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A research experience for American Indian undergraduates: Utilizing an actor–partner interdependence model to examine the student–mentor dyad

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Abstract

The majority of research examining Undergraduate Research Experiences focuses singularly on student-reported outcomes, often overlooking assessment of the mentor role in student learning and outcomes following these experiences. The goal of the current study was to examine the student-mentor dyad at the beginning and end of a 10-week summer research experience for American Indian undergraduates utilizing a series of actor-partner interdependence models within SEM. Participants included 26 undergraduate interns (50% American Indian; 50% American Indian and White; $M_{age} = 24$) and 27 mentors (89% White; $M_{age} = 47$). Findings indicated that in accounting for all potential paths between students and mentors, the partner path between mentor beliefs at the beginning of the program and students' skills related to autonomy ($\beta = .59, p = .01$) and academic resilience ($\beta = .44, p = .03$) at the end of the program were significant. These findings suggest the important impact of mentor beliefs on student outcomes, a relationship that should be adequately assessed and continue to be important focus of undergraduate research experiences. Findings further indicate the important role of mentors for American Indian undergraduates.

Keywords

Undergraduate research; Student-mentor dyad; American Indian undergraduates

Introduction

Recent movement in higher education has called for the implementation of research-based learning as a priority in college education (Boyer Commission Report, 1998). As such, there has been a surge of support for Undergraduate Research Experiences (UREs) that work to promote research opportunities specific to the social, behavioral, and health sciences and focus on discovery and innovation guided by experienced mentors. In line with support for UREs in general, there has been movement towards recruitment of underrepresented students within the research field. In 2012, the NIH working Group on Diversity in the Biomedical Research Workforce issued specific recommendations for ways in which

research-based programs could improve the recruitment of individuals from backgrounds underrepresented in biomedical research. American Indian (AI) undergraduates, in particular, have been consistently underrepresented in higher education (DeVoe & Darling-Churchill, 2008), and even more so in the healthcare professions (Sequist, 2007). AIs comprise nearly 2% of the population, yet make-up only 0.3% of all medical students, a five-fold disparity that exceeds those present for African American and Hispanic students (Sequist, 2007). Notwithstanding support for UREs in general, there remains an evident need for programs that focus on improving both the recruitment and educational attainment of AI undergraduates in the health sciences.

In order to build and sustain these programs, there is a need for appropriate assessment and evaluation highlighting both the short- and long-term impact of engagement in UREs. There is a growing body of program evaluation and research studies that suggest positive outcomes associated with UREs (e.g., Bauer & Bennett, 2003; Hunter et al. 2007; Kardash, 2000; Russell et al., 2007; Seymour et al., 2004) including increased overall self-efficacy related to science and increased desire to pursue a science-oriented career. While the frameworks of UREs often include pairing a mentor and student, there remain very few programs that have examined the mentor-student dyad in evaluating their program. The present study will examine the mentor-student dyad within a 10-week summer research experience for American Indian undergraduates.

Theoretical Overview

To better understand the basis of undergraduate research programs and to provide a theoretical framework for the current study, the following is a review of learning through a social constructivist model. Foundational to social constructivism is the premise that an individual engages in social interactions where knowledge is continually constructed and reconstructed to develop a personal understanding of the information at hand (Dennen, 2004). Student-mentor relationships, a common avenue for social constructivism, are based upon a notion of *scaffolding* (Vygotsky, 1962) where an individual more knowledgeable in the domain (i.e., mentor) provides support to an individual less knowledgeable (i.e., student) until they have mastered the task.

In order to facilitate this learning process, undergraduate research programs are often based upon *cognitive apprenticeships* where a novice and an expert work together within a specific discipline (Collins, 1991; Collins et al., 1989). Novices learn how to perform various tasks from the expert, yet specific to *cognitive* apprenticeships, novices learn to think (cognitively and metacognitively) about the task similar to how the expert would (Lave, 1995). Cognitive apprenticeships often include activities that are conducive to this process, including modeled demonstrations of tasks and timely feedback (Collins, 1991; Collins et al., 1989). Specific to UREs, a mentor's (expert) role is to monitor, advise, and facilitate learning with the ultimate goal of encouraging the student (novice) to take ownership of his or her own learning process. Once a student is able to complete a task on his or her own, it is common that he or she begin to construct a personal strategy for completing the task. This process is initiated when the skills learned become more salient, and are more easily transferred across tasks and settings (Schunk & Millen, 2013). In UREs, for example, this often takes place when the

student completes and/or presents a final research project to members within their discipline (Hakim, 1998).

