

Supporting Students from Day 1 of College: The Importance of Relatedness to Inclusivity†

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Day 1: Watershed (WS) is a first-year program designed to provide an inclusive environment for students and immerse them in research from day 1 of college. Originally developed to support students from underrepresented groups (URGs) including first-generation students and students of color, WS provides authentic research experiences for all students as they collect and analyze water and microbiological samples from the local watershed. WS also includes a living-learning community with students living in the same dorm and taking common courses during their first year. In the first year of our study, researchers investigated students' anxieties, feelings of belonging or isolation, supports received, and personal habits. In year 2 (the primary year reported), researchers used mixed-methods and self-determination theory to determine how WS students differed from students in other introductory and research-based courses in terms of basic psychological needs satisfaction (including autonomy, competence, and relatedness). Results indicated that although WS students felt less autonomous and, at times, less competent than other students, 90% reported a positive experience. Furthermore, findings suggest that WS students' feelings of connection with classmates and instructors, as well as a sense of belonging in the course, provided the necessary motivational support to facilitate a positive learning experience. These findings indicate that the WS program can be a viable model for supporting students in early science courses and making them feel included.

INTRODUCTION

In 2012, the President's Council of Advisors on Science and Technology (PCAST) released a report entitled *Engage to Excel* (1), which called for 1 million additional STEM graduates above the predicted number in the following decade. According to the report, this goal could be achieved by increased recruitment of underrepresented minority groups (URMs) to STEM fields. Recruitment is not the only challenge, however, as many have pointed out the "leaky pipelines" in STEM programs that continue to see a disproportionate number of URMs leaving these fields when compared with Asians and whites (2). In short, strengthening the STEM workforce through recruitment and retention of URMs continues to be a priority for higher education.

The current study evolved from efforts by an institute of higher learning to respond to these initiatives and promote

more inclusivity in STEM. An inclusive environment is one in which students from diverse backgrounds feel a sense of belonging (3). The program that emerged at the institution, Day 1: Watershed (hereafter referred to as WS), was developed to foster inclusivity in students from traditionally underrepresented groups (URGs), including first-generation college students, financially disadvantaged students, and students of color (although the program was open to all freshman). (Note: URG is used in place of URM when a population includes URMs as well as underrepresented groups who differ for reasons other than race or ethnicity.) The original purpose of this study was to determine differences between WS students and students from generalized STEM courses in terms of: a) anxieties about college, b) feelings of belonging or isolation in the classroom and at the institution, c) anticipated and/or received supports, and d) personal habits as related to college life.

Literature review

The authors of *Engage to Excel*, in addition to calling for more recruitment, discussed how retention is often a problem for STEM fields because of uninspiring introductory courses and/or difficult math courses (1). For URGs,

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†Supplemental materials available at <http://asmscience.org/jmbe>

however, leaving STEM majors is also linked to feeling unwelcomed in the classroom. In contrast, some studies show a correlation between college retention and belongingness, i.e., feeling a sense of fit or social integration (4), particularly in URGs (5). Evidence suggests that belonging is tied closely to retention, and past research has used motivational theories to explain the connection.

Although there are many theories of motivation, self-determination theory (SDT) (6) has been verified in over 700 school-related studies (7) and has been described as one of the most supported motivational theories (8). It posits that all humans have basic psychological needs of autonomy, competence, and relatedness. These needs are defined as follows: a) autonomy is a desire to regulate one's own behavior and avoid being controlled; b) competence is the desire to engage in challenging tasks and experience mastery in the physical and social worlds; and c) relatedness is the desire to feel belongingness and intimacy with others (9). In a school context, SDT proposes that students who find fulfillment for their needs will be more motivated. As a result, these students will be more academically successful and satisfied (10).

National publications, including *Supporting Students' College Success* by The National Academies (5), have cited SDT research suggesting that individuals are likely to engage and perform positively in settings in which they feel connected or related (11). A specific example of a program that has intentionally sought to reduce feelings of isolation and promote belongingness in URGs is the University of Maryland–Baltimore County Meyerhoff Scholars Program. This program produced over 1,000 STEM undergraduates between 1989 and 2016, with 209 receiving PhDs. Seventy percent of these PhDs were earned by URM students (2). A key aim of the program was to reduce amotivation by decreasing isolation and promoting belongingness through peer-support networks and bridge programming.

