A Critique of the Commonly Used Approach to Study the Effectiveness of Technological Interventions for Raising Students' Sense of Belonging

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Abstract: In this article, the authors critique the common approach used to study the effectiveness of technological interventions for raising students' sense of belonging. Two studies are reviewed, one used Facebook groups and the other used a makerspace. Both studies primarily failed to include any variable that measures the extent of student involvement in the use of the applied technology. Future research could be extended to overcome this drawback and/or to provide students with an active role, if possible, in designing part of the intervention.

Keywords: sense of belonging, Facebook group, makerspace, t *test, use of technology*

College efforts using psychological interventions to raise students' sense of belonging have been found to improve not only (minority) students' academic performance but also their well-being and health condition over three years (Walton & Cohen, 2011). Given these findings, the effectiveness of various interventions (e.g., psychological interventions (Walton & Cohen, 2011), social-emotional interventions (Costello et al., 2022), curricular interventions (Harben & Bix, 2020; Mendoza & Venables, 2023; Stoddard, 2022), ecological interventions (Burk & Pearson, 2022), and technological interventions (Andrews et al., 2021; Sheeran & Cummings, 2018), that could impact students' sense of belonging is worth investigating.

Prior studies on technological interventions' effectiveness have primarily used the snapshot approach, which involves comparing a treatment group with a control group (e.g., in Sheeran and Cummings (2018)) or comparing the pre- and post-intervention conditions of the same sample (e.g., in Andrews et al. (2021)). The effectiveness is then interpreted from the mean value of the measured variable(s) obtained from across groups by survey or between pre- and post-surveys conducted on the same sample at the designated level of statistical significance. But this approach has two major drawbacks.

First, how much effort the students put into an intervention is entirely or at least partially ignored. At the same time, the corresponding effectiveness associated with different levels of student effort cannot be investigated. The effort invested by different student populations (e.g., sorted by gender, race, year in their study program, etc.) can vary. It would be helpful to build a measure of their effort in the interventions and associate this with a measure of their sense of belonging. Second, the interventions investigated have often been passively imposed on the students, for instance, by attaching a Facebook group to a course (Sheeran & Cummings, 2018) or requiring/strongly encouraging students to visit a makerspace (a collaborative workspace) to complete course assignments (Andrews et al., 2021).

An individual's creation of a sense of belonging to a system/environment calls for his/her experience of personal involvement in that system/environment (Hagerty et al., 1992). Opportunities

for interaction, among other factors, can also play a role in sense of belonging development in the individual (Ma, 2003; Winter-Collins & McDaniel, 2000). Leach (2005) assembled related views from earlier literature, including Butler (1993), Fortier (1999), and Riger and Lavrakas (1981), provided evidence that people develop a sense of belonging to a place/space (e.g., a neighborhood) via their active and passive participation, in addition to forming social networks and social interactions. Young et al. (2004) confirmed that interaction and participation are two of the factors affecting an individual's complex psychological and physical understanding and interpretation of a neighborhood, which are critical for his/her formation of a sense of belonging in that environment.

These findings also have relevance to the academic environment. Meeuwisse et al. (2010) found a positive relationship between an active learning environment, peer and teacher interactions, and students' sense of belonging. We believe students' sense of belonging would substantially increase if they were allowed to participate in designing the interventions meant to enhance it (which is a relatively higher level of interaction and active participation, compared with interventions without this designing component).

In this article, we review two recent exemplary studies, in which a technological intervention has been used to enhance student outcomes (e.g., connectedness, engagement, self-efficacy, and sense of belonging), although we limit our critique to an exploration of the interventions' effects on sense of belonging. Sheeran and Cummings (2018) explored whether attaching a Facebook group to a course increased students' sense of belonging. On the other hand, Andrews et al. (2021) studied whether requiring or strongly encouraging students to use a makerspace to complete their course assignments helped increase the students' sense of belonging to the makerspace and to the community of their specific field of study on their campus. We compare the two studies focusing on their strengths and weaknesses (see Table 1) and provide recommendations for future studies.

Table 1. Summary of the Two Articles Reviewed in this Critique, with Respect to Students' Sense of Belonging.

