

Short-Term Impact of the Undergraduate Research Experience: Results of the First Summer Survey 2001

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Introduction

In the first year of a three-year project on the nature and impact of effective undergraduate research experiences on learning, attitude, and career choice a survey was created and distributed to undergraduate students working on summer undergraduate research projects at four institutions: Grinnell College, Harvey Mudd College, Hope College, and Wellesley College¹. This extensive instrument consisted of 42 questions concerning the experience and a list of 45 possible benefits for the student to evaluate. The instrument was distributed locally on the four campuses in the summer of 2001. Students completed paper copies of the survey. Local facilitators collected the surveys and mailed them to the principal investigator. An analysis of the 249 returned surveys was performed in the autumn of 2001. The purpose of the project is to create and improve a useful measure of the effects of undergraduate experience. As part of the overall method, the research includes a second track involving the qualitative analysis of interviews of students at the four institutions. The qualitative analysis is not presented here.

Areas of Interest

The survey included questions about the students' background, postgraduate plans, motivation and preparation for the research experience. The survey then focussed on variables regarding the structural and consideration aspects of the experience. For convenience, we rely on the language of leadership studies in organizational psychology (e.g., Kerr and Schriesheim, 1974) that distinguishes between *initiating structure* and *consideration* variables. These two terms refer to a leader's behavior in a business setting. In the present work it is useful to think of them as referring to a faculty mentor's behavior. Initiating structure "reflects the extent to which an individual is likely to define and structure his role and those of his subordinates toward goal attainment." Faculty mentors set program requirements (e.g., by demanding a paper or poster at the conclusion of the research experience) and structure student experiences (e.g., by creating a schedule or by organizing students into groups). Consideration "reflects the extent to which an individual is likely to have job relationships characterized by mutual trust, respect for subordinates' ideas, and consideration of their feelings." Faculty mentors influence consideration variables such as personal contact and availability as well as treatment of students as colleagues or collaborators. Most of the survey questions were concerned with either structure or consideration.

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Several questions explored the ways in which students categorized their projects. These are not reported here. Finally, students evaluated their experience by assessing their gains on 45 possible benefits. They also indicated which of these benefits were the most important.

Sample Characteristics

The group included 26 rising sophomores, 82 rising juniors, 128 rising seniors, and 13 others. The most frequently represented majors were chemistry and biology, followed by math, computer science and physics. The students included 150 women and 93 men. The group was not ethnically diverse; 77% of the students are Caucasian.

The group was not a random sample of the students at these institutions. Each institution has a formal or informal procedure for selecting undergraduate researchers. Therefore, selectivity slants the results. The group had high aspirations. Forty four percent indicated they intend to go to graduate school. An additional 20% intend to go to professional schools in medicine, education or law. Most students (75%) reported that the undergraduate research experience helped build their credentials for post-graduate plans, and almost as many (71%) reported that the research experience helped them learn what the field was like. There were no sex, ethnic or institutional differences in these statistics.

Structure Variables

Assignment of project: The majority of the students reported that they became involved with the project initially by having the project assigned by the faculty mentor (56%). Twenty one percent reported choosing from a group of projects suggested by the mentor; 15% worked with the mentor to design a project. Only 4% of the students reported designing a project on their own. Analysis of student satisfaction with their experience indicates that having a project assigned by the mentor, although the most common tactic, is associated with less overall satisfaction than the other alternatives.

Supervisory structure: About half (54%) of the students reported that their mentor set a rough or flexible schedule to meet research goals for the summer. Twenty three percent reported no structured schedule was set up, and only 1% reported a highly structured schedule. Students described the style of interaction with their mentor. The dominant style (39%) was “learning by example” from the mentor. Collaborative or division of labor styles were reported by 17% of the students, while working on their own was reported by 27% and following the directions of an executive mentor was reported by 16% of the students.

Communication: Virtually all students reported that their project resulted in a paper, poster or talk.

Teams: Forty eight percent of the students reported that they worked as a member of a working group. The most common dynamic used to describe the group was democratic (41%), and most groups were characterized as friendly or very friendly (85%). Working with other students was characterized as either moderately enhancing the research experience (49%) or as the best part of the project (30%).

Consideration Variables

Contact and Availability: Students reported the amount of direct contact with their mentors and the mentor's general availability. Students reported a mean of 10.7 hours of weekly contact with their mentors. Contact was a strong influence on satisfaction with the research experience (see Figure 1). Forty eight percent of the students reported that their mentor was "always available", while only 7% reported that the mentor was never or only occasionally available. Availability and satisfaction with the research experience were strongly correlated (see Figure 2).

Mentor characteristics: Students rated their mentors on eight characteristics, including friendliness, reliability, respect, organization, democratic style, communication, responsiveness, and treatment as a colleague. A positive rating on these characteristics was correlated with overall satisfaction with the research experience.