Although not explicitly using SDT as a framework, many other studies about course-based undergraduate research experiences (CUREs) and retention have used measures that relate to the basic psychological needs. For example, in a recent publication about the development of the Persistence in the Sciences survey (PITS) (12), the authors mentioned several factors influencing retention for URGs, including project ownership, self-efficacy, and networking. These variables tangentially relate to autonomy, competence, and relatedness, respectively. A different study (13) reported that more student input in CUREs (i.e., increased student autonomy) led to greater understanding and skills (i.e., competence). Furthermore, Eagen, Hurtago, and Chang (14) reported that undergraduate research provided space for students to develop the competencies that gave them the best chances for success in STEM. Additionally, students who experienced more faculty support reported higher probabilities of postbaccalaureate studies (i.e., retention [14]). Finally, mentoring relationships (i.e., relatedness) have been shown to motivate and encourage students from URM students

the point that their confidence in themselves increased (15). In that particular study, 52% of URM students reported their mentor relationship changed their career path and influenced them to attend graduate school.

In sum, evidence suggests an association between support of the basic psychological needs and greater satisfaction and persistence in science for all students. As SDT proposes that students are motivated through basic needs support, it is important to consider these factors when assessing science learning experiences. In fact, in *A Framework for K–12 Science Education*, the presidents of The National Academies recognized the link between motivation and recruitment and retention in STEM: “The percentage of students who are motivated by their school and out-of-school experiences to pursue careers in these fields [science and engineering] is currently too low for the nation's needs” ([16], p. x). In effect, more focus needs to be placed on understanding and promoting basic needs satisfaction in science learning contexts.

METHODS

Program background

WS is a first-year program at a 4-year, research-intensive liberal arts undergraduate college in the Midwest. College enrollment typically exceeds 3,000 students, with about 40% of the student body enrolling in an introductory STEM course during their first year and 23% ultimately majoring in the sciences. Students in WS are immersed in research from day 1 of college by participating in authentic CUREs (17). CUREs allow more students to experience science by doing research with faculty investigators as part of their coursework. The CURE component of the WS program focused on local efforts to remediate a watershed that is closely associated with the Great Lakes. Specifically, students collected water samples to measure suspended sediment and nutrient levels (i.e., phosphorous, nitrate), fecal indicator bacteria counts (i.e., *Escherichia coli*), and 16S rRNA-based composition of microbial populations found in the watershed. The WS course fulfilled an introductory biology and a general chemistry laboratory credit for students.

In addition to authentic research, WS included a living–learning community (LC). LCs integrate students' social and academic lives to promote greater achievement and persistence in college (18). The residential component of WS required students to live in the same dormitory and take some courses together, including an introductory biology lab and general chemistry lab. Also, WS students arrived on campus 1 week before regular classes to meet each other, start collecting data, and acclimate to campus life before the official beginning of the semester.

The purpose of the exploratory study in year 1 (Fig. 1) was to determine whether WS students differed from students in a more generalized science course in terms

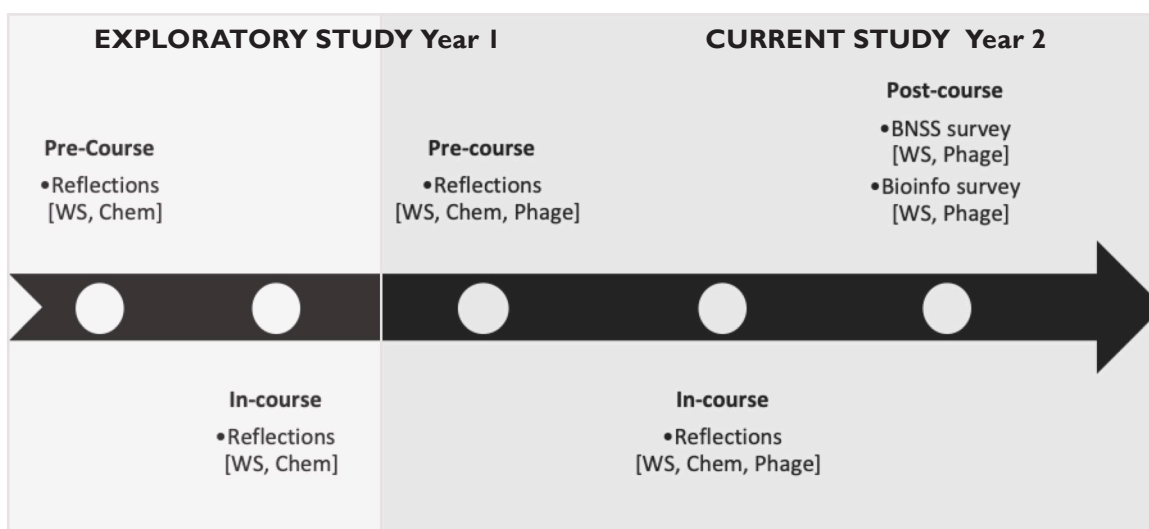


FIGURE 1. Timeline for data collection in year 1 exploratory study and current study (year 2). The figure includes data collection timing (pre-, in-, or post-course), instruments (reflections or surveys), and sample groups (WS, Chem, Phage).