Specific to the present study is the implementation of *academic mentoring*, involving post-secondary faculty and/or other experts guiding a student in a learning relationship focused on career and personal development within a higher education institution (Fletcher & Mullen, 2012). Unique to *academic mentoring* versus academic teaching or coaching is a reciprocal relationship, one in which both the mentor and student is active and subsequently impacted by the mentoring relationship (Johnson, 2007).

Evaluation of Undergraduate Research Experiences

To date, given the premise that student-mentor relationships are a socialized learning partnership focused on strengthening the student's skills and overall knowledge growth, programs have primarily examined student-reported outcomes. One of the most systematic evaluations utilized in URE programs focuses exclusively on student-reported outcomes, including gains in skills specific to their discipline such as opportunities for professional advancement, increased self-confidence, and feelings of accomplishment (Lopatto, 2006; 2010). Students are also asked to evaluate their mentors, with findings suggesting that student opinions of their mentor significantly impact student learning gains (i.e., highly rated mentors were associated with higher gains in student learning, etc.). However, there has been no adequate assessment of the interactional relationship between students and mentors and little consideration of how mentors' beliefs may impact student outcomes.

In one study, Kardash (2000) examined students' perceptions of a URE by asking them to rate their ability to perform research skills at the beginning and end of a research program. Distinct from evaluations of other UREs, the study also assessed mentors' ratings of change in their students' research skills at the end of the URE. As a result, this study was able to examine the changes in student perception of skills over the URE and compared this to the mentor's perception of the student's skills at the end of the program. Findings focused primarily on differences in student and mentor ratings, suggesting that compared to the mentors ratings, students often overestimated their abilities on various research-related skills. Accounting for variations in both student-mentor beliefs can be useful; however, these analyses (i.e., paired samples t-tests) are unable to examine the overall dynamics and impact of the student-mentor relationship.

While various assessments of UREs have relied on data analysis at the individual level, it is evident that studying a student-mentor relationship at this level alone may be theoretically and empirically problematic. As suggested by social learning theory, members in a dyad are involved in consistent interaction thus studies examining these relationships should work to simultaneously analyze both members of the dyad to account for shared experience. The goal of the current model is to account for the dynamic and developmental process that occurs between mentors and students over the course of a 10-week URE program through the use of the Actor-Partner Interdependence Model (APIM).

APIM

Individuals involved in dyadic relationships (even short-term relationships) can influence one another's beliefs and behaviors (Kenny, Kashy, & Cook, 2006). When studying dyads there is a need to account for both an individual's own influence (actor path) and its impact on their partner (partner path). APIM is a dyadic analysis that accounts for each of these paths and the nonindependence that occurs in mutual relationships. To date, APIM has often been used to analyze dyadic data in family (parent-child, siblings, romantic partners) and therapy (therapist-client) settings, but has been used less often within the educational setting. As suggested above, however, the educational setting lends itself to the study of mutual relationships via processes of scaffolding and academic mentoring that rest on the notion of meaningful, mutual learning relationships between a teacher/mentor and a student.

Research findings support the application of dyadic analyses, specifically in URE settings, as findings suggest mentors who prioritize scientific skills assist in developing their students' scientific knowledge and competence, promoting their identity as a scientist (Carlone & Johnson, 2007). Conversely, findings suggest that as students develop their research skills and knowledge, mentors/teachers often feel a sense of accomplishment and pride in their student's outcomes (Prunuske, Wilson, Walls, & Clarke, 2013). This sense of accomplishment may be associated with mentors' ratings of their students' post-program outcomes. Together, these findings suggest the mutual influence between students and mentors and the important role APIM could provide in better understanding these relationships within an URE setting.