Criterion	Sheeran and Cummings (2018)	Andrews et al. (2021)
Definition of sense of belonging	The authors did not define sense of belonging.	"An individual's self-perception of fit" (p. 2)
Intervention	Use Facebook groups (and associated social media sites) to support the delivery of course information, formal and informal discussions, and reminder of deadlines	Assign a makerspace-based project in engineering courses
Study sample	$N = 471$ students at a large, Australian university	$N = 213$ undergraduate engineering students at a public university in the southwestern United States
Study year	Not given	Fall 2018 to Spring 2019
Research question	Do courses with an attached Facebook group increase students' sense of belonging compared to courses without Facebook groups?	Does the use of a university makerspace in engineering course projects impact student's sense of belonging in the engineering space, among other factors?
Methodology	T tests for between-subjects analysis of differences in students' sense of belonging between students who had a course with a Facebook group (official and unofficial) and students who did not.	Paired t tests on matched responses from pre-intervention and post-intervention surveys and repeated measures analyses of variance on subsamples of students by year in their program, gender, and race.

Criterion	Sheeran and Cummings (2018)	Andrews et al. (2021)
Findings	Students with either an official or unofficial Facebook group attached to at least one of their courses demonstrated an increased sense of belonging. A second analysis compared students taking a course with only an official Facebook group to those enrolled in a course with no Facebook group attached and, again, found an increased sense of belonging.	Students who visited the [university's makerspace] facility showed significant gains in a sense of belonging to the makerspace and to the engineering community. Only 2nd-year (1st-year) students felt a statistically significantly higher sense of belonging to the engineering community (the makerspace) over a semester. Gender did not significantly impact students' sense of belonging; some races (White, Asian, and Hispanic/Latinx) demonstrated statistically significant gains in students' sense of belonging to the makerspace.
Discussion	A course with a Facebook group, either official or unofficial, attached to it increased campus engagement attributes (including students' sense of belonging). These findings are consistent with those of Barczyk and Duncan (2013), Hung and Yuen (2010), Hurt et al. (2012), Kabilan et al. (2010), and McCarthy (2010).	Findings on the sense of belonging agree with those of Good et al. (2012), Hausmann et al. (2007), Rainey et al. (2018), Seymour and Hewitt (1997), and Tate and Linn (2005). Results suggest that requiring students to visit the makerspace as part of an assignment/course may (1) reduce student hesitation about the space (so that they are more likely to return) and (2) help engineering students make the space more inclusive and ensure that more students are receiving the space's benefits.
Conclusion	The results of this study indicate that Facebook groups may be a useful addition to university courses.	The research results have reaffirmed the value of including a makerspace in students' early educational experiences.
Stated research shortcomings	Causality could not be inferred, and effect sizes were small in the study results. There was little consistency in or measurement of how the Facebook group was used and no indication of student–staff interaction, which could have moderated the effect. The investigation was limited to the existence of Facebook groups in the courses only, with no control for potential individual-level variables.	Examination of causality was impossible, and student's engagement with the makerspace, in terms of time and effort spent, was not tracked to study its impact on student's sense of belonging.
Stated limitations and recommendations for future research	A high proportion of unofficial Facebook course groups was found, but further research into these courses was determined to be beyond the scope of this study. There is a potential to expand this study to look at moderating student-level variables such as personality or academic motivation. Future studies	This study investigated one makerspace at one institution in only eight courses with few instructors included. As such, generalization is limited. Variables that might have had an influence on results (e.g., other coursework, interactions with makerspace staff, number of visits) were not captured. In the future, researchers

Criterion	Sheeran and Cummings (2018)	Andrews et al. (2021)
	could also control for instructors' teaching approach and communication style.	should investigate the generalizability of the findings of this study across other STEM disciplines and makerspace contexts. As students' belief in feeling a higher sense of belonging to the engineering community might vary over their undergraduate years, examining how this happens should also be a future research direction.

Note. STEM = Science, technology, engineering, and mathematics.

Facebook Group

The purpose of Sheeran and Cummings (2018) was to investigate whether attaching a Facebook group to a course was associated with increased students' sense of belonging. More specifically, the authors hypothesized that courses with a Facebook group (either official or unofficial) would be associated with an increase in students' sense of belonging compared to courses with no Facebook group.

On the social media platform Facebook, groups are a virtual place where users can engage and share information, stories, and media with other people. Numerous types of Facebook groups exist, with topics ranging from home baking to dating etc. These groups can be listed as public or private, and each may have a unique set of rules and parameters for user participation (Meta, n.d.).

In Sheeran and Cummings (2018), official Facebook groups were created by instructors, and all students enrolled in the courses were invited to join them. Unofficial Facebook groups could be created by instructors or by any student in the class. There was no expectation that all students would be invited to an unofficial Facebook group or that they were aware that one existed during their time registered in the class.