of anxieties, feelings of belonging or isolation, supports received, and personal habits. After analyzing data from year 1, researchers added sample groups, data collection instruments, and SDT as an interpretive framework. As a result, the study expanded in year 2 and also investigated whether WS students differed from other students in terms of basic psychological needs satisfaction (Fig. 1). Researchers hypothesized that students involved in CUREs, like WS students, might report greater feelings of autonomy as they engaged in a more authentic research experience. Furthermore, researchers predicted that WS students would report more relatedness satisfaction, as they were more intimately associated with their cohort in both research and living arrangements. The findings from this study will inform future efforts to create and modify CUREs and LCs

to make them more inclusive and motivationally supportive for all students.

Sample description and data collection and analysis

The current study, including the informed consent process and confidentiality parameters, was reviewed and approved by the college's Institutional Review Board (IRB). Participant recruitment was done electronically through e-mail solicitations using course rosters. Over the 2 years of the study, the female/male percentage ratios for the courses were as follows: 43/57 WS; 68/32 Phage; 49/51 Chemistry. [The "Phage" program, a shortened term for the Science Education Alliance-Phage Hunters Advanced Genomics and Evolution Science (SEA-PHAGES) program, is described

TABLE 1.
Laboratory course descriptions, sample sizes, and general student characteristics for year 1 (exploratory study) and year 2 (current study).

| Course or Group | n (%) | Description | Student Characteristics |
|-----------------|--|---|---|
| Watershed | 10/10 (100%) (year 2); 10/13 (77%) (year 1) | 100-level general biology laboratory for first-year students designed as a CURE. Students lived together in a residence hall and took other courses together. | First-year students with science major/minor interest. Overall enrollment was 31% URG in year 1 and 30% URG in year 2. |
| Phage | 17/18 (94%) (year 2 only) | 100-level general biology laboratory for first-year students engaged in SEA-PHAGES research. Distinct CURE design. Students lived in randomly assigned housing. | First-year, academically strong students with science major/minor interest. Overall enrollment was 37% URG in year 1 and 28% URG in year 2. |
| Chemistry | 22/24 (92%) (year 2); 9/24 (38%) (year 1) | 100-level general chemistry laboratory not limited to first-year students and not designed as a CURE. Students lived in randomly assigned housing. | Students from various years and levels with science major/minor interest. Overall enrollment was 40% URG in year 1 and 41% URG in year 2. |

below in our presentation of the year 2 data.] In all three programs 76% of solicited students accepted the invitation to participate over the 2-year period. (Note: The ratio of consented to solicited students for each course is given in Table 1. Solicitations to participate were not sent to all Phage and general chemistry students. Only one section of Phage or Chemistry was solicited in a given year.) Students were offered a small grade compensation for their participation.

In year 1, data were collected and analyzed from two courses, WS ($n = 10$) and general chemistry laboratory (Chemistry; $n = 9$) (see Table 1). These two courses were chosen in year 1 for the initial exploratory study in order to compare the experiences of students in the WS program with students in a more traditional science lab experience. Over a 15-week, single semester in year 1, data were collected via weekly electronic reflections (Table 2). The reflections solicited responses to open-ended questions (Appendix 1) to determine students' anxieties, feelings of belonging or isolation, perceptions of support, and personal habits in college. Responses were transferred to the software program NVivo and analyzed using inductive methodology (19, 20). A critical component of the qualitative analysis was the use of constant comparison, a process in which different pieces of data are compared with each other to determine similarities and differences (20). Identifying these similarities and differences helped researchers organize the data into emerging categories that were established directly from student responses and defined explicitly.

Training coders and analyzing the qualitative data took place according to the following process: a) all coders were trained in inductive methodology and the use of NVivo; b) two groups with two coders each (i.e., coding teams) coded 10% of the transcripts; c) all coders met to compare coding and categorization from the initial batch; d) all coders negotiated to agreement on categorization, defined categories, and identified exemplary statements to represent each category; and e) coding teams divided the remaining transcripts and coded independently. During this time, coding teams met many times per week to consider difficult phrases and evaluate any emerging categories. This process, which was also repeated in year 2 with a different group of coders, provided trustworthiness as group collaboration and negotiation at critical points ensured coding

was done consistently, categories were grounded in the data, and categories were defined explicitly.