Present Study

The present study is part of a broader evaluation of the Summer Undergraduate Research Experience (SURE). SURE is a 10-week URE where students obtain hands-on experience in biomedical or behavioral research projects. American Indian undergraduate students interested in healthcare careers or health disparity research are recruited and matched with a mentor to work in an area of interest. Mentors are drawn from a research institute under a healthcare organization (lead organization), local Veteran's Affairs research arm, and one public university. Students attend weekly seminars focused on professional development (e.g., literature searches) and health disparities research (e.g., history of research with American Indian/Alaska Native). Throughout these experiences, students learn strategies for working within the research field, including problem-solving skills and general research knowledge.

There are also scaffolded opportunities through which students are guided by their mentors and in the end are able to engage in the activity on their own, thus building their sense of autonomy within research. One of the culminating events of the summer is when students design and present a scientific poster on their work. A weekly seminar series is also held which exposes students to a broad background of content knowledge in the health sciences as well as a weekly journal club where students present and lead discussion among a larger group. Opportunities are also built in for each student to give a tour of their "labs", to further describe and demonstrate the work they are doing to their fellow students.

In addition to the informal support offered, the SURE program provides close involvement with ongoing activities in the mentor's lab. For example, the SURE project staff meets with the mentor and student pair at the beginning and middle of the internship to conduct an Individualized Learning Plan (ILP) to outline and revisit their goals to gain concrete research skills and content knowledge in the health sciences. Much of the ILP meeting is focused on narrowing the scope of the students' research for the end of the summer poster symposium and upcoming conferences. In addition to the weekly formal meetings and informal availability of the staff, the principal investigator meets with the students between the ILP meetings to discuss available resources, short-term and long-term career plans, and satisfaction with the program. SURE project staff are always encouraging completion of students' degrees, discussing possibilities for continuing their education (e.g., medical school), and planning for attendance and presentation at national and regional conferences. In this way, the SURE program works to ensure successful student-mentor relationships wherein both students and mentors are engaged in a dyadic, mutual relationship based on learning and support.

Given the various opportunities and support provided throughout SURE, the overarching goals of the program are to increase students' research process knowledge, innovation, academic resilience, and overall autonomy as a researcher. Both students and mentors are asked to report on these student outcomes as a social learning framework makes evident the need to account for the impact of both individuals within a learning dyad. As previously outlined, there are few programs that have adequately evaluated their URE and even fewer that assess the dyadic relationship between students and mentors. The goal of the present study, therefore, is to examine the student and mentor dyads within the SURE program, an often overlooked or inadequately assessed relationship impacting student outcomes.

In the current study an Actor-Partner Interdependence Model (APIM) will be used to examine the actor and partner effects present in the student-mentor relationship. As seen in Figures 1–4 depicting APIMs, there are various effects tested within the model (implying relationship, not causation). It is expected that students' and mentors' beliefs at baseline, or time one (T1) would be associated with their beliefs/behaviors post-program, or time two (T2), indicating significant actor effects. It is hypothesized that in accounting for actor paths in the overall model, that mentor's beliefs about the importance of skills at T1 would significantly impact students self-rated skills at T2 (partner path). These findings would support the notion that while student's beliefs regarding their own skills are important, the impact of the mentor's beliefs regarding the importance of a skill is integral to the student-mentor relationship and subsequent student outcomes. We would expect that the mentor's beliefs at T1 would significantly impact student skills at T2 such that high mentor beliefs would be associated with high student outcomes/behaviors at T2. This relationship is expected for the following models: research process knowledge, innovation, autonomy, and academic resilience. We will also test the partner path between student self-rated skills at T1 and mentor ratings at T2. A significant path may indicate that students' beliefs about their own behaviors at the beginning would be exuded throughout the program, in turn impacting the mentors' perceptions of their skills post program.

Methods

Procedure

Pre- and post-survey measures were designed to investigate the perceptions of students and mentors regarding their skills, character, and program experiences. All SURE students ($n = 20$) and mentors ($n = 35$) were invited via email to participate in pre- and post-surveys using the Survey Monkey online survey system. Data were collected in the summers of 2011–2014 at the beginning and end of the SURE program. At the onset of the program, program staff explained study procedures. Participants were not compensated for their participation. All study procedures were approved by Sanford Research Institutional Review Board (IRB) and University of South Dakota IRB. Baseline data was collected during the first week of the program, and post-surveys were collected in the last week of the program.

