Hidden Identities Shape Student Perceptions of Active Learning Environments

Jeremiah A. Henning[1]*[†], Cissy J. Ballen[2,3], Sergio A. Molina[2] and Sehoya Cotner[2]

[1] Ecology, Evolution, and Behavior, University of Minnesota, Saint Paul, MN, United States, [2] Biology Teaching and Learning, University of Minnesota, Minneapolis, MN, United States, [3] Biological Sciences, Auburn University, Auburn, AL, United States

Active-learning pedagogies represent one suite of tools commonly thought to promote greater classroom inclusivity. However, the social aspects of many active-learning techniques, such as in-class group work, may differentially impact students who feel pressure to conceal certain aspects of their identity, such as sexual orientation, political affiliation, or religion. We used a post-course survey of over 1300 students at a large midwestern University to ascertain which aspects of a student's identity are most salient in their experiences in active-learning environments, especially with respect to group work. Using path analysis, we show that students who are politically conservative, religious, or who commute to campus perceive lower inclusion in active-learning environments, while students who identify as queer report negative experiences in groups. These and other findings lead us to conclude that targeted efforts to improve classroom climate, such as equitable teaching strategies, will benefit students who might feel marginalized in peer-learning environments.

Keywords: hidden identity, active learning, gender, sexual orientation, political affiliation, religiosity, first-generation-college student

INTRODUCTION

Attempts to improve the representation of historically underserved groups within science, technology, engineering, and mathematics (STEM) fields include targeted national efforts to promote and retain students at the undergraduate level (e.g., Maton et al., 2012; Wilson et al., 2012; Hernandez et al., 2013; Snyder et al., 2016; Yeager et al., 2016). Among those efforts, science educators committed to using evidence-based teaching methods have turned toward a suite of evidence-based pedagogies in large-enrollment classes, typically characterized collectively as "active learning pedagogies," or ALP.

Active learning is based on constructivist learning theory and as such rests on the assumption that students *actively* construct—rather than passively acquire–their own knowledge by integrating new information with past experience and prior knowledge (Dewey, 1938; Vygotsky, 1963; Bruner, 1985). Under this broad umbrella, many pedagogies can be defined as active learning, e.g., games and simulations, worksheets, problem-based learning exercises, case studies, concept maps, and so on. However, in higher education, and in STEM in particular, much emphasis has been placed on the importance of the social, or interpersonal, aspects of active learning (Freeman et al., 2014). Emphasizing group work and its importance to individual learning has its roots in Vygotsky (1963) theory of social constructivism, whereby learning is initiated in a social context. Critically, social constructivism posits that learning relies on interpersonal interactions such as those promoted during in-class discussions and group work.

The inclusion of ALPs within STEM courses has rapidly increased over the last decade, due in part to national calls for change (Olson and Riordan, 2012), university programs and departments aimed at supporting active learning initiatives, and peer-reviewed journals focused on evidence-based biology education research (e.g., *CBE Life Science Education*) and curricular resources for active learning in biology (e.g., *CourseSource*). While empirical evidence highlights the value of ALP—from positive impacts on student performance and the reduction of achievement gaps in under-represented groups in STEM, to enhanced well-being and improved classroom social climate (Eddy and Hogan, 2014; Ballen et al., 2017) – the interpersonal aspects of many of these pedagogies by definition include social elements not present in the traditional lecture (Eddy et al., 2015; Cooper and Brownell, 2016; Freeman et al., 2017; Sullivan et al., 2018).

Within the social settings, students are often required to actively engage with other students and instructors and are often awarded points based on their ability to contribute ideas in class discussion or as members of small lecture groups. The interaction among students in these situations may heighten awareness of social identity differences among peers compared to traditional lecture courses where student social identity is relatively invisible to peers and the instructor. The heightened awareness of identity differences among students in a course may impact engagement and participation for minority-identity students, which will likely impact their science self-efficacy (Ballen et al., 2017) and sense of social belonging (Weaver and Qi, 2005; Aschbacher et al., 2010; Rocca, 2010). For instance, a students' gender, racial background, socio-economic status, and whether they are the first member in their family to attend college (i.e., first-generation students) can shape student-instructor interactions, willingness to speak up in class, as well as student aspirations for advanced degrees (Kim and Sax, 2009a; Aschbacher et al., 2010; Rocca, 2010). Thus, group work and other forms of class discussion may have unintended consequences for students with minority social identities by exacerbating feelings of isolation and reducing participation and intent to remain in a discipline (Rankin et al., 2014; Cooper and Brownell, 2016; BrckaLorenz et al., 2017).

While many aspects of social identity—such as race, cis gender, or physical disability—can be gleaned (or guessed) from external attributes, other aspects of individual identity can be invisible or hidden. We use the term *hidden identity* to refer to any personal, invisible descriptors of a person's identity that are not apparent—accurately or not—from outward appearance (**Table 1**, Vandrick, 1997; Quinn, 2006). However, we recognize that "identity" is itself a complex topic (e.g., Gee, 2000) and realize the facets of identity we present are not all-encompassing, nor do they exist apart from the multiple aspects of a student's identity we do not consider here. Rather, our emphasis is on "identities in practice," namely aspects of student identity that are most salient in the STEM classroom (e.g., Barton, 1998; Tan and Barton, 2008).

Hidden identities are unique from conspicuous identities in that individuals can choose to reveal hidden identity facets to peers and instructors or may choose to keep them hidden (Quinn, 2006; Cooper and Brownell, 2016; Hughes, 2018). When students working in groups drift into conversation not directly related to course content, such as how they spent their weekend, students with hidden identities must consider whether to reveal personal information about themselves that might lead to discrimination from their peers as a result of conscious or unconscious bias. The choice to reveal or conceal hidden identities is determined by a multitude of factors including the perceived social identities of peers and instructors, classroom climate, campus climate as well as intrinsic

TABLE 1 | Social identity facets included within our survey, hypotheses in how identity may impact experiences in ALPs with relevant citations.