In addition to the aforementioned process, the research team adhered to other measures of trustworthiness as suggested by Johnson (21): a) use of low inference descriptors (e.g., using direct quotes to support categories); b) investigator triangulation (i.e., multiple researchers coding together and meeting frequently with other coding groups to reach agreement); and c) reflexivity. Reflexivity, in this context, was the process in which the coding teams openly discussed preconceptions, assumptions, and/or systematic biases that may have affected initial coding. Furthermore, researchers recorded extensive memos throughout the analysis to provide an audit trail as per Strauss and Corbin (19). The audit trail allowed researchers to review the coding process and verify that categorization and coding decisions were grounded in the data. In many cases, qualitative data were quantified (22). In these cases, responses (i.e., categories) conveyed by at least 20% of any particular student group were reported (20% was chosen as the cutoff, as responses with lower percentages were deemed unrepresentative of the respective groups).

Findings from the year 1 exploratory study drove decisions about how to proceed in year 2 (the year primarily reported in this study). Year 1 findings included WS students mentioning fears of "not fitting in" in precourse responses more often than Chemistry students. Moreover, as the year progressed, WS students mentioned developing a sense of belonging in the course and at the institution more often than Chemistry students. Finally, WS students often revealed insecurities about their abilities and the preparation they received in high school. As a result of these trends, researchers expanded data collection in year 2 to include one additional sample population, making a total of three sample groups (WS, Chemistry, Phage; see Table 1). Also, two surveys were added to the data collection instruments. Figure 1 summarizes data collection timing, sample groups, and instruments.

In year 2, students from the college's SEA-PHAGES program were added to the study, as researchers wondered whether the differences in WS and Chemistry students in year 1 might be linked to course structure (i.e., CURE versus traditional) (see Table 1). SEA-PHAGES is an undergraduate

TABLE 2.
Data collection methods, comparison groups, and analytical methods for year 2.

| Data Collection Method | Comparison Groups | Analytical Method |
|---|---|---|
| Weekly reflections (pre- and in-course) | Introductory courses (WS – Phage – Chemistry) | Inductive methodology using constant comparison |
| Bioinformatics survey (post-course) | CURE courses (WS – Phage) | Mann-Whitney U test |
| BNSS (post-course) | CURE courses (WS – Phage) | Mann-Whitney U test |

TABLE 3.
Comparison of CURE students' responses on BNSS (post-course) in year 2.

| Construct | Phage (n = 13) | | WS (n = 10) | | U | Z | p |
|-------------|----------------|------|-------------|------|-------|-------|-------|
| | Mean | SD | Mean | SD | | | |
| Autonomy | 5.34 | 0.57 | 4.50 | 0.72 | 23.50 | -2.58 | 0.008 |
| Competence | 5.73 | 0.72 | 5.10 | 0.63 | 30.50 | -2.15 | 0.030 |
| Relatedness | 6.05 | 0.67 | 6.10 | 0.64 | 61.50 | -0.22 | 0.832 |

Means are the results of answers given on a seven-point Likert scale (1 = not at all true; 7 = very true).

program initiated by the Howard Hughes Medical Institute that has been successfully implemented on numerous college campuses for many years (23). This program is an example of an introductory experience that puts students in a position to make discovery-based contributions to the field as students find and name their own bacteriophage. In the current study, Phage students provided additional first-year perspectives that mimicked WS in that both programs were designed as CUREs. However, these groups differed in that Phage had a selective admission policy based on higher academic achievement (WS and Chemistry had no academic prerequisites). The same reflection prompts from year 1 were used in year 2 (Appendix 1). The qualitative

data generated from these reflections was coded using the previously-described process. Although researchers were open to new, emerging categories in year 2, the coding themes from year 1 sufficiently accommodated year 2 data. This outcome suggested theoretical saturation and a robust coding scheme (19).

