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INNOVATION ARTICLE

Improv Activities in an Engineering Classroom Increase Student Self-Perceptions of Engagement, Adaptability, and Communication

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Abstract
Improv activities have been shown to increase student engagement, enjoyment, and confidence in higher education classrooms. However, there are few examples of STEM courses designed with dedicated and repeated time allotted to improv activities. We sought to determine the effects of scheduled improv activities on engagement and learning in an upper-level biomedical engineering course. The engineering course was modified to include dedicated class time for implementing improv activities. Student perception of this format and of the activities was assessed via pre- and post-implementation surveys. These surveys focused on student engagement, self-confidence, communication, and comfortability in the classroom in prior courses (pre-implementation survey) and after 4 weeks of improv activities (post-implementation survey). Based on survey feedback, most students thought that the improv activities were helpful in facilitating an engaging and collaborative classroom experience. Students indicated that the improv activities helped improve their general communication skills, and many positively remarked on how the activities brought some energy to the classroom and helped them get to know their peers. Overall, this study suggested that students responded favorably to the improv activities, with several remarking that the activities should be used more in STEM courses. These results demonstrate that improv activities can be successfully implemented in engineering classrooms and could become an important part of the engineering education curriculum.

Keywords Improv activities · Student engagement · Classroom environment

Introduction

Improv, a form of creative, collaborative theater, has been gaining attention as a strategy to increase student engagement, enjoyment, and confidence in higher education classrooms [1, 2]. While this form of live theater may seem out of place in formal engineering education settings, many of the base principles of improv lend themselves to the establishment of an active, engaged class. For example, the major tenets of improv include practices of collaboration, acceptance, and spontaneity as well as the focus that there are no wrong answers [3]. As such, improv is commonly implemented in classes of all levels focused on communication skills and practices, where improv activities are used to help participants increase both their engagement in discussions and their comfort in public-speaking scenarios [4, 5]. Furthermore, improv has been correlated to increased creativity, brainstorming, and overall well-being, making it a potential avenue for transforming general teaching practices to high-impact teaching practices [6–8]. In one study, Felsman et al. studied how improv activities can influence divergent thinking and uncertainty tolerance in undergraduate students. They found that when comparing improv activities to controlled, prepared activities, the improv activities significantly improved participants' affective well-being and uncertainty tolerance, as well as slightly increased the frequency of divergent thinking [6]. These results are important because they help to quantify how improv activities can influence the classroom setting by facilitating positive learning experiences for the students.

Several educational studies have investigated the effect of introducing improv activities into higher education courses outside of theater arts. In general, these have been concentrated in the realms of business [9–13] and health sciences [14–18], with several colleges and universities offering improv-based classes or seminars for students.

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In almost all cases, assessments after improv activities showed improvement in communication skills, self-confidence, and empathy compared to control groups. Furthermore, student feedback indicated that improv activities were viewed as positive, worthwhile experiences. For example, Grossman et al. investigated how an improv intervention affected the communication skills of medical students, specifically related to patient-centered and empathetic communication. By assessing performance in standardized patient interactions, they found that student groups who received improv intervention had significantly higher scores of empathetic communication than the control group [14]. More recently, there has been focus on introducing improv principles and practices into additional STEM fields, with studies demonstrating benefits to students in geology, technical communication, engineering, and math courses [19–22]. In many of these studies, student survey responses demonstrated the benefits of introducing improv activities in STEM classrooms, including improved communication and teamwork skills [19–21]. These positive outcomes align directly with several student outcomes delineated by ABET: Outcome 3, which is "an ability to communicate effectively with a range of audiences" and Outcome 5, which is "an ability to function effectively on a team…" However, despite the fact that numerous studies have demonstrated the benefits of improv practices in teaching and learning, implementation of improv activities in STEM fields remains limited compared to other disciplines. In addition, due to the challenges associated with qualitative survey data, replicating these studies across additional fields would help to further validate the positive effects of employing improv in STEM classrooms.