Engagement: Students reported on how their feelings were affected by the project they were doing. Eighty three percent of the respondents to this question answered that the project had either a moderate or large influence on their feelings. There were, however, no results that indicated the feeling of engagement was affected by the current project. Neither structure nor consideration variables were correlated with this response. Nevertheless, the level of engagement was related to a group of 12 benefits, with greater engagement correlated with more gain on the benefit.

Satisfaction and Benefits

Satisfaction: There were five specific and one overall measure of satisfaction. Overall satisfaction ratings indicated that the majority of the students were satisfied with their research experience. Ninety one percent were either moderately or very satisfied with their experience. The five specific items measured satisfaction with student input, contact with the mentor, availability of the mentor, satisfaction with structure, and satisfaction with supervision. The five specific satisfaction items related to the overall measure with a multiple correlation of +.50. In some cases satisfaction was positively and linearly related to the variable. Student satisfaction increased with contact and availability. In other cases one kind of program structure produced higher levels of satisfaction than others. For example, students were significantly less satisfied if the mentor provided no structure, and students were significantly less satisfied if they were assigned their research project instead of having some input into the project. Overall satisfaction correlated positively and significantly with 33 benefits of the undergraduate research experience. Therefore, it is plausible to regard student satisfaction as a mediating variable in the experience.

Benefits: The students rated their gains on 45 potential benefits of doing undergraduate research. The students were also asked to choose five benefits they thought to be the most important. The highest rated benefits according to gains were 1) Learning a topic in depth, 2) Enhancing your professional or academic credentials, 3) Learning laboratory techniques, 4) Understanding the research process in your field, and 5) Opportunities for poster or oral presentations. According to student choices for most important benefits, the five most important were 1) Enhancing your professional or academic credentials, 2) Clarification of a career path, 3) Understanding the research

process in your field, 4) Learning a topic in depth, and 5) Developing a continuing relationship with a faculty member.

Grouping of benefits (personal and professional): Because 45 benefits is an unwieldy number, a factor analysis was performed to better understand how benefits correlated. The factor analysis resulted in 11 factors that accounted for 73% of the variation in the data. Of greatest interest was the emergence of two factors that were related to satisfaction and engagement with the research experience. These factors may be called “professional growth”, including enhancement of credentials and understanding the professional behavior in your discipline, and “personal growth”, including leadership, sense of accomplishment and self-confidence.

What Do We Learn From Successful Institutions?

We knew at the outset of the survey procedure that the four sites for the survey had reputations for excellent science programs and overall undergraduate education. We also knew that the summer research undergraduates are selected by the faculty after formal or informal application. Therefore, to merely assert that the features of undergraduate research reported in the survey results are the key to successful experiences is specious. Instead, we take the attitude that we can learn something useful from exemplary programs. This useful information is focussed on the behavior of the faculty mentor and the student as reported by the student. Seen through the student’s eyes, the undergraduate research experience appears to be about professional and personal development. Elements of professional development, including enhancement of credentials, understanding professional behavior, understanding personal demands of a career, and understanding the research process, not only cluster together as variables but are related to satisfaction, mentor characteristics and student engagement with the project. Elements of personal development, including leadership, sense of accomplishment, self-confidence, tolerance for obstacles and sense of contributing to a body of knowledge, not only cluster together as variables but are related to satisfaction and engagement.

The elements of a good research experience may be better appreciated by the student’s reaction, including his or her future plans, than by the product created by the experience. Although it is too soon to tell, reports of satisfaction and benefits may correlate with the motivation to continue in the discipline. If that is so, than the structure and consideration variables related to these outcomes assume an important place in the undergraduate research experience. Even within the narrow range of programs represented by the four institutions there emerge “dose-response” relations or categorical differences among the tactics and personal traits used by mentors. Two examples of the functional relations between consideration and satisfaction are the contact time between faculty mentors and students and the availability of faculty mentors (Figures 1 and 2). As the figures show, it is possible to uncover a relation between the contact/availability variables and satisfaction with the research experience even within the relatively restricted range of campus cultures exhibited by the four institutions. The personal characteristics attributed to faculty mentors also correlate with overall satisfaction. When analyzed for their relation with satisfaction, all eight of the dimensions of faculty characteristics – friendliness, reliability, respect, organization, democratic style,

communication, responsiveness and collegiality – correlated with satisfaction in the expected direction. When re-analyzed through multiple linear regression to remove redundancy, three characteristics – reliability, democratic style, and responsiveness – continued to significantly relate to the student’s overall satisfaction with the research experience.

The hypothesis that a democratic and responsive mentor who spends time with the student is contributing to a satisfying and beneficial experience is not surprising. It is, however, intriguing when regarded in the context of literature on “how people learn”. Extrapolating from the literature, we may hypothesize that (1) college undergraduates enjoy gaining expertise within their chosen field; (2) that social interaction, including peer interaction, contributes significantly to learning; and (3) that students may have a “zone of proximal development”, that is, a potential to do more challenging work than they have done in the classroom if they can be shown how by an expert. The current survey results support these three hypotheses:

(1) The current survey data indicate that students did value mastering their field of expertise. The students selected expertise-related benefit items (such as learning a topic in depth and understanding the research process in their field) as items that were both most important and on which they made the largest gains.