A second change in year 2 was the development of a seven-question bioinformatics survey (Table 2; Appendix 2). This survey, administered postcourse to WS and Phage students, was designed to determine how competent students felt about engaging in the scientific method and using the specific techniques and tools for analyzing biological data. (This instrument was not administered to Chemistry

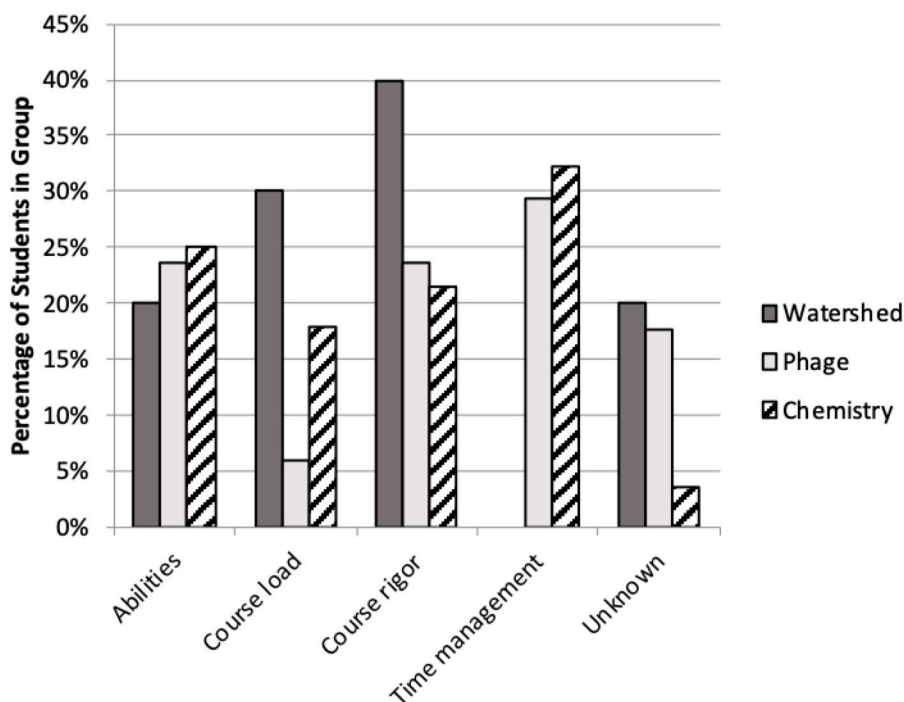


FIGURE 2. Precourse reasons introductory students felt anxious and/or doubtful about their respective courses (data from weekly reflections). X-axis categories were defined as follows: abilities (anxiety due to perceived lack of academic abilities and/or lab skills), course load (anxiety about volume of work in course), course rigor (anxiety about challenge of the course), time management (anxiety about being able to manage time) and unknown (anxiety about not knowing how college courses worked).

students because that course did not share course objectives related to bioinformatics.) Responses to the bioinformatics survey were on a five-point Likert scale.

A third change in year 2 was applying SDT as a framework to better contextualize the findings. SDT was chosen because, as previously described, year 1 findings suggested differences between WS and other students in terms of belonging and competence (two constructs considered to be basic needs in SDT). It is accepted practice to infuse theory at different points in a qualitative study, particularly when developing research questions, interpreting findings after an initial qualitative analysis, and/or triangulating qualitative findings (24). In year 2, researchers used SDT in two of these ways: a) to interpret the inductive qualitative findings (25), and b) to triangulate those findings with the quantitative results generated by an SDT-based survey. The SDT-based survey was a modified version of the Basic Needs Satisfaction at Work Survey (BNSS) (26; Table 2). The BNSS is a standardized survey that includes 21 items answered on a seven-point Likert scale. The survey measures perceived satisfaction of autonomy, competence, and relatedness after participants engage in an experience. This survey was administered postcourse to students in the CURE courses (WS, Phage). All survey data were entered into SPSS and analyzed using descriptive and appropriate inferential statistics. Due to the ordinal survey data and smaller sample sizes, the nonparametric Mann-Whitney U test was used to determine whether there were differences between groups. In the end, all qualitative and quantitative data were combined in a convergent mixed-methods approach as per Creswell and Plano Clark (27). Table 2 outlines data collection methods, comparison groups, and analytical methods for year 2.

RESULTS AND DISCUSSION

The following results and discussion focus on year 2 and are framed by SDT, which predicts that feelings of autonomy, competence, and relatedness lead to greater satisfaction and well-being as one engages in activities (28). Table 3 contains descriptive statistics and inferential results from the Mann-Whitney U test on the BNSS survey results. These results provide a comparison between students in the two CURE courses (WS, Phage) in terms of their basic needs satisfaction as a direct result of the course.