Participants

In the present study, the sample included 26 students (19 females), with a mean age of 24 years ($SD = 6.4$, range 18–45). Race/ethnicity breakdown for the students was as follows: AI/AN only (50%), AI/AN and White (50%). There were 27 mentors (15 male) who took part in the SURE program over the four summers, including primary and secondary mentors, with a mean age of 42 years ($SD = 12.7$, range 22–68). Race/ethnicity breakdown for mentors was as follows: 89% White and 11% Asian.

Measures

Student and Mentor Prompts—Students and mentors were surveyed regarding similar behaviors and outcomes including research process knowledge, academic character, academic resilience, and innovation; however, there were differences in the prompts provided. Prompts for students assessed the “extent to which you feel you possess the following abilities” and the extent to which “you feel that you are proficient in the following skills” in the first week of the program (T1) with the same prompt again after having completed the SURE program (T2). Prompts for mentors at T1 asked “to what extent do you feel that it is important for your student intern(s) to gain the following skills at the completion the SURE program” and “to what extent do you feel that it is important for your student intern(s) to gain the following abilities from the SURE program”. At T2, mentor prompts asked “to what extent do you feel that your student intern(s) are proficient in the following skills having completed the SURE program” and “to what extent do you feel that your student intern(s) have gained the following abilities having completed the SURE program”. All responses were recorded on a 4-point Likert scale with possible responses ranging from 1 = *Not at all* to 4 = *Extensively* or *Always*.

Research Process Knowledge—Student- and mentor-reported Research Process Knowledge was measured at T1 and T2 via fourteen questions adapted from Kardash (2000). Example items included, “understand and draw upon contemporary concepts in your field” and “relate results to the ‘bigger picture’ in your field”. Cronbach alphas were acceptable at all time points, ranging from .89 to .95.

Innovation—Student- and mentor-reported Innovation was measured at T1 and T2 via 3 questions adapted from Singer and Weiler (2009). Items included “provide new insights to the problem at hand” and “combine information in new ways and/or demonstrate intellectual resourcefulness.” Cronbach alphas were acceptable at all time points, ranging from .75 to .91.

Autonomy—Student- and mentor-reported Autonomy was measured at T1 and T2 via 4 questions adapted from Singer and Weiler (2009). Example items included, “the ability to work independently and identify when input, guidance, and feedback are needed” and “manage time well to ensure work gets accomplished and deadlines are met”. Cronbach alphas were acceptable at all time points, ranging from .68 to .93.

Academic resiliency—Student- and mentor-reported Academic Resiliency was measured at T1 and T2 via 3 questions adapted from Singer and Weiler (2009). Items included “learn from rather than being discouraged by set-backs and unforeseen events”, “flexibility, determination, a willingness to take risks”, and “ability to trouble-shoot problems, search for new ways to do things more effectively, and select between alternatives.” Cronbach alphas were acceptable at all time points, ranging from .68 to .90.

Results

Descriptive Statistics

Preliminary analyses included an examination of bivariate correlations (see Table 1). Means, Standard Deviations, and ranges are also reported along with results from paired-sample t-tests (see Table 2) that examined the change in student-reported skills and mentor-reported perceptions at the beginning and end of the SURE program.

Students—Paired-sample t-tests indicated that students’ self-reported research skills significantly changed from T1 to T2 for all of the measures examined; innovation ($t(20) = -4.24, p < .001$), academic resilience ($t(20) = -3.28, p < .01$), autonomy ($t(19) = -5.12, p < .001$), and research process knowledge ($t(20) = -3.29, p < .01$). These findings indicate that student reported behaviors significantly increased on all measured behaviors from the beginning of the program to the end.

Mentors—Mentors’ beliefs regarding the importance of a skill and perception of their student’s ability at the end of the summer did not significantly change from T1 to T2 for innovation, academic resilience, and autonomy, indicating that mentor expectations did not deviate significantly from their reported student outcomes. There was a significant change in mentors’ perceptions about students’ research process knowledge ($t(20) = 2.55, p < .05$). However, this change was negative, indicating their beliefs regarding the importance of research process knowledge at T1 were higher than their perceptions regarding their student’s abilities at T2.