Factors	Logic for inclusion	Relevant citations that describe factors' relevance to an active learning environment
Gender	Women may prefer active learning; gender ratios matter during group work; structured active learning may disproportionately advantage women. Gender-variant students may prefer to work alone and may be unwilling to engage ALP activities out of fear of misgendering	Rankin et al., 2014; Garvey and Rankin, 2015a; Cooper and Brownell, 2016; BrckaLorenz et al., 2017; Sullivan et al., 2018; Neill et al., 2019; Rainey et al., 2019
Race/ethnicity	Active learning may disproportionately benefit underrepresented minority students (URMs); psycho-social interventions benefit URMs.	Cohen, 2006; Haak et al., 2011; Ballen et al., 2017
Generation in college	Faculty-student interactions may vary by generation in college; psycho-social interventions disproportionately benefit first-generation college students.	Kim and Sax, 2009b; Soria and Stebleton, 2012; Stebleton and Soria, 2013; Harackiewicz et al., 2014
Political beliefs	Political conservatives may feel alienated and less likely to contribute in class in institutions that are perceived as dominated by liberal faculty and students.	Navarro et al., 2009
Religiosity	Religious conservatives are less likely to identify as scientists, and may be less likely to engage in discussions that could reveal or threaten their religious identities.	Rios et al., 2015; Barnes et al., 2017
Sexual orientation	Sexual minorities report feeling marginalized by their peers on campus and in classroom interactions; LGBT students exhibit disproportionately high attrition in STEM.	Garvey and Rankin, 2015b; Pryor, 2015; Cooper and Brownell, 2016; Garvey et al., 2018; Hughes, 2018
Commuter status	Students who live off-campus may feel less included in all aspects of the community, including classroom discourse and group work; commuters may be less open to diversity.	Pike, 2002; Jacoby and Garland, 2004

factors (Garvey and Rankin, 2015a; Cooper and Brownell, 2016). Suppression and concealment of identity may exacerbate feelings of exclusion and undermine the psychosocial gains often associated with ALP, however research on this topic has been mixed (Frable et al., 1990; Vandrick, 1997; Smart and Wegner, 1999; Cooper and Brownell, 2016). Further, we felt compelled to illustrate, for our colleagues, how multiple aspects of student identity—beyond the broad categories so commonly discussed, such as race/ethnicity and gender—may impact a student's willingness to engage in class activities, and may consequently impact student learning.

Here we used a survey of 1,305 introductory-biology students to quantify the relationship between twelve facets of student identities and student experiences of courses that implement social aspects of ALP. While ALP can represent a range of curricular elements (e.g., small group discussions and activities, online homework and quizzing and consistent formative assessment), we focus here on the interactive aspects of ALP (i.e., group work and student-faculty interactions). We chose to focus on these social aspects of ALP because of their broad implementation at our institution, and a general sense that the interpersonal nature of these pedagogies would be more likely to highlight identity differences. Specifically, we were interested in understanding how students' identities influenced: (1) science self-efficacy, (2) sense of belonging and participation in ALP courses, and (3) perceptions of campus and course climates. We implemented a voluntary, post-course survey across five introductory courses which included a number of questions related to student confidence in their ability to read and interpret scientific data (Ballen et al., 2017), student experiences interacting with peers and the instructor in the context of ALP, as well as student perceptions of institutional inclusivity.

METHODS

Participant Pool

Our student population included undergraduates at the University of Minnesota, a large, public, research institution in the upper Midwest, USA. Our work is restricted to a single institution with one cultural profile—predominantly white (63%), liberal, *outwardly* LGBTQIA-friendly, female-dominated (53%), and metropolitan (University of Minnesota Office of Institutional Research, 2019). In the present study, we investigated variables that influenced student perceptions of active learning by surveying students across 10 sections in five large introductory biology classes taken in spring 2018 by non-biology majors (**Table S2**). Surveys were administered as a larger post-course survey and student participation in the study was completely voluntary. Within these five courses, the amount and type of active learning pedagogies implemented differed and lecturing composed between 19.5 and 54.8%, on average, of class time (Petra Kranzfelder, pers comm). While we did not directly ask students about implemented ALPs within their courses and percentages used, all courses implemented small-group discussions and activities, a classroom response system (app-based, devices, or notecards), consistent formative assessment, online homework and/or quizzing. None of the

courses were fully-flipped or relied solely on problem-based learning or case studies. Next, a third-party individual, not involved in the course or this research, matched student survey responses to institutional data on student gender, race/ethnicity, age, and incoming academic preparation (American College Test, hereafter ACT). In a few cases ($N = 13$), student self-reported gender misaligned with the information we obtained from the institution. In these cases we used self-reported gender. Survey items and methodology were granted an exemption from full review by the University of Minnesota's IRB, #1405E50826.

Study Design and Questionnaire Development

Student Experiences Within ALP Courses

We asked students to complete a survey that related to their experiences in ALP courses, with a focus on their interactions with peers and the instructor (**Table S1**). Because no research-validated inventory exists to address the specific questions we had related to perceptions of the social elements of active learning, we designed a survey to reflect the most relevant themes, and validated the survey through exploratory factor analysis (**Tables S1**, **S3**) and principle component analysis (**Tables S4**, **S5**). Themes included group interactions (e.g., "In group work, my enjoyment is impacted by the members in my group."), peer dynamics (e.g., "I feel students will judge me if I express my true identity within the classroom."), student-instructor dynamics (e.g., "I feel comfortable having personal conversations with the instructor(s) in this class."), and general preference for ALP courses over traditional lecture ("e.g., I enjoy the active learning classrooms more than traditional style lecture classes.") (for full questionnaire see **Table S1**). We asked students to rate the extent to which they agreed with statements on a 1–7 Likert scale ranging from strongly disagree to strongly agree. Additionally, we explored elements of science self-efficacy because of its demonstrated influence on student retention and performance in different educational contexts (Chemers et al., 2011; Ballen et al., 2017).