WS students lower in autonomy and competence

The BNSS results (Table 3) indicated WS students felt significantly less autonomous ($U = 23.50, p = 0.008$) than Phage students at the end of the course. As the reflection prompts did not specifically inquire about students' feelings of control (and students offered little commentary on this construct), it is difficult to ascertain exactly why WS students felt less autonomous (recall that the reflec-

tion prompts were developed before the decision to use SDT). However, it is interesting that 90% of students in WS still reported they enjoyed the course (compared with 94% in Phage), even though autonomy is often reported in the literature as the most critical need for motivation and satisfaction (29).

Regarding competence, all groups had students who reported precourse concerns (from reflections) related to course load, rigor, and the unknowns of college, as well as some anxieties about their own abilities (Fig. 2). For WS students, the apprehensions about course rigor and load were often directly related to their perceived lack of preparation: "My high school did not have the funding that allowed for many lab experiments. Because of this, I thought I was inadequate when it came to lab techniques" (WS student). It is important to note that feeling less competent does not necessarily indicate a person is functionally less competent. SDT simply states that when one feels less competent, motivation and satisfaction suffer. At the end of the course, the BNSS results indicated that WS students felt significantly lower in competence than Phage students ($U = 30.50, p = 0.030$; Table 3). Bioinformatics survey results (Table 4) reinforced these findings and revealed that WS students specifically felt less competent than Phage students in regard to: a) integrating large-scale data with experimentation (Q1; $U = 30.50, p = 0.030$), b) using bioinformatics tools to understand data (Q2; $U = 30.50, p = 0.030$), and c) analyzing data from sequencing (Q5; $U = 20.00, p = 0.004$). In contrast, no significant differences were found between the WS and Phage groups on questions related to students' competence to do basic scientific tasks: a) generate hypotheses (Q3; $p = 0.186$), b) design experiments (Q4; $p = 0.313$), c) analyze data from wet lab experimentation (Q6; $p = 0.101$), and d) draw conclusions from data (Q7; $p = 0.257$). In sum, WS students felt less confident than their CURE counterparts (i.e., Phage) when performing specialized tasks related to the research experience (e.g., manipulating large-scale data sets and analyzing bioinformatics data).

The realization that WS students felt less confident when using technology skills and manipulating big data reminds educators it is important to support new learners in critical process skills. While many introductory instructors formatively assess students on their science content learning, perhaps fewer gauge students' comfort levels when engaging in integrated processes related to modern science learning (e.g., bioinformatics analysis). These findings illustrate that some students who successfully navigate an introductory science course (as did these WS students) still feel insecure about their abilities in supporting areas and could benefit from additional interventions.

The importance of relatedness to WS students

The discovery that competence was lower in WS students (from the BNSS; Table 3) was somewhat concerning, as competence has been linked to academic success and

TABLE 4.
Comparison of CURE students' feelings of competence using post-course bioinformatics survey from year 2.

| Question and Survey Topic | Phage (n = 13) | | WS (n = 10) | | U | Z | p |
|--|----------------|------|-------------|------|-------|-------|-------|
| | Mean | SD | Mean | SD | | | |
| Q1: Integrate large-scale data analysis with wet lab experimentation | 4.54 | 0.52 | 3.90 | 0.57 | 30.50 | -2.43 | 0.030 |
| Q2: Use bioinformatics tools to understand large-scale data sets | 4.54 | 0.52 | 3.80 | 0.79 | 30.50 | -2.43 | 0.030 |
| Q5: Analyze data generated from sequencing | 4.62 | 0.51 | 3.80 | 0.42 | 20.00 | -3.16 | 0.004 |

continuation in college (30). Moreover, with both competence and autonomy being lower in WS students (Table 3), researchers questioned why these students continued to report high levels of satisfaction. The following discussion about relatedness attempts to answer this question.

The BNSS results indicated that relatedness was the construct for which WS students responded most similarly to students in Phage (Table 3). All incoming students reported precourse anxieties (from reflections) about belonging, at the institutional level, particularly because they were apprehensive about making friends (Fig. 3). However, during the course, WS students reported in their reflec-

tions that friends, professors, and tutors were sources of support (i.e., relational supports) that helped them succeed (referenced by 50% of WS students; Fig. 4). On the contrary, when Phage and Chemistry students discussed supports in their reflections, they most often referenced their own abilities (Fig. 4). It is also interesting that WS and Phage, the two CURE-based courses, had much higher percentages of students who mentioned relational support when compared with Chemistry (which was a traditional lab). Perhaps the CURE model promoted more connections between students as they worked on authentic lab activities related to research projects.

