2015).

Table 7. Summary statistics of academic ability and demographics variables across NSSE sample, and across UK student population (2015)

	NSSE sample of UK students n = 2,030	UK student totals n = 30,720
Mean ACT score	26.9	25.5
Mean High School GPA	3.7	3.7
Proportion Asian	5.9%	2.5%
Proportion Black or African American	5.0%	7.5%
Proportion Hispanic or Latino	4.3%	4.2%
Proportion First generation	22%	15.5%
Proportion Appalachian	11.9%	2.4% (undergraduate population only, n=22,761)

Academic ability

The mean high school GPA among survey respondents, as well as the mean among all UK students in 2015, is 3.7. This is the standard GPA, which may be greater than 4.0 for some students due to the addition of advanced placement credits. The maximum high school GPA found among NSSE responders was 5.8. Some records are missing, presumably because they are transfer students who did not report high school GPA to UK. These records are eliminated from the regression analyses.

The mean composite ACT score across survey respondents is 26.9 with a standard deviation of 4.2, a minimum of 13, and a maximum of 36. The mean score of all freshmen entering UK in the Fall of 2015 is lower, however, at 25.5 (mean of only entering freshmen, n = 4,788).

Demographics

Proportionately fewer students identifying as Black or African American responded to the survey than is represented among the UK student population, while proportionately more Asian, First generation, and Appalachian students responded.

Major field of study

NSSE responses cover thirteen major type categories. The number of observations for each major type category are presented previously in table 7 of the data source discussion.

Unmet need

Students in the sample report an average of 6 hours spent working off campus for pay each week, with a standard deviation of 9.7 hours, a minimum of 0 hours, and a maximum of 33 hours.

Regression results

The results varied between regression models as expected. I present the results for each model, and then discuss the similarity and differences of results between models. I use only p values less than 0.01 to define significance in these results.

Model 1: Freshman intent to engage in research

Neither of the student ability variables was significant in predicting a Freshman's intent to engage in research.

Only one of the demographics variables was found to be a significant predictor of Freshman intent. Asian students were 48% ($p<0.01$) more likely to select the next higher response category for research intent. For example, Asian Freshmen were 48% more likely to select "planning to do" as opposed to "haven't decided", or to select "haven't decided" rather than "do not plan to do".

The greatest predictive significance in the model was found among the major field of study variables. Math and sciences majors other than Biology were 54% ($p<0.01$) more likely to select the next higher response category for research intent than their Arts and Humanities peers, while likelihood increased by 59% ($p<0.01$) for Biology majors, and 81% ($p<0.001$) for Psychology majors.

Student unmet need measured as time spent working off campus was not significant at $p<0.01$ in predicting a Freshman's research intent.

Table 8. Impact of independent variables on a Freshman's intent to engage in research (Model 1)

Independent Variables		Coefficient	Std. Err.
Academic ability	ACT	0.0164	0.012
	HS GPA	0.0194	0.100
Demographics	First generation	0.0371	0.094
	Appalachian	0.2406*	0.118
	Black	0.2959	0.176
	Asian	0.4792**	0.191
	Hispanic	0.2933	0.169
Major field of study	math & sciences other than biology	0.5434**	0.216
	psychology	0.8055***	0.245
	social sciences other than psychology	-0.0442	0.259
	business w\ hospitality	0.0044	0.199
	agriculture	0.6243*	0.287
	biology	0.5872**	0.215
Unmet need	time working off campus for pay	0.0622*	0.028

p<0.05* p<0.01** p<0.001***

Model 2: Freshman successful engagement in research

As with Freshman intent, student ability variables were not strong predictors of a Freshman's successful engagement in research.

Likewise, no demographics variables were strong predictors of engagement from this model.

Predictive significance of successful Freshman engagement was found for one of the major field of study variables. Biology majors were found to have a 21% ($p<0.001$) increased probability of selecting "done or in progress" as compared to Arts and Humanities majors.