Student Identities

Following the *Perceptions of ALPs* survey, we asked students to provide their ethnicity, sexual orientation, gender identity, religiosity, spirituality, political affiliation, the size of the community they grew up in, how far they commute to campus, whether they live alone, with families, or with roommates, whether they are a first-generation college student, were internationally born, or are part of a historically under-represented group in STEM disciplines (**Tables 1**, **2**). At the end of the survey, we asked three open-ended questions to explore experiences and challenges they face within ALP courses, and how their identities shape interactions with peers and/or instructors within ALP courses. From these qualitative responses we categorized themes from select individuals that highlighted the multi-dimensional dynamics of student identities and how multiple identity facets shape ALP engagement. Further, these open responses served to confirm whether we had, in fact, included the most salient—to the students—identities in our constrained-choice options.

TABLE 2 | Identity facets and categories of each facet.

Identity facets	Categories
Community size	**Urban (252)**, Suburban (411), Rural (105)
Commuter Status	**On campus (467)**, Within 1 mile (174), Within 5 miles (33), Within twin cities (57), Outside (39)
Ethnicity	American Indian (11), Asian (89), Black (44), Hawaiian (2), Latinx (37), **White (587)**
First-generation student	Yes (154), **No (616)**
Gender Identity	**Cis male (283)**, Cis Female (481), Non-binary (2), Neutral (2), Trans (2)
International born	Yes (7), **No (763)**
Living situation	**Live alone (60)**, Live with roommates (612), Live with family(98)
Political affiliation	Very conservative (24), Conservative (123), Middle of the road (154), Liberal (270), **Very liberal (93)**, Not political (86), Other (20)
Religiosity	Very religious (61), Moderately religious (190), Slightly religious (216), **Not religious (257)**, Not sure (46)
Sexual Orientation	Asexual, Bicurious (8), Bisexual (31), Gay (18), Lesbian (0), Pan, Queer (3), **Different Sex (straight) (690)**, Other (8)
Spirituality	Very spiritual (85), Moderately spiritual (200), Slightly spiritual (240), **Not spiritual (172)**, Not sure (73)
Under-represented group	Yes (94), **No (676)**

Bolded categories were the categories against which comparisons were made. For instance, when trying to understand how the size of community shaped how students responded to questionnaire items, we compared suburban and rural responses to students from urban areas.

Data Analysis

All statistical analyses were conducted in R version 3.3.2 (R Development Core Team, 2016) and RStudio version 1.0.44 (RStudio Team, 2015), with packages cited where applicable. From our initial pool of 1,305 participants, we omitted any participants that did not respond to all survey items, leaving us with 976 total participants. In order to simplify our analyses and to explore patterns in how respondents answered questions, we performed a maximum-likelihood exploratory factor analysis using the *factanal* function with a varimax rotation. To determine the proper number of factors to include within our factor analysis, we used the *nScree* function (*nFactors*, Raiche and Magis, 2015). and *vss* function (*psych,* Revelle, 2016) as two independent measures of numbers of factors to include. We found that both Velicer's minimum average partial test and parallel analysis tests converged on the retention of 8 factors. Final factor groupings were determined based on Comrey and Lee (1992) criteria; we rejected any factor loading <0.5 (**Table S3**). Because our eighth factor did not have any components that passed the Comrey and Lee criteria, we were left with a total of seven factors (**Table S3**).

Overall, factor groupings seemed to conform to logical themes within our survey questions (**Tables S1, S3**). For instance, our first factor consisted of 11 questions related to the participant's level of confidence in their ability to do tasks related to science, which we termed "science self-efficacy." Survey questions consisted of self-reported student confidence in their ability to evaluate science literature, analyze graphs and figures, develop hypotheses, design an experiment, analyze data, and draw conclusions with the results; this factor explained 15% of the variation within our questionnaire data. Factor 2, "pressure to conform," grouped survey questions together that asked students the extent that they think about the identity of others as well as their own in class, fear judgment from peers and instructors

for expressing their identity or opinions in the classroom, and feel the pressure to conform to peers and instructors within the classroom; this factor explained 12% of variation in questionnaire data (**Table S1**). The third factor, "sense of belonging in the class," explained an additional 9% of variation and the questions related to student comfort with having personal conversations in class, enjoyment of those personal connections with both peers and instructors, and perceived valued as a unique individual in the classroom. The fourth factor related to student "preference toward ALP courses" and included survey questions about enjoyment of active learning, learning experiences and comfort in ALP courses relative to traditional lecture courses and explained 6% of questionnaire data variation. The fifth factor related to "active learning courses as a community" and combined survey questions exploring the perceptions of being part of student-led learning communities in ALP courses; this factor explained 5% of data variation. The sixth factor, "science as a career," explained 4% of questionnaire variation and was related to student interest in taking more science courses and pursuing a career in science. The final factor was related to ALP courses highlighting differences in gender, sexual orientation, socio-economic status, religious, and cultural backgrounds among peers and explained 4% of questionnaire variation (**Tables S1, S3**).

To reduce the number of statistical models we ran, we created composite outcome measures with the results of our factor analysis using principal component analysis (PCA). For each of our seven factors, we conducted a PCA using the *rda* function (*vegan*, Oksanen et al., 2015), then we extracted scores of the first principal component to serve as our composite outcome measure (Results in **Tables S4, S5**).