Analytic Plan

Primary analyses tested Actor-Partner Interdependent Models (APIM) within Structural Equation Modeling (SEM) using Mplus software (v. 7.11; Muthén & Muthén, 2013). Although both multilevel modeling and SEM strategies can be used to analyze APIM, the following guidelines from Kenny et al. (2006) were utilized here. An advantage of SEM is that the model in its entirety is estimated, allowing all variables that would otherwise have to be estimated separately, to be estimated simultaneously (Kenny et al., 2006). SEM is also preferred over pooled-regression approaches wherein homogeneity of variance (where the variance for the student and mentor are assumed to be equal) is assumed; SEM approaches to APIM do not require this assumption. Finally, APIM effects can be viewed simply as a path-analytic model and, therefore, are easily translatable.

For this study, path analysis within an SEM framework was used to analyze APIMs (Kenny, Mannetti, Pierro, Livi, & Kashy, 2002). The following models estimate all potential paths between student and mentor, including all actor and partner paths. Because of this, the APIMs tested here were saturated (or just-identified, $df = 0$) and fit statistics were therefore irrelevant and not reported.

Actor-Partner Interdependent Models

Research Process Knowledge—Figure 1 displays the APIM results for student-reported research process knowledge and mentor perceived importance of research process knowledge at T1 and T2. As seen in the figure, the student actor effect was not significant ($\beta = .38, p = .16$), while the mentor actor effect was significant ($\beta = .49, p = .01$), suggesting the stability of the actor path for mentors (higher T1 associated with higher T2). Both partner effects, student T1 to mentor T2 ($\beta = -.42, p = .14$) and mentor T1 to student T2 ($\beta = -.09, p = .72$), were not significant. Together, T1 student and mentor research process knowledge accounted for 11% of the variance in T2 student research skills and 48% of the variance in T2 mentor research skills. The model indicates that, in accounting for all potential paths between the student and mentor, only the actor path between mentor-reported importance of (T1) and perception of (T2) the student's research process knowledge was significant. Given the non-significance of the path of interest (Mentor T1 to Student T2), these findings suggest that what the mentors believe regarding the importance of research process knowledge at T1 is not significantly associated with student's research process knowledge at T2.

Innovation—Figure 2 displays the APIM results for student-reported innovation and mentor perceived importance of innovation. The student actor effect ($\beta = .41, p = .05$) was significant; however, the mentor actor effect ($\beta = .36, p = .06$) was non-significant suggesting the stability of the actor path for students (higher T1 associated with higher T2). The partner effect between student T1 and mentor T2 ($\beta = -.05, p = .83$) and the partner effect from mentor T1 to student T2 ($\beta = -.15, p = .50$) were both non-significant. Together, T1 student and mentor innovation accounted for 52% of the variance in T2 student innovation and 20% of the variance in T2 mentor innovation. The model indicates that, in accounting for all potential paths, only the actor path between students-reported skills at T1 and T2 was significant. Given the non-significance of the path of interest (Mentor T1 to

Student T2), these findings suggest that what the mentors believe regarding the importance of innovation at T1 is not significantly associated with student's innovation at T2.

Autonomy—Figure 3 displays the APIM results for student-reported autonomy and mentor perceived importance of autonomy. The student actor effect ($\beta = .66, p = .02$) was significant, the mentor actor effect was non-significant ($\beta = .25, p = .32$). The partner effect between student T1 to mentor T2 ($\beta = -.04, p = .85$) was not significant; however, the partner effect from mentor T1 to student T2 ($\beta = .59, p = .01$) was significant. T1 student and mentor autonomy, together, accounted for 47% of the variance in T2 student autonomy and 9% of the variance in T2 mentor autonomy. The model indicates that, in accounting for all potential paths between students and mentors, the student actor path remained significant along with the partner path between mentor perceived student autonomy at T1 and student-rated autonomy at T2. The significant partner path suggests that what mentors believe regarding the importance of autonomy at T1 significantly impacts student's autonomy skills at T2; the higher mentor beliefs at T1, the higher student skills at T2.

Academic Resilience—Figure 4 displays the APIM results for student-reported academic resilience and mentor perceived importance of academic resilience. The student actor effect ($\beta = .53, p = .03$) and the mentor actor effect ($\beta = .45, p = .02$) were both significant. The partner effect between student T1 to mentor T2 ($\beta = -.31, p = .21$) was not significant; however, the partner effect from mentor T1 to student T2 ($\beta = .44, p = .03$) was significant. Together, T1 student and mentor academic resilience accounted for 61% of the variance in T2 student academic resilience and 33% of the variance in T2 mentor academic resilience. The significant partner path suggests that what mentors believe regarding the importance of academic resilience at T1 significantly impacts student's academic resilience at T2; the higher mentor beliefs at T1, the higher student skills at T2.