Unmet need was again found not to have predictive significance with this model.

Table 9. Impact of independent variables on a Freshman's successful engagement in research (Model 2)

Independent Variables		Coefficient	Std. Err.
Academic ability	ACT	0.0088*	0.004
	HS GPA	-0.0250	0.029
Demographics	First generation	0.0077	0.028
	Appalachian	-0.0055	0.034
	Black	0.0485	0.052
	Asian	0.0794	0.056
	Hispanic	0.1129*	0.049
Major field of study	math & sciences other than biology	0.1556*	0.062
	psychology	0.1138	0.071
	social sciences other than psychology	0.0033	0.075
	business w\ hospitality	0.0858	0.057
	agriculture	0.0902	0.083
	biology	0.2059***	0.062
Unmet need	time working off campus for pay	0.0053	0.008

p<0.05* p<0.01** p<0.001***

Model 3: Senior intent to engage in research

For each one point increase of a Senior's composite ACT score, they were 3.5% ($p<0.01$) more likely to select a higher response category for intent to engage in research.

No demographics variables had predictive significance on intent to do research among Seniors in this study.

The greatest predictive significance in this model was found in one major field of study category, Business. Business Seniors were 48% ($p<0.01$) less likely to choose the next highest category for research intent than their Arts and Humanities peers.

Student unmet need measured as time spent working off campus was, again, not significant in predicting research intent.

Table 10. Impact of independent variables on a Seniors's intent to engage in research (Model 3)

Independent Variables		Coefficient	Std. Err.
Academic ability	ACT	0.0353**	0.013
	HS GPA	-0.0842	0.062
Demographics	First generation	-0.1804	0.114
	Appalachian	0.0845	0.126
	Black	0.0704	0.261
	Asian	-0.2276	0.230
	Hispanic	0.0403	0.261
Major field of study	math & sciences other than biology	0.1316	0.222
	psychology	0.4741*	0.229
	social sciences other than psychology	-0.1633	0.238
	business w\ hospitality	-0.4757**	0.181
	agriculture	-0.1030	0.242
	biology	0.2066	0.200
Unmet need	time working off campus for pay	-0.0076	0.019

$p<0.05$ * $p<0.01$ ** $p<0.001$ ***

Model 4: Senior successful engagement in research

As with Senior intent, composite ACT score is predictive of a Senior's successful engagement in research, with a 1.5% ($p<0.01$) increase in the probability of engagement for each one point increase in score. For example, a student with a score of 28 on the ACT has a 7.5% greater probability of engagement than a student with a score of 23.

No demographics variables were strong predictors of engagement from this model.

Two major field of study categories were found to have significance in predicting successful Senior engagement, one with a positive relationship and the other with a negative relationship. Psychology majors have a 30% ($p<0.01$) increased probability of engagement over Arts and Humanities majors, while Business majors have a 23% ($p<0.01$) decreased probability.

Unmet need was again found not to have predictive significance with this model.

Table 11. Impact of independent variables on a Senior's successful engagement in research (Model 4)

Independent Variables		Coefficient	Std. Err.
Academic ability	ACT	0.0152**	0.006
	HS GPA	-0.0141	0.027
Demographics	First generation	-0.0261	0.049
	Appalachian	0.0166	0.055
	Black	-0.0349	0.111
	Asian	-0.1782	0.096
	Hispanic	-0.0134	0.108
Major field of study	math & sciences other than biology	0.1247	0.097
	psychology	0.2966**	0.100
	social sciences other than psychology	-0.0490	0.105
	business w\ hospitality	-0.2345**	0.079
	agriculture	0.0077	0.106
	biology	0.0999	0.087
Unmet need	time working off campus for pay	-0.0112	0.008

P<0.05* p<0.01** p<0.001***

<u>Results comparisons between models</u>

Composite ACT score is significantly predictive of research intent and successful research engagement among Seniors in the study, but the relationship does not hold for Freshmen. High school GPA has no significance to predict research intent or engagement across all four models.