Participants in the study were recruited from a large, Australian university with approximately 46,000 students. Students voluntarily participated in this experiment in exchange for partial course credit in an introductory psychology course. The study was also mentioned in a university-wide email sent to all students asking for volunteers for the research project. The authors used eight items to measure students' sense of belonging. Each item was tested for internal consistency and rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The online survey was given on Qualtrics, and students were asked how many courses they had completed/were completing that semester and whether the courses had a Facebook group. To reduce participant burden, a maximum of two courses were selected for each participant (one course with an official Facebook group and one without).

Sheeran and Cummings (2018) noted increased interest in studying the use of social media sites as an educational tool in an academic setting, such as in Aydin (2012), Manca and Ranieri (2016), Piotrowski (2015), and Tess (2013). Following suit, they investigated the effect of Facebook groups as a course-specific resource over many different courses on student engagement categories, including students' sense of belonging. However, they did not control for or measure teaching-specific approaches or interventions of the Facebook groups. Sheeran and Cummings anticipated large variances in usage, engagement, and effectiveness of the Facebook group due to the broadness of their study.

Students with either an official or an unofficial Facebook group attached to at least one of their courses had an increased sense of belonging compared to students in courses with no Facebook group attached. Further, students with only an official (no unofficial Facebook group in any course)

Facebook group attached to a course compared to students with no Facebook groups attached to any course also showed an increase in the sense of belonging. The authors concluded that Facebook groups may be a useful addition to university courses in raising students' sense of belonging. This study provides further confirmation that supports the use of technology in the classroom as a resource to increase students' sense of belonging. It is the first study to specifically investigate the effect of using Facebook on student engagement, including sense of belonging, in the classroom across a broad range of courses. Although this study focused on Facebook, there is potential that the value of this technology may be generalized to other technologies in the classroom to increase students' sense of belonging.

The study was not without shortcomings. First, the authors could not infer causality based on the design of their study. They also noted that the effect sizes throughout the study were small. This may have been caused by including participants without measuring their Facebook group interaction. If students had low interaction levels, it could have dampened the captured effect size. The authors did not control or measure how Facebook groups were used in the courses, and there was no indication of student–staff interaction. This study simply associated a Facebook group in a course with increased students' sense of belonging on campus. It did not control for potential student-level variables either, which may have had a moderating effect on some of the findings.

The authors noted a surprising finding that there was a high proportion of unofficial Facebook groups associated with courses, but an investigation into these groups was beyond the scope of their study. Given that Sheeran and Cummings found differences in students' sense of belonging depending on whether the Facebook groups were official or unofficial, these authors recommended that future research should extend their investigation to include a more in-depth look at unofficial Facebook groups. Another recommended area of future research was to investigate the moderating effects of individual-level variables such as student personality or academic motivation. Future research could also control for instructors' teaching approach, communication style, and early indications of students' degree identity.

University Makerspace

Andrews et al. (2021) explored the use of a makerspace-based project in engineering courses. Students were either required to visit the space or strongly encouraged to do so. In either case, students could choose whether to visit the makerspace or not.

A makerspace is broadly defined as a facility that "enables making." These spaces can provide access to cutting-edge technology and a variety of traditional hand tools (Andrews et al., 2021). Different spaces might require different equipment and layouts of facilities (Barrett et al., 2015; Dougherty, 2012). In Andrews et al. (2021), the makerspace was referred to as "The Invention Space," a 23,000+ square-foot two-floor centerpiece facility of the largest engineering building on campus. Most of the square footage was used as a digital fabrication lab and as space for open worktables for use by students. From there, students could access engineering-related equipment (e.g., various 3D printers and full-spectrum laser cutters, etc.) and various relevant handheld tools (e.g., manual mills and lathes). The makerspace was open to engineering students (undergraduate and graduate) and faculty. Students visited the makerspace for reasons such as (1) to work collaboratively with classmates, (2) to tinker with personal projects, or (3) to meet with their extracurricular organizations.

Six hundred and ten students agreed to participate in the study. However, only 213 responded to both the pre-intervention and post-intervention surveys in the same semester without omitting data on one or more of the nine study factors, including their sense of belonging. The study took place in eight undergraduate engineering courses across five disciplines from fall 2018 to spring 2019 at a southwestern public university in the United States with an undergraduate engineering enrollment of

about 6,000 students. Two of the courses were interdisciplinary. Five of the courses were lower division, three upper division. Their distribution by year in the program was four 1st-year courses, two 3rd-year courses, one 4th-year course, and one multilevel course. Half of the courses were required and the other four were electives.

The study examined how the use of a university makerspace ("The Invention Space," in this study) in engineering course projects impacted students' sense of belonging (or an individual's self-perceptions of fit) within the engineering space, among other factors. See Table 1 for the primary research question.