Discussion

The present study is unique in its examination of a Summer Undergraduate Research Experience for AI undergraduates, accounting for the relationship present between students and their mentors. While prior research studies have assessed student outcomes associated with UREs, their findings have relied on self-reported change in student behavior, often overlooking the important impact of the mentor on student outcomes. As suggested by social learning theory, for individuals to progress in their knowledge, one engages in interactions with another individual who is more knowledgeable in that content area, thus constructing new knowledge (Dennen, 2004). Innate within this theory is the premise that students and mentors play integral, mutual roles in the learning process (Fletcher & Mullen, 2012). Findings from the current study support the important learning process of the student and the role a mentor has in it, specifically for AI undergraduates. Further, it supports the need for URE's to assess both student behaviors and mentor perceptions when examining the potential change in student knowledge or behavior over the course of a program.

Student and Mentor Change

Descriptive analyses (t-tests) indicated a change in student-rated skills from the beginning to the end of the SURE program. These findings suggest the important impact of the program on students' skill levels, indicating students significantly increased in their self-reported research process knowledge, autonomy, academic resilience, and innovation over the 10-week program. For the mentors, t-tests indicated that, in general, they had high beliefs regarding the importance of all skills at T1; however, their beliefs about their student's ability to portray these skills at T2 were lower. For two of the measures, academic resilience and research knowledge skills, there was a significant decline from T1 to T2 for mentors. This decline may be due, in part, to mentors overestimating their expectations of the students at the beginning of the summer. While it was important to the mentors that students gain high levels of each of the skills as indicated by their T1 scores, the T2 scores suggest that throughout the course of the 10-week program, mentors may have gained a more realistic understanding of the skills that could be attained over the short time period. For the SURE program in particular, these findings suggest the importance of providing mentors with realistic expectations of what skills can be attained over a 10-week period at the beginning of program.

Student-Mentor Dyad

The primary analyses for the current study examined mentor perceptions and student behaviors utilizing APIM. Findings indicated that when accounting for all potential actor and partner paths between student and mentor pre- and post-assessments, the partner path of interest between mentors' beliefs at T1 and students' behaviors at T2 were positive and significant in the academic resilience and autonomy models. This suggests that mentors' beliefs about the importance of their students' learning skills in autonomy and academic resilience at the beginning of the program significantly and positively (the higher mentors' beliefs are, the higher students' skills are) impacted students' autonomy and academic resilience skills at the end of the program. The two models that had this significant partner path, academic resilience and autonomy, are particularly reflective of the larger goals of the SURE program, including the importance of setting and meeting goals and deadlines and engaging in activities where students take ownership of their research such as reporting to the larger group about their personal projects or giving a tour of their lab. When looking at the mean levels, both academic resilience and autonomy had the highest T1 means among the mentors suggesting the level of importance mentors placed on these skills initially and the likely emphasis they subsequently placed on building these skills throughout the program.

In relation to the larger literature, findings have suggested that mentors who spend time with their students recognize the importance of undergraduate research experiences in developing the confidence needed to conduct independent research (i.e., autonomy-related skills) and to persist within the field (i.e., academic resilience-related skills), rather than simply developing knowledge of the research process (Houser, Cahill, & Lemmons, 2014). This reflects our current findings where higher mentor-reported importance of academic resilience and autonomy at the beginning of the summer was related to higher student-reported academic resilience and autonomy at the end of the program.

The partner path between mentor T1 and student T2 on research skills and innovation was not significant. Findings suggest gaining research skills, including process knowledge and innovation, often take time. The slow enculturation into scientific practices, and feeling confident in enacting them, suggest why survey results from even full year UREs have generated little progress (Linn, Palmer, Baranger, Gerard, & Stone, 2015). Further, students are often poor raters of their own skills (e.g., Langendyk, 2006). That is, while students may report that they have progressed in their research process knowledge and innovation (as indicated by the paired t-tests), their mentors (similar to the accuracy of teacher-ratings; Achenbach, 1991) are likely to be more accurate in assessing their skills, recognizing the difficulty in fully acquiring research process knowledge and innovation skills in a 10-week program.