To understand the relationship of facets of student identity and outcome measures, we constructed multiple regression models using our 12 facets of identity to explain all outcome measures (Summary statistics in **Table S6**). In addition to the

seven composite outcome measures, we also constructed multiple regression models on seven outcome measures from our survey questions that did not cluster with other outcome measures in our factor analysis (**Table 3**, **Table S1**), for a total of 14 outcome measures. From these full models, we used a multi-model inference and model averaging (Grueber et al., 2011) to determine which identity facets best predicted outcome measures, using the *dredge* function in the *MuMIn* library (Grueber et al., 2011).

We used the final averaged multiple regression models to parameterize a path model to better explore the relationships among identity facets and to understand how a student's multidimensional identity shapes perceptions to ALP courses. We performed multilevel path analysis (Shipley, 2009, 2013) using the *piecewiseSEM* package (Lefcheck, 2016). Our initial path model included all the identity facets that were retained within the final multiple-regression model for all 14 outcome measures. Next, we tested for goodness of fit using the d-separation test (Shipley, 2009), derived an AIC score from Fisher's *C* statistic (CIC) (Cardon et al., 2011; Shipley, 2013), and extracted path co-efficients from models which fit using the *sem.fit* function. Next, we fit additional paths and removed non-significant paths from our model based on estimates of path strength using a step-wise fitting procedure. To improve model fit, we added correlated error terms between several outcome measures (for example: Pressure to conform to the views of peers and instructors & sense of belonging among peers in class, see **Table S7** for full list of correlated error terms). From our best fit path model, we report standardized path coefficients, calculated *p*-values using the Kenwood-Roger method (Lefcheck, 2016), and the variation explained by our fourteen regression models (Nakagawa and Schielzeth, 2013). To simplify results, we removed four outcome measures from our analysis (Inclusion—Course community, Science as a career path, distractions in ALP courses, importance of group selection) due to low explanatory power of the identity facets ($R^2 < 0.02$, Full model fit results can be found in **Table S8**).

RESULTS

Identity Facets as Predictors of Outcome Measures

We set out to investigate how different facets of student identity impact outcome measures in classrooms that use active learning, such as sense of social belonging and the extent to which groups shape enjoyment in class. To understand which identity facets predicted our seven outcome measures, we first constructed full multiple regression models which included all 12 identity facets and used multi-model inference and model averaging to determine the identity facets that predicted each outcome measure. Overall, we found that each of our identity facets was a significant predictor for at least one of our outcome measures (**Table 3**). While no identity facet was retained in all 10 outcome measures (**Table 3**), it was apparent that certain identities impacted student perceptions in active learning environments, which other identities played less of a

TABLE 4 | The total amount of variance explained by identity facet predictor variables within our best fit piecewise path model.

Outcome measure	n	R^2
Science self-efficacy	768	0.05906
Pressure to conform	770	0.10838
Sense of belonging in ALP courses	770	0.03139
Preference toward ALP courses	770	0.04233
Awareness of identity differences in ALP courses	770	0.03542
Institutional Inclusion	770	0.06714
Preference to work alone	770	0.03992
Group identity enjoyment	770	0.1099
ALP courses more inclusive	770	0.05663
Comfort speaking in class	770	0.06336

See **Table S1** for detailed explanations of these constructs.

role in reported outcome measures. For example, being from a historically under-represented group and commuter status was retained in 6 of 10 multiple regression models (**Table 3**). Internationally-born and first-generation college status were identity facets that were retained in 5 of 10 regression models; gender identity, ethnicity, religiosity, spirituality, and political affiliation were retained in 3 of 10 regression models. We found that sexual orientation was retained in 3 of 10 models and finally, the size of the community the student grew up in was retained only in a single regression model (**Table 3**). All of our outcome measures were predicted by multiple identity facets, confirming that student perceptions of ALP courses are driven by multi-dimensional aspects of student identity, including often-overlooked "hidden" identity facets.

Path Models to Understand Multidimensional Student Identities

We used the final averaged multiple regression models to parameterize a multi-level path analysis model to better explore the relationships among identities. Overall, our identity predictors were able to explain 3.5 to 11 % of the variation of outcome measures (**Table 4**). Similar to the multiple regression results, we found that all 12 identity facets were significant predictors for all 10 outcome measures, however *which* identity facets are significant and their relative strength differed depending on the outcome measure considered (**Figure 1**, **Table S9**).