In this study, we implemented improv activities into an upper-level biomedical engineering course by dedicating specific time for the activities within the course schedule. Our objectives were to assess the feasibility of this approach and to test the hypothesis that incorporating brief improv activities into a biomedical engineering course would improve communication skills and enhance teamwork abilities for at least half of the student participants. We evaluated communication and teamwork skills, among other outcomes like classroom engagement and a positive learning experience, using student feedback collected from pre- and post-improv surveys, as well as instructor feedback following the improv activities. Importantly, these objectives are also tied to the ABET student outcomes described above and to several course-specific learning objectives, such as an ability to "respectfully and intelligently discuss stem cell topics with peers and with the public" and to "…[communicate] results and proposals to [peers and] the public…".

Methods

This study was approved by the University of Iowa Institutional Review Board (IRB, Project # 202205064, documentation available upon request). In order to address our research questions, we introduced brief (~5 min) improv activities in upper-level biomedical engineering course. Each class session already included some time dedicated to community-building (e.g., a fun fact, light-hearted survey, or nature photo presented by the instructor), which we replaced with improv activities for part of the semester. The course, "Stem Cells in Regenerative Engineering", is designed for students who are interested in tissue engineering and regenerative medicine, and particular emphasis is placed on practical knowledge that students may find useful as they pursue careers (research or industry) in these areas. In addition to assignments and quizzes, typical course activities include in-class discussions, the most prominent of which are six in-depth case studies, and a final group presentation with a paper. During the semester of intervention, 48 students were enrolled in the course: 10 3rd-year undergraduates, 32 4th- or 5th-year undergraduates, and 6 graduate students. The general format of the study is as follows: At the beginning of the second week of class, a member of our team introduced the overall concept of the improv activities and invited students to participate in the pre-improv survey. The motivation of the study was explained as assessing student interaction and engagement in the classroom, with a secondary goal of helping to improve student communication skills. The pre-improv survey was a voluntary, anonymous, online survey, which was open for responses for 1 week. This survey asked about students' experiences with past courses, focusing on student engagement, self-confidence, and comfortability in the classroom. Starting the third week of the semester, and continuing for a total of 4 weeks, the research team, which included the course instructor, led twice-weekly improv activities at the beginning of class (Fig. 1). Each activity was about five minutes in duration and focused on student participation, interaction with peers, and being comfortable making mistakes (Table 1). Ad hoc small groups were formed with 10–15 students and one member of the research team. Each improv activity was introduced to the students according to its description (e.g., Table 1), and then performed for 5–10 min.

Following the 4-week implementation phase, students were invited to participate in another voluntary, anonymous, online survey about their experiences with improv activities in the course. These surveys were partially adapted from previous studies on improv activities and teaching, enabling us to compare our results to the literature across several STEM fields [19–21]. In addition, the instructor was invited to complete a survey about their thoughts on implementing improv

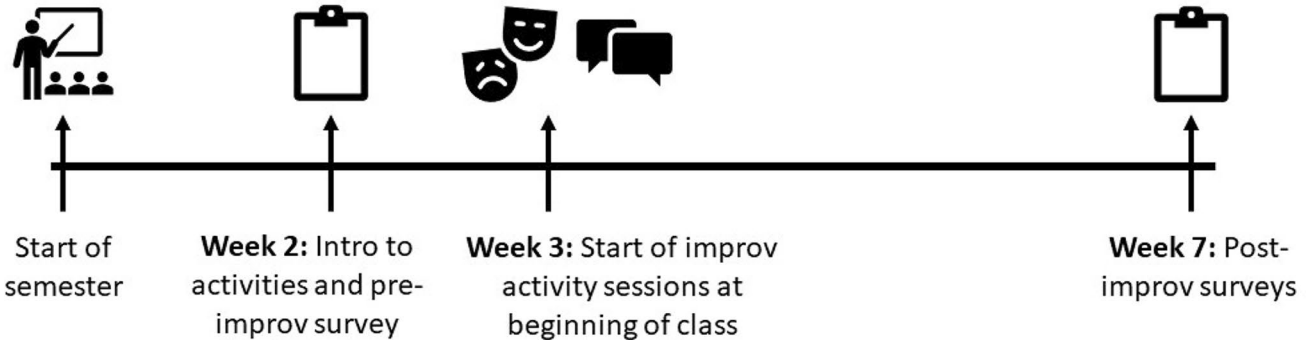

Fig. 1 Timeline of the study approach including pre-improv survey, improv activity implementation, and post-improv surveys