The study applied paired t tests on matched responses [i.e., repeated measures by pre-intervention (during the 1st week of class) and post-intervention (during the last week of class) surveys (with a Bonferroni correction for multiple correlations). Repeated measures analyses of variance were also conducted on subsamples of students by year in program, gender, and race. The surveys each took 15 min to complete and included Likert-type, multiple-choice, and open-ended questions about students' sense of belonging and other factors. As the surveys were taken during class time, students were not incentivized to complete them.

The following findings were obtained from the students who provided complete data for analysis. Like in Cohen (2013), students who visited the university makerspace facility had significant gains in six of the nine measures, including a sense of belonging to the makerspace and the engineering community on campus. These findings agree with those of Good et al. (2012), Hausmann et al. (2007), Rainey et al. (2018), Seymour and Hewitt (1997), and Tate and Linn (2005). Of the students who did visit the makerspace, the results for the subsamples by year in program, gender, and race were as follows: (1) only 2nd-year students felt a statistically significantly higher sense of belonging to the engineering community on campus; (2) only 1st-year students experienced a statistically significant gain in the sense of belonging to the makerspace over a semester; (3) gender did not demonstrate an incremental impact on either type of sense of belonging; and (4) White, Asian, and Hispanic/Latinx students demonstrated statistically significant gains in the sense of belonging to the makerspace.

These findings suggest that requiring students to visit the makerspace as part of an assignment or course might (1) reduce student hesitation about using the space (so that they would be more likely to return) and (2) help engineering students make the space more inclusive and ensure that more students were receiving the space's benefits. The research results also reaffirmed the value of including a makerspace in students' early educational experiences. On the other hand, the authors concluded that more attention needed to be paid to prevent the creation of further disparities in engineering education for female students and racial minorities.

The matched responses from the pre-intervention and post-intervention surveys did not allow causality to be examined. Students were asked to use a general-purpose makerspace that was open to them and their peers from all engineering fields and levels of undergraduate courses. Students just visited there on their own and at their preferred time. Unless a prior arrangement was made, they might not have been able to meet the people they intended to meet or use the equipment/technology they intended to use. This could have lowered their sense of belonging.

As only one makerspace at one institution was examined, associated with just eight courses and a few instructors, there was minimal generalization of the research. The study did not capture other variables (e.g., those for other coursework, interactions with makerspace staff, number of visits) that might have contributed to the results. The authors indicated that future work should examine the generalizability of the findings of this study across other science, technology, engineering, and mathematics disciplines and makerspace contexts. In addition, as students' belief in feeling a higher sense of belonging to the engineering community might vary over their undergraduate years, examining how this happens should also be a future research direction.

Strengths and Weaknesses of the Studies

The assumptions made in the two studies and their strengths and weaknesses are summarized in Table 2. Both Sheeran and Cummings (2018) and Andrews et al. (2021) shed light on a relevant topic in today's current teaching environment, and both studies examined the effectiveness of using technology to raise students' sense of belonging, an especially pertinent subject given the increased use of technology in education during the COVID-19 pandemic and after.

Little research has been conducted on using Facebook groups as a resource in the classroom and their impact on students' sense of belonging. Sheeran and Cummings (2018) made several assumptions in the study. First, the authors assumed that all students interacted with the course-associated Facebook groups in similar amounts and ways. Although there were over 400 participants surveyed in various classes, it was assumed that the Facebook groups, either official or unofficial, were employed in consistent ways in the classroom. The authors noted that the examination of unofficial course-attached Facebook groups was outside the scope of their study; however, when discussed, the assumption appeared to be that if an unofficial Facebook group existed, the students were all aware of and able to access the group. Finally, there was no information regarding how these Facebook groups were used in the classes and whether participation was required and assigned or completely voluntary. These assumptions and the varying uses of the Facebook groups in the classes may have caused a dampening of the overall effect.

A strength of this study is that the scales used were appropriately tested for validity, and the findings of this study were impactful for teachers in higher education. However, a more thorough literature review would have better supported the theoretical background of this paper. The authors also did not control for demographics in their study or several other student-level (motivation, self-efficacy, etc.) or faculty-level (communication style, approachability, etc.) factors.

Table 2. Assumptions, Strengths, and Weaknesses of the Two Reviewed Studies in this Critique.

Criterion	Sheeran and Cummings (2018)	Andrews et al. (2021)
Assumptions	• Facebook groups were used in the same manner from course to course, and students interacted in equal amounts. • Students were aware of unofficial Facebook pages when available.	• All students who visited the makerspace had the same exposure and demonstrated the same extent of engagement.
Strengths	• Validity of scales was tested for internal consistency. • First known study on using Facebook in the classroom to increase students' sense of belonging. • Broadness of study—the results may be generalizable to a variety of classes, student levels, and faculty. • Impactful findings regarding students' sense of belonging and use of social media.	• An appropriate literature review on the sense of belonging was provided. • Two data points for each observation allowed for studying growth in the sense of belonging. • A list of items for each factor (or construct) was clearly provided in the Appendix. • Students' sense of belonging was measured using a previously validated scale.