Gender

Overall, we found gender identity was a significant predictor in four of our outcome measures: (1) a student's pressure to conform to the views of peers and instructors in ALP courses, (2) the identity of the group shapes the enjoyment of group work, (3) ALP courses are more inclusive than traditional classes, and (4) classes using ALP highlight identity differences among peers. However, the directionality and relationships were somewhat surprising. For instance, cis-females reported lower pressure to conform, a lower sense of identity differences, and that ALP courses are more inclusive, relative to their cis-male
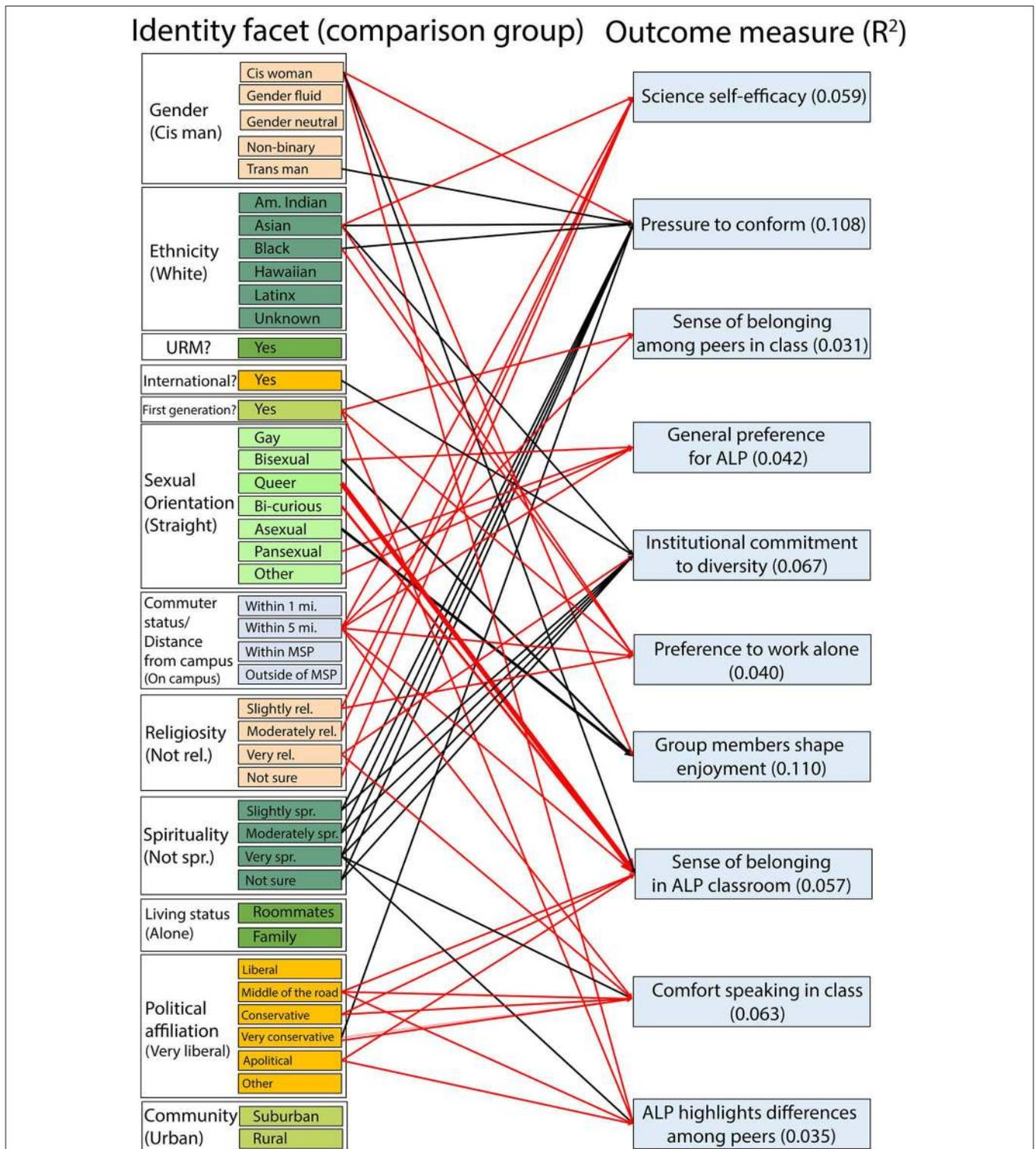
FIGURE 1 | Multiple identities influence student perceptions of active learning environments. Our best path model (AICc = 781.344, Fisher's C_{60} = 214.12, p = 0.998, **Figure 1**) included 10 of 14 outcome measures, four of which were removed because of low explanatory power with our identity facets. This model illustrates significant negative (in red) and positive (in black) associations between student identities (e.g., gender, spirituality) and perceptions of active learning, such as whether group work shapes their enjoyment in the course, or whether they prefer active learning classes. Additionally, we created a series of subset versions of this figure to highlight how gender identity (**Figure S1**), first generation college students (**Figure S2**), religiosity and political affiliations (**Figure S3**), and sexual orientation (**Figure S4**) shape perceptions of active learning environments. Lines are weighted to denote the strength of the association (i.e., by path coefficients).

counterparts. These differences may be due to the female-positive climates of these female-dominated biology classrooms. Future work would profit from close examination of whether survey items vary in different environments, such as those that are cis-male dominated and stereotyped (e.g., computer science courses). Conversely, gender-variant students (gender neutral, fluid, non-binary, trans identifying) often reported higher pressure to conform to the viewpoints of their peers and instructors and a lower feeling that ALP courses are inclusive relative to cis-gender peers, although these relationships were not all significant (**Figure S1**); however, our ability to interpret these results is limited by the low number of students reporting as gender-variant.

Ethnicity

Ethnicity was retained as a significant predictor within four outcome measures: (1) science self-efficacy, (2) pressure to conform to the views of peers and instructors, (3) institutional sense of belonging, and (4) preference to work alone. Specifically, Asian students (Asian-American and internationally born) reported lower science self-efficacy and higher pressure to conform to the views of their peers and instructors, but also a higher institutional sense of belonging and lower preference to work alone in ALP courses, relative to white peers (**Figure 1**). Black students reported higher pressure to conform to the views of their peers and instructors and lower preferences to work alone in ALP courses relative to white students (**Figure 1**). We did not observe significant differences in perceptions or attitudes of ALP courses among other ethnic groups within our sampled population, however we may have been limited by low sample size.

First Generation College Students

Students that reported as first-generation had a lower sense of belonging in classes relative to peers from continuing-education

families (**Figure 1**, **Figure S2**). First-generation students also reported lower preference to work alone and were less likely to report that ALP courses highlighted differences among peers relative to students from continuing-education families (**Figure S2**). Additionally, retained within our best-fit model, first-generation students also reported lower science self-efficacy and a lower preference for ALP courses relative to continuing education peers, although these differences were not statistically significant (**Figure S2**, **Table S9**).

Sexual Orientation

Self-reported sexual identity shaped student perceptions and attitudes of ALP course inclusivity, enjoyment of working in groups, and preference toward ALP courses over traditional-style courses. For instance, students reporting as queer or bi-curious were less likely to say that active learning courses were more inclusive relative to their heterosexual, liberal, on-campus peers (**Figure 1**, **Table S9**). Students reporting as bisexual and pansexual reported a lower preference for active learning courses relative to their straight or heterosexual peers (**Figure 1**, **Table S9**). Students reporting as bisexual and asexual were more likely than their peers to report that group identity shapes their enjoyment in ALP courses.