Asian students show greater intent to engage in research than other demographics as Freshmen, but no other significance was found among demographics variables in the four regression models.

I describe three specific results of note among the major field of study categories.

Psychology students (investigated apart from other social sciences majors) indicate greater research intent as Freshmen, as well as an increased probability of successful engagement by the senior year. The research courses of the Psychology program occur in the senior year, explaining the significant increase in engagement specifically among Senior Psychology majors.

Business and hospitality majors, conversely, indicate a significant disinterest in research as Seniors, both as intent and as successful engagement. I am not aware of a specific cause for this apparent disincentive.

Biology majors (investigated apart from other STEM majors) show an increased intent as well as a very significant increased probability of successful engagement as Freshmen. This relationship does not hold, however, for the Senior sample in this study, even though the Seniors were surveyed in the same academic year as the Freshmen. Upon closer investigation of the Biology Department curriculum, I learned that the research course which led me to segregate that major from the others in it's category, BIO 199, is a new course first implemented fully in 2013. Therefore, the Freshmen sampled in this study in 2015 were offered the course to fulfill a degree requirement. The Seniors of 2015, however, were not given the opportunity to take the freshman course, and would have needed to find other pathways for research participation if they wanted to engage in this high impact practice. The Senior cohort, therefore, may serve as a control group, and the Freshman cohort as a study group, if we consider the BIO 199 course a "treatment" in future studies conducted with this dataset.

The analysis does not support the hypothesis that unnmet need, measured as greater time spent working off campus for pay, leads to decreased engagement in research. The surrogate measure I chose may not be as closely related to true unmet need as I anticipate, or unmet need may not be a good predictor of research engagement, it is not possible to differentiate the two with this analysis.

Limitations

Some student reported majors used in this study may be inaccurate, as NSSE may have misunderstood the student's text response, and categorized the major incorrectly. The use of institution reported majors, matched with the NSSE data by student ID, would be preferable, but were not available for this study.

Major categories may also have imperfect classifications or errors from my own placements, due to a lack of knowledge about the programs at UK, and the departments in which they are housed.

Variability in the way individual students define "research" may lead to overestimation, or underestimation, of reported engagement. For example, a student in the sciences may report time spent washing glassware in a research lab as "research", while a student investigating the types of museum collections appearing in different geographic regions may not use the term "research" to describe their work.

Selection bias is a potential limitation of this study. It is possible that students who are more engaged in the first place, are more likely to respond to the NSSE survey. However, there are many types of student engagement, and it is not clear that the selection bias affects the responses to the question about research specifically. Bias is not likely to impact the explanatory variables of this study, and non-response to the entire survey would result only in an overestimation of the likelihood of participating in research.

Conclusions and Policy recommendations

Although not all undergraduate students at UK participate in the high impact practice of faculty mentored research, this study indicates that the opportunities that exist are accessed equitably across demographic groups, and there is no evidence of information asymmetry. This is likely a result of the efforts within the UK Office of Undergraduate Research and The UK Center for Academic Resources and Enrichment Services to ensure information is disseminated to minority and at risk students.

The most significant determinant of a student's engagement in research during their undergraduate experience at UK is their major field of study, and specifically, if the chosen program embeds research courses in the curriculum. UK programs with objectives to increase undergraduate research in their strategic plans should use this evidence to support budgetary allocations toward new research course development. Furthermore, by embedding research within a course, faculty who mentor undergraduate research students will receive credit for doing so through the DOE and course evaluations.

The University of Kentucky already appears to involve undergraduates in research more than other institutions in Kentucky, and does so at a rate comparable with other R1 research institutions. This research suggests that UK may enhance that attractive feature by supporting the development of undergraduate research courses among the bachelor degree programs. The costs associated with undergraduate research curriculum development are high, however, and undergraduate research may not be a valuable investment for all programs. A cost benefit analysis is needed to determine if the development of curriculum embedded research is the most cost effective approach for a specific program, as compared to other methods of achieving the same outcomes.