Table 1 Description of improv activities implemented during the course

Improv activity	Description
Zip, Zap, Zop	Students stand in a circle. One person starts the sequence, pointing at another person and saying "Zip!". The person who has been "zipped" then passes it to another, saying "Zap!" The "zapped" person finishes the sequence by "zopping" a final person. The sequence then repeats. An alteration to the activity is that the starting person can change the first letter/sound of the sequence and subsequent players must adapt (e.g., Bip, Bap, Bop; Tip, Tap, Top)
Count up	Students arrange themselves in a circle. The goal of this activity is to count up to a number (e.g., 20). However, players are not allowed to simply proceed in a circle or say anything other than a number. If more than one person speaks on the same number, the group must restart at 1. Alterations can include counting by evens, odds, etc
Rock, paper, scissors (alteration)	Using the same hand gestures as the familiar game, but with a slight twist. Students stand in a circle, you count down (3…2…1), and then everyone must simultaneously make one of three hand motions: rock, paper, or scissors. The goal is for everyone to make the same motion at the same time without talking. You repeat this until everyone makes the same sign
One word story	Students arrange in a circle and are given a topic to create a story. The story is told one word at a time (for each person) around the circle. Students must work together to build sentences and tell a story that makes sense

activities during class time. All surveys can be found in the Supplemental Information section.

Both pre- and post-implementation surveys were anonymous, confidential, and had no impact on students' grades in the course. Surveys were designed as a mix of ranked and short answer questions and were administered via an online format (Qualtrics). Ranked questions were analyzed as a Likert-type scale, with the median response type calculated and reported. Short answer questions were coded and analyzed based on frequently occurring themes in the responses. Graphpad Prism was used for all statistical analyses and graphing.

Results

To evaluate how improv activities influenced student engagement in the engineering classroom, student feedback was gathered via pre- and post-improv surveys. The pre-improv survey focused on students' experiences in past courses, how students interacted with their peers, and what practices instructors could use to help students feel more comfortable. Of the 48 students enrolled in the course, 36 of them completed the first survey. A majority of students indicated they were more confident than not in their public speaking, verbal communication, listening, and adaptability ("think on your feet") skills, although public speaking had a greater number of unconfident responses than the other skills assessed (Fig. 2A). When rating past experiences with in-class participation levels, students indicated that both themselves and their peers were more likely than not to participate in class, although slightly more students rated themselves more likely to participate than their peers than the reverse condition (Fig. 2B).

An important part of the pre-improv survey was to gather student perspectives on what practices instructors had successfully used to help students feel comfortable in the classroom. In this free-response question, the two most common topics students brought up were breaking a large class into smaller groups/partners for discussions and instructors who interacted with students in a friendly and personable way (Fig. 3). Several students commented that the small-group discussions relieved some of the stress or pressure of answering questions in front of the whole class. In general,