Religion and Politics

Conservative and political leanings were critical factors that predicted a students' comfort speaking in class, their view of course and campus climate, a pressure to conform to the views of peers and instructors, and science self-efficacy. For instance, highly religious and conservative students reported less comfort speaking in ALP courses relative to non-religious and very liberal peers (**Figure 1**). Additionally, students reporting as very or moderately religious had lower science self-efficacy and a lower institutional sense of belonging relative to non-religious peers. Conservative students were less likely to report

TABLE 3 | Predictors retained (blue) within multi-model fitting of 10 multiple regression models that predicted outcome measures that were within 4 AIC score units.

	Gender	Ethnicity	URM	International-born	1st generation	Sexual orientation	Commuter status	Religiocity	Spirituality	Living status	Political affiliation	Community
Science self-efficacy		■	■		■		■					■
Pressure to conform	■	■							■		■	
Sense of belonging				■	■		■					
Preference toward ALP courses		■	■	■	■							
Awareness of identity differences		■	■		■			■	■			
Institutional inclusion			■	■				■				
Preference to work alone	■	■	■			■				■		
Group identity enjoyment	■	■	■					■		■	■	
ALP courses more inclusive			■			■		■			■	
Comfort speaking in class	■	■			■			■			■	

We used the retained predictor variables (blue) to parameterize our initial path model.

ALP courses as more inclusive and felt stronger pressure to conform to the views of peers and instructors than very liberal students (**Figure 1**, **Table S9**). Future work on this topic may highlight the context-dependent nature of these results; because the current study took place within the Midwest United States, highly religious or conservative students constitute a minority of the student population.

Commuter Status

Commuter status was retained as a significant predictor within six outcome measures (**Figure S5**). Relative to on-campus living peers, commuters had a lower science self-efficacy, lower sense of belonging among peers, lower preference for ALP courses, lower comfort speaking in class, but a lower preference to work alone in ALP courses (**Figure S5**). However, much of our significant commuter relationships were driven by commuters living within 5 miles from campus. The patterns observed within these short-distance commuters were not always observed within long-distance commuters, however we also had significantly fewer long-distance commuters (**Figure S5**).

Multi-dimensional Identities Through the Eyes of the Students

We provided open-ended questions for students to report how their identity facets shape their interactions with peers and instructors in ALP courses. Specifically, we asked students to describe how aspects of their identity impact their experiences in class. Overall, our student responses further highlight the multi-faceted nature of student identity and how those identities shape peer and instructor interactions within ALP courses (**Table 5**). Within the 200 participants that provided answers to the open-ended questions, we found culture, language, and ethnicity differences (23/200 participants) and religiosity (20/200 participants) were the two most commonly reported identity facets that shaped student interactions with peers and instructors. Additionally, socio-economic status (10/200), sexual orientation and gender identity (10/200), political affiliation (11/200), first-generation college status (6/200), growing up in a rural environment (8/200), and commuter status (2/200) were also reported by multiple students and were often reported together (**Table 5**). Although not considered within our initial study design, multiple students reported that differences in mental health strongly shaped their interactions with peers and instructors within ALP courses (**Table 5**). These student responses highlight the importance of student mental health struggles, which may be impacted in group learning environments that require interactions with peers.

DISCUSSION

Many faculty trained in inclusive pedagogy have likely encountered the "iceberg model" of cultural diversity, in which the bulk of an individual's identity is determined by sub-surface—or hidden—aspects such as beliefs and values (Hall, 1976; Vandrick, 1997). Our findings support the iceberg model in the context of student diversity, and confirm that not only are our students characterized by multiple visible and hidden identities, but these aspects of identity influence student perceptions in our courses. We can confirm some trends previously documented for students identifying along established race and gender spectra: black students are less likely to feel institutional inclusion and more likely to feel pressure to conform in groups (Thompson, 2004; Johnson, 2012; Booker, 2016; Boston and Warren, 2017), women prefer to work in groups (Kuhn and Villeval, 2011, 2015) and feel less comfortable speaking in class (Eddy et al., 2014; Ballen et al., 2018; Neill et al., 2019); and international student status predicts a greater awareness of identity differences in the classroom (Schmitt et al., 2003; Popov et al., 2012; Glass et al., 2015; Heng, 2017).

We advance the dialogue by highlighting how identities influence perceptions of interpersonal aspects of ALP. For example, students who commute to campus, those who are politically conservative, and those who are highly religious report lower sense of inclusion in courses that employ ALP (Navarro et al., 2009). Further, in many cases, these hidden identities hold more sway over student perceptions of active learning than previously assumed (Vandrick, 1997). Gender and sexual orientation serve as potent examples, whereby group work negatively impacts the enjoyment of queer students, and asexual and bisexual students prefer to work alone rather than in groups. These findings echo recent work demonstrating that, in ALP settings involving group work, LGBTQIA students felt an increased sense of these minoritized identities (Garvey and Rankin, 2015a; Cooper and Brownell, 2016; Garvey et al., 2018), and suggest mechanisms that may contribute to the lower retention of sexual and gender variant minorities in STEM (Garvey and Rankin, 2015a; BrckaLorenz et al., 2017; Garvey et al., 2018; Hughes, 2018). We thus question the idea that group work is a pedagogical panacea to the large-lecture problem. Faculty seeking to create a welcoming environment for all students should note the complexities of student identities in their classroom, many of which are not outwardly visible or outward appearance may not match internal identity.