Future research

Further analysis of this data should include careful re-categorization of the major types after a thorough investigation of the individual majors and associated research courses. There are likely other programs at UK that show significant research engagement results, if a dummy variable is created for students in those programs, as was the case for Biology and Psychology majors in this analysis.

It will be informative to analyze comparisons between Biology majors' research engagement responses and those of other STEM majors, rather than comparing to the Arts and Humanities base, as was the case in this study.

Future work to match NSSE survey responses across multiple years by student ID will allow for the use of time-series panel data to investigate the relationship of engagement in high impact practices at UK with student outcomes of retention and persistence.

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Appendices

Appendix A. Correlations between explanatory variables

	work_off	act	first_~n	appala~a	black	asian	hispanic	hs_gpa	major~e
work_off	1.0000								
act	-0.2328	1.0000							
first_gen	0.0600	-0.2415	1.0000						
appalachia	-0.0021	0.0325	0.1238	1.0000					
black	-0.0167	-0.2665	0.0979	-0.0346	1.0000				
asian	-0.0314	-0.0307	0.0522	0.0073	-0.0453	1.0000			
hispanic	0.0140	-0.0685	0.0776	-0.0494	-0.0458	-0.0429	1.0000		
hs_gpa	-0.1822	0.4792	-0.1398	0.0333	-0.1447	0.0053	0.0275	1.0000	
majortype	-0.0187	-0.0355	-0.0156	0.0118	0.0540	0.0048	-0.0128	0.0660	1.0000

Appendix B. Counties of residence used to identify UK students as Appalachian

Adair	Clinton	Greenup	Lee	Menifee	Powell
Bath	Cumberland	Harlan	Leslie	Metcalfe	Pulaski
Bell	Edmonson	Hart	Letcher	Monroe	Rockcastle
Boyd	Elliott	Jackson	Lewis	Montgomery	Rowan
Breathitt	Estill	Johnson	Lincoln	Morgan	Russell
Carter	Fleming	Knott	Madison	Nicholas	Wayne
Casey	Floyd	Knox	Magoffin	Owsley	Whitley
Clark	Garrard	Laurel	Martin	Perry	Wolfe
Clay	Green	Lawrence	McCreary	Pike	