For all of the models, the partner paths between student T1 and mentor T2 were not significant. Although prior research suggests the mutual influence in a student-mentor dyad, such that students should have an impact on their mentors (Prunuske et al., 2013), this was not seen in our models. This may be attributable to our measures that did not directly assess mentor outcomes; rather they examined mentor-rated student outcomes. Future research could assess mentors on both student and personal outcomes, providing a more traditional examination of the APIM within this context and potentially showing a significant partner path.

Several of the non-significant paths (e.g., students T2 was not related to mentors T2 on any of the measures) suggested a discrepancy between student and mentor assessments. This finding is not entirely surprising given the literature that suggests students are often inaccurate in their self-ratings – either underrating or overrating their own skills (Langendyk, 2006). Mentor-ratings (similar to teacher-ratings) are often more accurate in assessing student academic outcomes as they are less biased and more in-tune with students' actual skill-level (Achenbach, 1991).

Implications for Underrepresented Students

Our study is unique in its examination of a program focused on AI undergraduates, an underrepresented population in higher education, and in particular, the health sciences – a primary focus of the SURE program. Our findings indicate the pivotal role of the mentor on student outcomes, which may be of particular importance for AI undergraduates and underrepresented students for several reasons. First, for underrepresented students, such as first generation students, they may be lacking academic mentors reinforcing the integral role mentors in these programs can have in setting the stage for potential pathways into further education and career opportunities. Mentors likely play a significant role for those without prior research experiences, mentors, role models, or resources (Tinto, 1993). Other barriers to educational success for minority or underrepresented students often include financial problems, lack of family knowledge of the education system, and absence of support groups (DeLapp et al., 2008; Dickerson et al., 2000; Evans & Greenberg, 2006; Erikson & Hirshberg, 2008; Manifold, & Rambur, 2001). Therefore, prior research has stressed the importance of mentor and student interactions in the educational persistence of minority

students (Tinto, 1993). To date, however, there has been little empirical data indicating the important role of mentors for underrepresented or minority students undergoing a URE.

For AI undergraduates in particular, there are also cultural values that may serve an important role in their engagement and subsequent change regarding the acquisition of research skills. For example, while individuals within cultures with high individualism (i.e., United States) tend to have higher levels of confidence in their abilities, individuals in collectivist cultures are more likely to show self-effacement, as it is often culturally valued to defer to elders or to show humility (Markus & Kitayama, 1991; Kwan, Bond, & Singelis, 1997). Given these values, within this particular sample of AI undergraduates, it is of interest to note the impact mentors have in students' increase in their autonomy and academic resilience. These findings suggest the importance of the SURE program in encouraging the necessary skills essential to the success of AI undergraduate researchers.

Limitations

Although this study presents novel and provocative findings in regard to the impact of mentors on student behavior over the course of a 10-week URE program, its limitations should be discussed. The current results incorporate students' and mentors' outcomes spanning three summers of the SURE program, however given the limited number of students and mentors that take part in the program each summer, there was a relatively small sample size. While prior guidelines suggest that in the absence of latent variables, sample size requirements for APIM are the same as that for ordinary regression analysis (Kenny & Cook, 1999), more robust findings are likely to be found with a larger sample. For example, some of the paths were moderately weighted, however were not significant. In the Research Process Knowledge model, the path between student T1 and mentor T2 was $-.42$ and the path between student T1 and student T2 was $.38$, both moderate weights, but were not significant. Similarly, in the innovation model, the path between Mentor T1 and Mentor T2 was $.36$ and non-significant. The small sample examined here along with the number of paths estimated within each model indicates that the models tested may have been underpowered.

This is also a unique use of APIM in that we do not assess entirely interdependent measures of students and mentors. While students and mentors filled out parallel forms, they are not entirely identical. Further, outcomes at T2 are both assessing student outcomes (self- and mentor-rated) and do not directly assess mentor outcomes.

Taken together, while the current findings are unique there are significant limitations that should be discussed. In light of these limitations, however, the current study does address an understudied sample with data collected over four summers. There is an evident need for this work with AI undergraduates and in examining UREs through the application of APIM. As such, the current study provides a first step in this needed direction of research in higher education research.