We envision several research priorities stemming from these findings. First, our work is restricted to a single institution with one cultural profile—predominantly white, liberal, *outwardly* LGBTQIA-friendly, female-dominated, and metropolitan. At different institutions, with different profiles (e.g., minority-serving, conservative, rural), we may see different student identities emerge as predictive of engagement in active-learning settings. Given that sense of belonging, and subsequent performance and retention, are often affected by minoritized status, we predict that student concerns will vary as a function of institutional culture. For example, it is possible that URM students would approach active learning differently at a minority-serving institution where they are less likely to feel marginalized for their racial or ethnic identities. Further, our analysis did not include an exploration of interaction effects, although we are confident that intersectionality will be a key feature of this narrative. In fact, many of the student comments (**Table 5**) are difficult to assign to a single category of identification (e.g., "My disability and Christian faith has made it harder for me to express my opinion in the classroom…"). Thus, the impact of combined marginalized identities should be explored in future work.

TABLE 5 | We asked students which of their "*hidden identities*" influence social learning environments, and to describe in detail how those identities impacted experiences with peers or the instructor(s) in the classroom.

Facet of student identity	Example comments		
Religion ($n = 20/200$)	My identity as Christian makes people put up walls against me even though I would consider myself on the liberal side of things	There seems to be an all around negative perception of anyone with a faith.	My disability and Christian faith has made it harder for me to express my opinion in the classroom, due to my fear of being judged.
Political affiliation ($n=11/200$)	I feel as if this generation of college students try to shut down conservative viewpoints, which makes it hard to speak up,	My extreme conservative views are often looked down upon by those in the scientific community	I am more conservative so sometimes hearing certain things that do not exactly align with some of these views is difficult to adjust to
Sexual orientation/Gender identity (10/200)	Being transgender influence the experience I have with other students and with interactions with my professor. At times I feel the need to hide this part of myself.	As a bisexual woman in a relationship with another woman, sometimes I find it difficult to tell people about my relationship without being worried about judgment or losing friends	I get misgendered constantly
First Generation (6/200)	I am a first generation student so I sometimes feel that I have a lot to prove to myself and my family. I want to show them that this was the right decision.	I'm a first generation college student and that can sometimes be difficult but overall I feel comfortable in school	First generation in family to attend university because I sometimes don't know what to expect
Commuter (2/200)	The difference in commuter and the students who lived on the campus. Sometimes it's hard for me to study as a group because I can't stay with them and I don't know much people who can share their experiments with me.	I feel like I can't relate very well with my peers because I don't live on campus. People would talk about going to certain places after school and all that fun stuff, but I don't feel that I fit in because I go straight home after school because it's a long ride home (I use the bus). I prefer to waste little time.	
Culture/language/ethnicity (23/200)	Cultural identity, in China teachers are very strict and make me stress out, so I kind of afraid of asking questions to a instructor.	Usually cultural identity (being Indian) sometimes brings out stereotypical ideas and comments	As a minority I don't feel as accepted first hand especially with more attention in the lab setting. I feel underlying biases in the ways people treat or approach me; like they might be more cautious and less open unless I initiate first
Socioeconomic (10/200)	Due to my upbringing, culturally and through my family's socio-economic status, there have been many times where I have felt alienated and can't relate to many experiences. At these times, it can be hard to find simple common ground from someone who has lived so differently. Additionally, there have been cases of microaggressions or just ignorance of thought that have been offensive. And this all contributes to a distraction from what I'm in the classroom for- to learn.	I often cant afford classroom necessities and that's embarrassing to bring up	Being half black always puts you lower than those around you socially and economically.
Mental health (6/200)	My struggles with mental health most impact my experiences with my peers because they impact my academics but I do not feel comfortable explaining them to my instructors or peers	Social anxiety makes it difficult to learn in an active learning class.	I struggle with ADHD, as well as anxiety and depression Overcame a pretty bad drug addiction
Rural(8/200)	My identity as being African American, a first generation student, and upbringing in a rural community, and being a female makes my peers see me as undeserving to be in such upper-level college courses. I have to talk a certain way just to fit in because I'm from the South.	My cultural identity and upbringing in a rural area have effected certain views that I have and how people perceive where I have grown up based on how I look.	I come from a rural background, specifically a farm and it makes me sad how little about agriculture and the culture surrounding food and farms is taught.

We pulled three specific examples from the most common facets of student identities reported out of 200 total respondents. The most common include religion, political affiliation, sexual orientation and gender identity, first generation college attendees, commuters, culture and language, socioeconomic status, race/ethnicity, rural upbringing, as well as mental illness, which was not a targeted focus of our study but a barrier reported by some students.

Altogether, the twelve identity predictors explained anywhere from 3.5 to 11 % of the variation of outcome measures. This suggests that any individual identity facet explained anywhere from about 1–3% of the variation in an outcome measure which is inline within previous studies that have reported the effects of a single identity facet like: gender identity, students identifying as an URM, socio-economic status, first-generation students, age, science self-efficacy (Ballen et al., 2017) and academic performance (Gilardi and Guglielmetti, 2011; Richardson et al., 2012). The low predictive power of our identity facets reinforces the idea that student perceptions of small-group dynamics, interactions with peers and instructors, comfort speaking in courses, and science self-efficacy are not wholly determined by these broad identity groupings. While a shared ethnic, gender, political affiliation, or sexual orientation may provide us some insight into challenges faced by our students, ultimately, our students are complex, multi-faceted, with unique past experiences that will fully shape their perceptions of courses that use ALP. For instance, student motivational factors and specific personality traits (Richardson et al., 2012), access to social support (Baker, 2013) as well as other external pressures, like maintaining employment (Gilardi and Guglielmetti, 2011) can exert stronger influence than inclusion in broad gender, ethnicity, URM, or first-generation groupings.