Criterion	Sheeran and Cummings (2018)	Andrews et al. (2021)
		• The authors also validated their modified constructs.
Weaknesses	• Intervention was not consistently applied to the students. • Participants' interaction with the Facebook groups was not measured. • Lacked sound literature review and variable definitions, including the sense of belonging variable. • Did not control for demographics or other external factors that may have influenced findings, such as student motivation or faculty approachability.	• Intervention was passively imposed on the students. • Students' extent of engagement in the makerspace was not tracked.

Using a similar set of implicit assumptions to those in Sheeran and Cummings (2018), that the intervention was applied equally across all classes and that students engaged with the intervention in equal amounts (see Table 2), Andrews et al. (2021) studied the impact of makerspace usage on students' sense of belonging. An appropriate literature review on the sense of belonging was included in the article. Two data points for each observation in the study sample allowed for studying growth in the sense of belonging. A list of items for each factor (or construct), including three items specific to belonging to the makerspace (The Invention Space) and another three items specific to belonging to the engineering community on campus, were provided in the Appendix. Students' sense of belonging was measured using a previously validated scale (as in Hurtado and Carter (1997)), with adjustment to the specific intervention and target sample in this study. This enabled an objective comparison of results across studies. The modified constructs were also validated by the authors using explanatory factor analysis, which provided evidence that all three items in the individual constructs loaded onto the same factor. A follow-up confirmatory factor analysis for the six items also illustrated that a two-factor solution was a good fit.

However, the intervention was passively imposed on students. Moreover, both the pre-intervention and the post-intervention surveys asked students whether they had visited the makerspace, but not how often or for how long on each visit. Thus, students' extent of engagement in the makerspace was not tracked, which could be a significant factor in their sense of belonging.

Conclusion and Future Studies

Although both studies succeeded in providing evidence that supports the use of technology in raising students' sense of belonging, further insights cannot be made without fine-tuning the research methods and/or extending the studies to include more measure variables (see Table 3).

Sheeran and Cummings (2018) could be extended in various ways. Future studies could examine student-level (e.g., motivation, confidence, self-efficacy) and faculty-level (e.g., approachability, communication style) moderating variables that might influence the relationship

between the Facebook group and students' sense of belonging. Investigating the differences between official and unofficial Facebook groups and their resulting impact on students' sense of belonging would also help advance the existing literature frontier. Future researchers could also consider ways to examine the causality between these two individual variables and students' sense of belonging. For instance, do students with a higher sense of belonging drive interaction in course-attached unofficial Facebook groups, or do unofficial Facebook groups help reinforce students' sense of belonging? A measure of student interaction could also be added in future studies that would capture the amount of time and the ways a student interacts with the technology.

Table 3. Recommendation for Related Research in the Future.

Criterion	Sheeran & Cummings (2018)	Andrews et al. (2021)
Recommendations for future research	• Include moderating variables at both the student-level and faculty-level • Further examine the effect on the sense of belonging between courses with an official versus an unofficial Facebook group. • Include a construct to measure Facebook group interaction.	• Include some assignment-related activities to be held at the makerspace in the intervention. • Create a construct to track students' engagement with the makerspace.

For studies like Andrews et al. (2021) in the future, researchers could consider enhancing the intervention by including some assignment-related activities, such as a presentation or demonstration of students' work and/or small group or panel discussions related to the topic of the individual assignments, to be held at the makerspace. This would give students a chance to design at least part of the invention process and make their participation more active, and it would also help them establish connections with makerspace users who have the same or similar interests as theirs. As we mentioned in the Introduction section, such an intervention would involve a higher level of student interaction and active participation, which would help raise students' sense of belonging. The extent of students' engagement in the makerspace could positively affect their sense of belonging to the space and to the engineering community. Incorporating a construct to track students' engagement with the makerspace by including items that question how often students go to the makerspace and how much time they spend there would help readers interpret the research findings.

Whereas psychological interventions aim to change the mindset of students (Walton & Cohen, 2011), technological interventions improve their existing environment (Andrews et al., 2021; Sheeran & Cummings, 2018). Students might hardly feel the impact of technological interventions or enjoy the benefits once they no longer have access to the class environment. Following students to track the long-term impact of those interventions would not be expected to produce meaningful findings.

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