Appendix C: Major field of study categories used in this analysis

Major Type code used in this analysis	Major Type used in this analysis	NSSE Major Type	NSSE Major	Count	NSSE Major Code	CIP 1	CIP 2	CIP 3
1	Arts & Humanities	Arts & Humanities	Arts, fine and applied	16	1	50.0701	50.0702	50.0409
1	Arts & Humanities	Arts & Humanities	Architecture	26	2	04.0201		
1	Arts & Humanities	Arts & Humanities	English (language and literature)	26	4	23.0101		
1	Arts & Humanities	Arts & Humanities	French (language and literature)	3	5	16.0901		
1	Arts & Humanities	Arts & Humanities	Spanish (language and literature)	6	6	16.0905		
1	Arts & Humanities	Arts & Humanities	Other language and literature	10	7	16.0101		
1	Arts & Humanities	Arts & Humanities	History	15	8	54.0101		
1	Arts & Humanities	Arts & Humanities	Music	11	10	50.0901	50.0903	
1	Arts & Humanities	Arts & Humanities	Philosophy	5	11	38.0101		
1	Arts & Humanities	Arts & Humanities	Theater or drama	7	13	50.0501	50.0506	50.0101
1	Arts & Humanities	Arts & Humanities	Other fine and performing arts	6	14	88.9999	50.0408	50.0301
1	Arts & Humanities	Arts & Humanities	Other humanities	4	15	88.9999	05.0102	05.0103
2	Science other than Biology	Biological Sciences, Agriculture, & Natural Resources	Biochemistry or biophysics	10	18	26.0202	26.0203	
2	Science other than Biology	Biological Sciences, Agriculture, & Natural Resources	Biomedical science	3	19	26.0102		
2	Science other than Biology	Biological Sciences, Agriculture, & Natural Resources	Marine science	1	23	30.3201	26.1302	
2	Science other than Biology	Biological Sciences, Agriculture, & Natural Resources	Neuroscience	2	27	26.1501		
2	Science other than Biology	Physical Sciences, Mathematics, & Computer Science	Chemistry	31	35	40.0501		
2	Science other than Biology	Physical Sciences, Mathematics, & Computer Science	Computer science	42	36	11.0701		
2	Science other than Biology	Physical Sciences, Mathematics, & Computer Science	Earth science (including geology)	6	37	40.0601		
2	Science other than Biology	Physical Sciences, Mathematics, & Computer Science	Mathematics	17	38	27.0101		
2	Science other than Biology	Physical Sciences, Mathematics, & Computer Science	Physics	12	39	40.0801		
2	Science other than Biology	Physical Sciences, Mathematics, & Computer Science	Statistics	2	40	27.0501		
2	Science other than Biology	All Other	Network security and systems	1	132	11.1003		
3	Psychology	Social Sciences	Psychology	81	50	42.0101		
4	Social Science other than Psychology	Social Sciences	Anthropology	11	43	45.0201		
4	Social Science other than Psychology	Social Sciences	Economics	23	44	45.0601		
4	Social Science other than Psychology	Social Sciences	Geography	4	47	45.0701		
4	Social Science other than Psychology	Social Sciences	International relations	13	48	45.0901		
4	Social Science other than Psychology	Social Sciences	Political science	26	49	45.1001		
4	Social Science other than Psychology	Social Sciences	Sociology	3	51	45.1101		
5	Business	Business	Accounting	47	53	52.0301		
5	Business	Business	Business administration	7	54	52.0201	52.0101	
5	Business	Business	Finance	31	56	52.0801		
5	Business	Business	Hospitality and tourism	13	57	52.0901		
5	Business	Business	International business	2	58	52.1101		
5	Business	Business	Management	30	59	52.0205	52.0204	
5	Business	Business	Marketing	52	61	52.1401		
5	Business	Business	Other business	24	64	88.9999	52.1001	52.1902
6	Communications, Media, & Public Relations	Communications, Media, & Public Relations	Communications (general)	11	65	09.0100		
6	Communications, Media, & Public Relations	Communications, Media, & Public Relations	Broadcast communications	3	66	09.0701	09.0402	10.0202
6	Communications, Media, & Public Relations	Communications, Media, & Public Relations	Journalism	7	67	09.0401		
6	Communications, Media, & Public Relations	Communications, Media, & Public Relations	Mass communications and media studies	7	68	09.0102		
6	Communications, Media, & Public Relations	Communications, Media, & Public Relations	Public relations and advertising	27	69	09.0903	09.0902	
6	Communications, Media, & Public Relations	Communications, Media, & Public Relations	Telecommunications	3	71	15.0305		
6	Communications, Media, & Public Relations	Communications, Media, & Public Relations	Other communications	17	72	88.9999	09.9999	