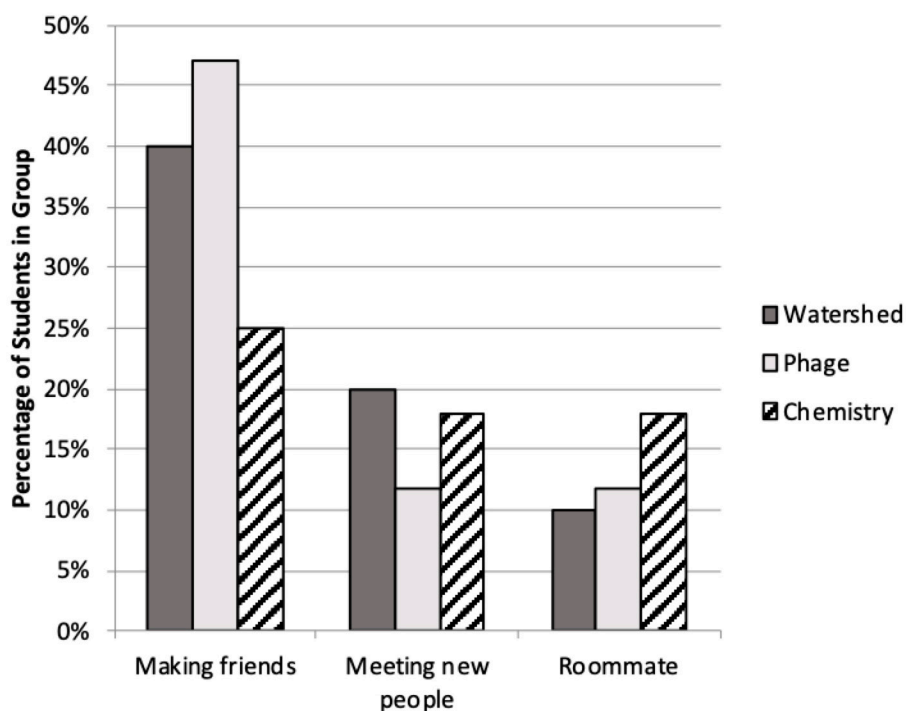


FIGURE 3. Precourse reasons why introductory students felt anxious about belonging at the institution (data from weekly reflections). X-axis categories were defined as follows: making friends (general apprehension about making friends on campus), meeting new people (general fearfulness about interacting with new people), roommate (apprehension about roommate, specifically).

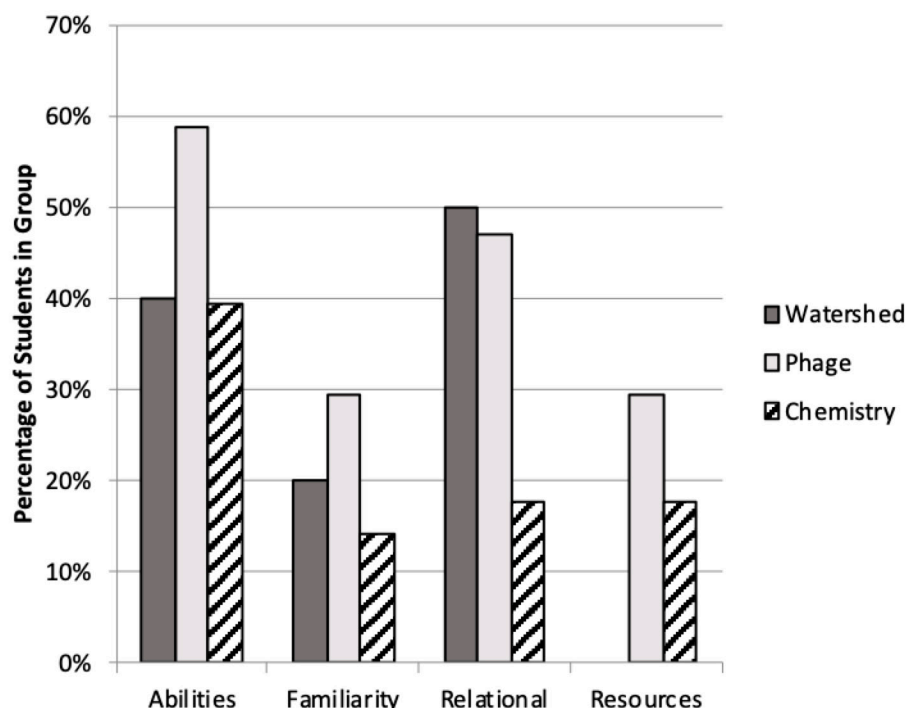


FIGURE 4. Reasons why introductory students felt confident they would be successful in the course (in-course; data from weekly reflections). X-axis categories were defined as follows: abilities (skills students had or could gain quickly), familiarity (confidence gained by becoming familiar with the course, teacher, etc. in first meetings), relational (references to specific support persons, e.g., peers, professors, teaching assistants); resources (general academic supports, e.g., tutoring, library).