Future research would also profit from exploring the impact of established equity interventions on students' multiple identities. For example, affirmation exercises have demonstrated success with improving the performance of students from certain underrepresented racial and ethnic groups (Cohen, 2006), women (Miyake et al., 2010), and first-generation college students (Tibbetts et al., 2016). These affirmation exercises could thus be explored as a possible belongingness intervention for lowering the barriers perceived by students with other non-dominant or marginalized identities—non-traditional students, LGBTQIA students, commuters, etc. Similarly, role-modeling interventions, designed to introduce diverse student populations to scientists from diverse backgrounds, have been successful (Schinske et al., 2016; Barnes et al., 2017; Holt et al., 2018); broadening the reach of these interventions, and being intentionally inclusive of some of the hidden identities discussed herein (e.g., political conservatives, LGBTQIA students) may serve to help more students feel included during in-class activities.

Group work itself—the cornerstone of many transitions to active learning (Prince, 2004; Michael, 2006; Freeman et al., 2014) —should be critically evaluated from the standpoint of multiple student identities. Many active learning techniques rely on students collaborating in small groups, either in or out of class. These techniques include Process Oriented Guided Inquiry Learning (POGIL; Thomas et al., 2008) and team-based learning (TBL; Jeno et al., 2017), possibly in the context of the flipped classroom (Baepler et al., 2014; Betihavas et al., 2016). While the benefits of small-group learning, especially for women (Lewis et al., 2016; Sullivan et al., 2018; Neill et al., 2019), have been documented, less attention has been paid to students who may feel their identities put them at a disadvantage in small groups. An exception includes Cooper and Brownell's (2016) work with LGBTQIA students, in which they document the social anxiety triggered by group work in some sexual minorities. Specifically, students are not compelled to "out" themselves in the traditional large-lecture setting, but the nature of informal group discussions can demand more personal sharing—revelations that can be stressful. Similarly, our work suggests that religious students and politically conservative students may feel less comfortable sharing ideas in classes that emphasize evolution (often considered at odds with religious doctrine; Pobiner et al., 2018) or climate change (the acceptance of which is generally aligned with more liberal ideologies; McCright and Dunlap, 2011; Walker et al., 2017). And group work that requires in-person, out-of-class commitments may be especially difficult for non-traditional students, commuters, or those with full-time work responsibilities.

Preparing for Group Work

The best practices for implementing group work will necessarily consider inclusion and equity from multiple perspectives. We have compiled a number of suggestions that can help instructors prepare implementing group work in their classroom. A good start may simply involve designing groups in ways that minimize anxiety: assign students to groups, rather than permit them to self-assort, to reduce anxiety and feelings of marginalization (Englund, 2018); create a pattern of expected student and instructor behaviors to reduce anxiety (McCroskey, 2009); avoid cold-calling on individual students and instead opt for a transparent—possibly random—method of calling on groups, ideally after time for discussion (Rocca, 2010); and be clear about course expectations (Neer, 1990; Zhang and Zhang, 2005). However, future work should explore the effectiveness of these anxiety-reduction strategies in improving the engagement of *all* students in ALP.

LIMITATIONS

Our conclusions are limited by the singular focus of our study—one large research institution in the upper Midwest. Our findings are restricted to students in introductory-biology courses. We did not include other aspects of social identity or personality traits within our survey items (Rocca, 2010). For example, we did not ask about student abilities, but would certainly do so in future surveys. We did not explore interactions and intersectionality between identity facets and perceptions of active learning. And, even though all surveyed students were in ALP courses, some of these courses were offered in technology-enhanced active-learning classrooms (Cotner et al., 2013), and some were not. Thus, we cannot be sure that all students interpreted survey prompts the same.

While we were interested in understanding how students' identities were influencing their experiences in ALP courses, our questionnaire items did not allow us to asses or understand processes of student identity development (Waterman, 1999; Morgan, 2013; Cooper and Brownell, 2016), meaning making and the influence of the ALP experience on identity development (Singer, 2004; McAdams and McLean, 2013). To assess these

aspects, we would need to collect richer open-ended qualitative data, allowing students to describe their experiences in ALP courses. As such, our findings provide baseline data indicating differences in attitudes in ALPs among different social identities, which will inform qualitative data collection in follow-up studies.

Additionally, since all courses implemented ALPs in some capacity, we are really not able to disentangle differences between ALP courses and traditional lecture style courses in terms of classroom climate, comfort, and perceptions of ALPs and how identity shaped those relationships. For instance, gender-queer, politically conservative, and commuters were more likely to report that ALP courses were less inclusive, however it's unknown whether students were drawing on experiences in this course, all their courses, or overall campus climate. Follow-up studies could attempt to disentangle certain aspects of ALP courses are less inclusive for these individuals by addressing certain ALPs specific to these courses. Additionally, we also did not specifically test for differences in course logistics (e.g., class size, seating structure, time of day) within our analyses, however we did account for differences among courses broadly by including course as a random effect within our mixed-effect models. Finally, we invite researchers to implement similar questionnaires across a range of geographically, politically, and culturally diverse institutions to understand how campus climate and social identities shape student perception of ALPs.

CONCLUSIONS

Regardless of limitations, these findings should alert our colleagues to several key implications: (1) our students are multi-faceted individuals, with many sub-surface aspects of identity; (2) these complex identities result in complex perceptions of ALP, and well intentioned faculty may repel the very students these pedagogies are designed to attract or retain; (3) no single classroom tactic is likely to be effective for all of our students, thus we echo previous calls for diverse pedagogies to reach diverse student populations; and (4) national and global initiatives to promote diversity in STEM should consider diversity broadly, and realize that our collective goal is unlikely to be a "one-size-fits-all" pedagogy.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Minnesota IRB approval #1405E50826. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JH, CB, and SC conceived, designed the questionnaire, and wrote the manuscript. SM and SC collected and organized data. JH and CB analyzed data. All authors reviewed drafts of the paper and gave final approval for publication.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2019.00129/full#supplementary-material

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