Future Directions

Given the current findings, future directions for the SURE program should focus on training mentors in areas where they appeared to have less impact (i.e., research knowledge skills

and innovation) on student outcomes. This may include more comprehensive mentor training at the beginning of the summer where mentors are provided with information on the skills expected of students at the end of the program. This may help offset the relatively high expectations of the mentors at the beginning of the summer, or help teach mentors ways to focus on building the targeted skills of the program.

Taken together, it is evident that the current study provides novel information regarding the importance of the student-mentor dyad within UREs. Future research should work to incorporate mentor assessments alongside student assessments to examine the important role of mentors' beliefs in students' change in skill level. The current study was able to shed light on the pivotal role mentors play for underrepresented students, and in particular, AI undergraduates. There is need for further research and programs that work to address the evident educational disparities among this population of undergraduates while also working to adequately assess the impact of such programs.

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Figure 1.
Actor-partner interdependence model for student and mentor pre- and post- assessment of Research Process Knowledge.

Figure 2. Actor-partner interdependence model for student and mentor pre- and post- assessment of Innovation.

Figure 3. Actor-partner interdependence model for student and mentor pre- and post- assessment of Autonomy.

Figure 4.

Actor-partner interdependence model for student and mentor pre- and post- assessment of Academic Resilience.

Table 1

Correlations for Variables of Interest ($N = 53$).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>Student</i>																
1. Innovation T1	—	.31	.67	.09	.50	.14	.80	.14	-.10	.01	-.14	-.09	-.10	.06	-.24	-.07
2. Innovation T2		—	.40	.22	.19	.28	.46	.68	-.12	.09	-.03	-.27	.04	-.22	-.21	-.02
3. Acad Res T1			—	.40	.63	.54	.72	.34	.07	-.17	.17	-.23	.26	-.14	-.01	-.11
4. Acad Res T2				—	.61	.58	.27	.63	.21	.13	.49	.25	.56	-.04	.26	-.03
5. Autonomy T1					—	.65	.69	.42	-.08	-.21	.19	-.32	.41	-.22	-.04	-.22
6. Autonomy T2						—	.46	.52	.37	-.11	.46	-.24	.67	-.26	.31	.07
7. Res Know T1							—	.23	-.15	-.26	-.02	-.37	.08	-.26	-.25	-.30
8. Res Know T2								—	-.06	.19	.12	.03	.31	-.08	-.05	.10
<i>Mentor</i>																
9. Innovation T1									—	.34	.47	.21	.50	.07	.76	.28
10. Innovation T2										—	.05	.70	.35	.75	.27	.91
11. Acad Res T1											—	.29	.76	-.02	.82	.17
12. Acad Res T2												—	.34	.86	.41	.74
13. Autonomy T1													—	.28	.68	.32
14. Autonomy T2														—	.12	.74
15. Res Know T1															—	.36
16. Res Know T2																—

Note. Bolded items indicate $p < .05$; Acad Res designates Academic Resilience; Res Know designates Research Knowledge.

Table 2

N, Range, Means, SD, t-test

	T1				T2				t-test
	N	Range	Mean	SD	N	Range	Mean	SD	
<i>Student</i>									
Innovation	19	2.33–4.00	3.28	.49	17	3.00–4.00	3.67	.43	4.24**
Academic Resilience	19	2.67–4.00	3.46	.52	17	3.00–4.00	3.71	.36	3.28*
Autonomy	19	2.75–4.00	3.40	.43	17	3.00–4.00	3.73	.33	5.12**
Research Process Knowledge	19	2.00–3.86	2.96	.50	17	3.00–3.93	3.60	.32	3.29**
<i>Mentor</i>									
Innovation	22	2.00–4.00	3.18	.67	23	1.00–4.00	2.88	.82	–1.46
Academic Resilience	22	2.00–4.00	3.56	.53	24	1.33–4.00	3.35	.56	–1.39
Autonomy	22	2.75–4.00	3.65	.48	24	1.75–4.00	3.58	.59	–0.09
Research Process Knowledge	22	1.93–4.00	3.38	.55	24	1.36–3.86	3.06	.59	–2.55**

*Note.** = $p < .05$ ** = $p < .01$