(2) The data indicate that students benefited most when the mentor exhibited traits (discussed above) that are consistent with positive social interactions. Students also benefited from working in groups or teams. As reported above, students frequently characterized group work as either moderately enhancing the research experience or as the best part of the experience. Further analysis shows that students working with peers had a higher overall satisfaction with the undergraduate research experience than students working alone, and that they reported higher gains in their ability to collaborate and to show leadership.

(3) The data indicate that students who described their style of interaction with their mentor as one of learning by example rated their satisfaction with the experience as slightly higher than students who described their style of interaction as self-organized (working alone) or as executive (mentor gave the orders). This tentative finding is obscured somewhat because of the interactions with two other variables: student’s year in school and student’s engagement with the project. Some of the sample sizes in these interactions are too small to analyze reliably, but the data carry that suggestion that interactional styles suitable to the student’s “zone of proximal development”, including learning by example, are better related to satisfaction than styles that leave the student on his or her own.

There are two variables that influence the student’s perception of the benefits of the undergraduate research experience and yet appear to stand apart from the experience. The student’s intention to major in the discipline and go on in the discipline may have formed earlier in his or her career. Surveys of freshman just entering one of the site institutions (Grinnell College) reveal that science students are accurate in their forecasts of their college major and plans to go to graduate school. Thus, the motivation to build credentials for postgraduate education (sometimes called “instrumental” motivation because it leads to behavior that is instrumental in attaining a goal) may precede the undergraduate research experience, especially for older students. Second, the survey’s measure of student engagement, a question asking how affected the student was by the

project itself, resulted in data that correlated with both professional and personal development benefits, but the engagement data did not correlate with structure and consideration variables. While it is important to the level of benefit from the undergraduate research experience, the degree of engagement with work may be a precursor to the experience. Thus, while satisfaction may mediate between the experience and benefits, instrumental motivation and engagement may be called moderator variables, providing a context that enhances or diminishes the experience.

Reference

Kerr, S., & Schriesheim, C. (1974). Consideration, initiating structure, and organizational criteria – an update of Korman's 1966 review. Personnel Psychology, 27, 555-568.

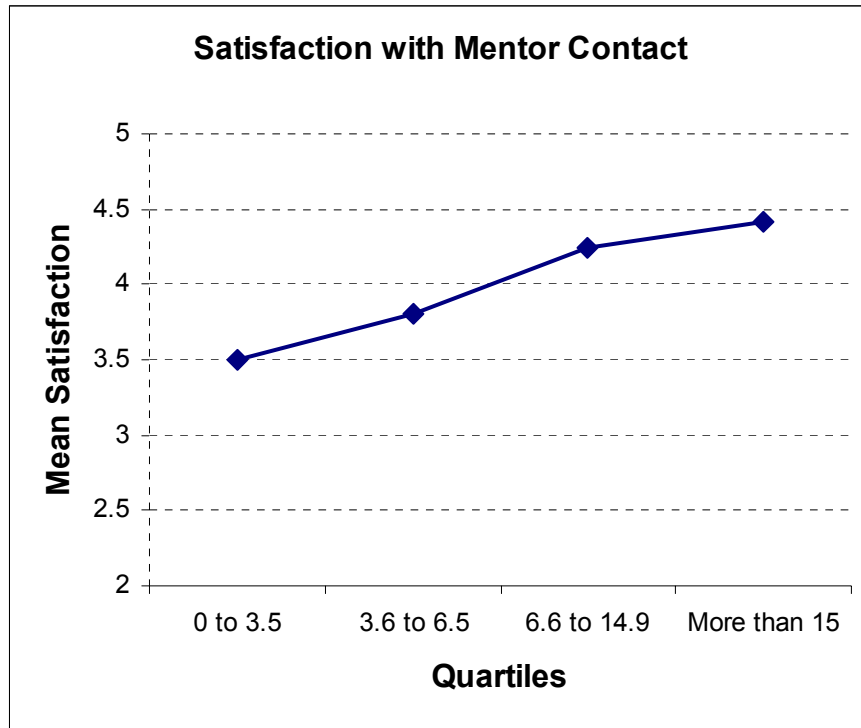


Figure 1. The relation between hours of contact with the faculty mentor and overall satisfaction with the research experience. For convenience, the reported number of hours is grouped into four categories. The mean scores are from 249 students across four institutions. Overall satisfaction is, in turn, related to benefits in the areas of personal development and networking skills.



Figure 2. The relation between faculty availability and overall satisfaction. Availability differs from contact in that the mentor is not in contact with the student but is nearby or can be contacted.