In looking at WS students specifically, evidence suggests these students gained confidence to meet challenges through relational supports. In other words, their competence was sometimes boosted by feelings of relatedness. Qualitative data from reflections support this interpretation, as WS students freely reported how specific people helped them when they needed it most: “The professors and [teaching assistants] are very willing to help”; “I have my peers to help me out when I don’t understand something.” SDT literature provides at least two explanations for this finding: a) relatedness brings critical feedback from others who are valued by a person, and that feedback leads to increased competence (31), and/or b) relatedness leads a person to try harder, especially when s/he wants to please others (32). It is not possible to deduce from this study which explanation (or others) might account for what was seen in WS. However, it was clear from reflections that Phage (and Chemistry) students were not as reliant on others. Instead, they most often reported their own abilities as leading to success: “I will not let failures and challenges stop me along the way... I can assure that I will not stop working to find more answers.”

Self-determination theory posits that autonomy is primarily important for self-determined behavior and fulfillment, with competence being a close second (9). In this study, WS students reported in reflections a general satisfaction with their courses and the program, yet they were most like other groups in terms of relatedness and least like them in terms of autonomy and competence (Table

3). While certainly unexpected in terms of the general principles of SDT, this finding is not contrary to all SDT research. In school settings in particular, students rarely feel autonomous (i.e., they report low autonomy) and can often be either overwhelmed or unchallenged by the curriculum (i.e., feel less competent). Under these conditions, a strong relationship (i.e., established relatedness) with others has been shown to stimulate student motivation and fulfillment (33). Evidence from this study suggests relatedness may have been a key motivational support for WS students, even though they felt less autonomous and often less competent than students in other groups (Table 3).

CONCLUSION

WS was developed to be more inclusive of students through active research opportunities and engagement in a STEM learning community. The purpose of this study was to determine differences between WS students and other science learners in terms of anxieties about college, feelings of belonging or isolation, anticipated and/or received supports, and personal habits related to college. After initial analysis, SDT was added as an interpretive framework, and the study was expanded to determine whether WS students’ satisfaction in terms of autonomy, competence, and relatedness differed from that of students in other courses. Although WS students felt less autonomous and

competent, they felt highly related, and these connections seemed to help them find fulfillment in the course and at the institution. This is an encouraging finding as institutions seek to develop inclusive STEM environments, since stimulating feelings of belonging is possible if the right conditions exist (5). Furthermore, building strong relationships (i.e., establishing relatedness) with others can be invigorating (33) and provides the needed support to overcome other deficiencies in basic need satisfaction.

Limitations

This study was small in scale and represents one institution's experience with a research-based, learning community model for increasing inclusivity in STEM. In addition, the exploratory approach and subsequent research design did not allow researchers to determine whether the living community or the WS course itself was most responsible for the positive results. Future studies will seek to disaggregate these factors. Furthermore, longitudinal data are being collected to determine how the program affects long-term retention.

The authors also recognize that resources at institutions vary, and implementing this model may be difficult for some institutions. However, while there is little doubt that living-learning communities and course-based research experiences come at a higher cost than traditional models, low retention rates also come at a cost of lost time, spent human energy, and missed opportunities (34). More initiatives and research in these critical areas is needed. It is the hope of the authors that this study positively contributes to the conversations surrounding recruitment and retention in STEM and helps other institutions develop programs that are inclusive of all students.

SUPPLEMENTAL MATERIALS

Appendix 1: Reflection prompts

Appendix 2: Bioinformatics survey questions

ACKNOWLEDGMENTS

We thank Brent Krueger, Graham Peaslee, Michael Pikaart, Matthew Hughes, Chelsea Payne, Sarah Brokus, Randall Wade, Frank Moen, Justin Shorb, Joseph Stukey, and Carrie Dummer for implementing these courses and programs and allowing their students to participate. We also thank the students who participated in this study. This research was supported in part by an institutional award from the Herbert H. and Grace A. Dow Foundation entitled, "Meeting the Persistent Challenges: Recruiting, Retaining, and Graduating Michigan STEM Students." Furthermore, the material is based upon work supported by the National Science Foundation under grants I616737 and I229585. Any

opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors declare they have no conflicts of interest.

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