7	Education	Education	Education (general)	3	73	13.0101		
7	Education	Education	Early childhood education	5	75	13.1210		
7	Education	Education	Elementary, middle school education	37	76	13.1202	13.1203	
7	Education	Education	Mathematics education	3	77	13.1311		
7	Education	Education	Music or art education	8	78	13.1312	13.1302	
7	Education	Education	Secondary education	12	80	13.1205		
7	Education	Education	Social studies education	3	81	13.1317		
7	Education	Education	Special education	8	82	13.1001		
7	Education	Education	Other education	6	83	88.9999	13.1305	
8	Engineering	Engineering	Engineering (general)	2	84	14.0101		
8	Engineering	Engineering	Bioengineering	16	86	14.0501		
8	Engineering	Engineering	Biomedical engineering	2	87	14.0501		
8	Engineering	Engineering	Chemical engineering	65	88	14.0701		
8	Engineering	Engineering	Civil engineering	32	89	14.0801		
8	Engineering	Engineering	Computer engineering and technology	22	90	14.0901	15.1201	
8	Engineering	Engineering	Electrical or electronic engineering	39	91	14.1001		
8	Engineering	Engineering	Materials engineering	15	93	14.1801		
8	Engineering	Engineering	Mechanical engineering	80	94	14.1901		
8	Engineering	Engineering	Other engineering	17	97	88.9999	14.0301	14.1401
9	Health Professions	Health Professions	Allied health	1	98	51.0000		
9	Health Professions	Health Professions	Dentistry	1	99	51.1101		
9	Health Professions	Health Professions	Health science	18	100	51.0000		
9	Health Professions	Health Professions	Health technology (medical, dental, laboratory)	7	101	51.1005		
9	Health Professions	Health Professions	Healthcare administration and policy	3	102	51.0701	51.0702	51.0706
9	Health Professions	Health Professions	Kinesiology	53	103	31.0505	26.0908	
9	Health Professions	Health Professions	Medicine	5	104	51.1102		
9	Health Professions	Health Professions	Nursing	101	105	51.3801	51.3808	
9	Health Professions	Health Professions	Nutrition and dietetics	33	106	51.3101	19.0501	30.1901
9	Health Professions	Health Professions	Occupational therapy	1	108	51.2306	51.1107	
9	Health Professions	Health Professions	Pharmacy	14	109	51.2001	51.2010	51.1103
9	Health Professions	Health Professions	Physical therapy	4	110	51.2308	51.1109	
9	Health Professions	Health Professions	Speech therapy	22	112	51.0204	51.0201	
9	Health Professions	Health Professions	Veterinary science	46	113	51.2501	01.0901	51.1104
9	Health Professions	Health Professions	Other health professions	11	114	88.9999	51.2201	51.1504
10	Social Services Professions	Social Service Professions	Criminal justice	1	115	43.0104	43.0107	
10	Social Services Professions	Social Service Professions	Forensics	2	117	43.0106		
10	Social Services Professions	Social Service Professions	Law	1	119	22.0000	22.0001	
10	Social Services Professions	Social Service Professions	Social work	25	123	44.0701		
11	Multi, Interdisciplinary, undeclared, other	All Other	Multi, Interdisciplinary studies	2	131	30.0000		
11	Multi, Interdisciplinary, undeclared, other	All Other	Other, not listed	11	138	88.9999	49.0101	12.0504
12	Agriculture	Biological Sciences, Agriculture, & Natural Resources	Agriculture	20	17	01.0000		
12	Agriculture	Biological Sciences, Agriculture, & Natural Resources	Environmental science/studies	3	22	03.0103	03.0104	
12	Agriculture	Biological Sciences, Agriculture, & Natural Resources	Natural resources and conservation	5	25	03.0101	03.0601	03.0501
12	Agriculture	Biological Sciences, Agriculture, & Natural Resources	Other agriculture and natural resources	21	30	88.9999	01.0102	01.0601
12	Agriculture	All Other	Family and consumer studies	19	126	19.0701	19.0101	
13	Biology	Biological Sciences, Agriculture, & Natural Resources	Biology (general)	134	16	26.0101		
13	Biology	Biological Sciences, Agriculture, & Natural Resources	Botany	1	20	26.0301		
13	Biology	Biological Sciences, Agriculture, & Natural Resources	Cell and molecular biology	2	21	26.0401		
13	Biology	Biological Sciences, Agriculture, & Natural Resources	Microbiology or bacteriology	1	24	26.0502	26.0503	
13	Biology	Biological Sciences, Agriculture, & Natural Resources	Other biological sciences	4	31	88.9999	26.1301	26.1201