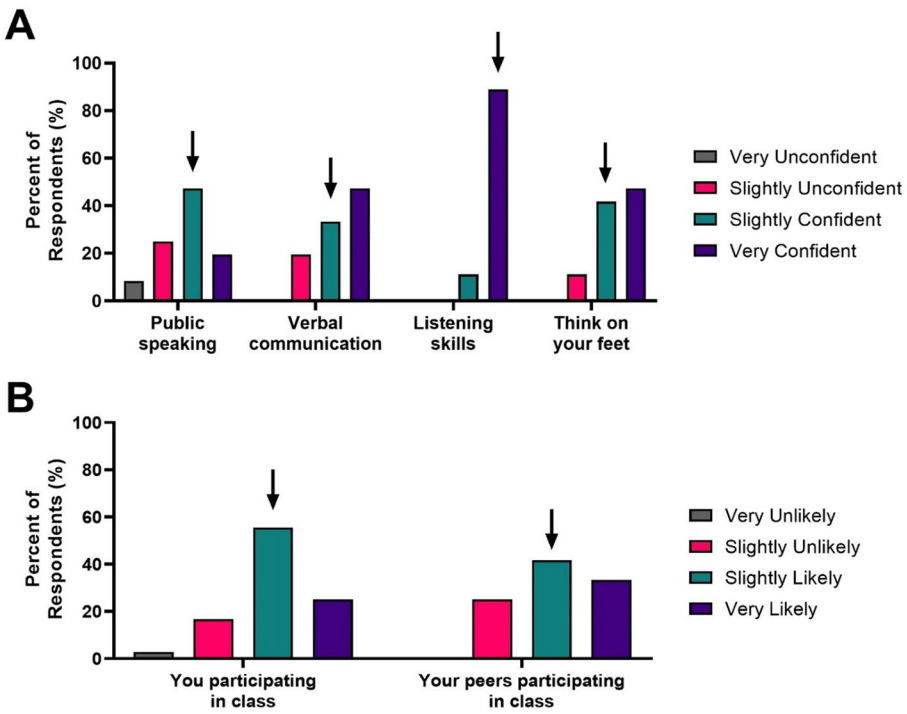

Fig. 2 Student responses about their **A** confidence levels in several different skills and **B** in-class participation levels of themselves and their peers prior to improv implementation. Arrows indicate the rating that corresponds to the median of all responses

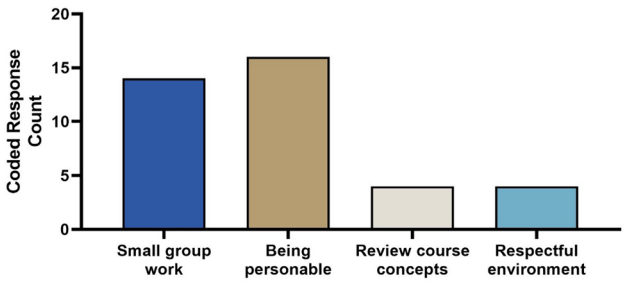

Fig. 3 Student response counts, from the pre-improv survey, as coded categories for how past instructors maintained a comfortable classroom environment

responses coded into the personable category included instructors knowing student's names, telling jokes, and checking in with students (not just about coursework). Other themes in student responses included instructors regularly reviewing course concepts and establishing expectations of a respectful classroom environment.

The post-improv survey was designed to assess how students responded to in-class improv activities. Out of the enrolled 48 students, 32 of them completed the second survey (compared to the 36 responses in the pre-improv survey). In both the pre- and post-improv surveys, students were asked to respond to how comfortable they felt working and interacting with their peers in a variety of situations. Both before and after participating in the improv activities, a majority of students indicated they were more comfortable than not in all of the situations. However, there were changes in the distributions of the rankings between the pre- and post-improv responses (Fig. 4). In three situations (Asking a peer for help, explaining course material to a peer, and working with a peer on homework) the percentage of responses in the Very Comfortable category decreased by approximately 10%. While in the other three situations (speaking up in class, studying with a peer for an exam, and working with peers on group projects) the percentage of responses in the Very Comfortable category increased by roughly 5%.

To determine student familiarity with improv activities, the post-improv survey asked if students had participated in improv activities in the past. While roughly 60% of students indicated they had participated in some form of improv activity previously, only 12% said they had participated in improv activities in an engineering class. When asked about how comfortable students felt during improv activities and among their peers, a majority of respondents indicated they were more comfortable than not during improv activities (Fig. 5A). Importantly, more than 75% of respondents indicated that improv helped them feel more comfortable with their classmates and vice-versa, and that improv activities can have a positive impact on teamwork (Fig. 5A). Furthermore, when asked about the influence of improv activities on communication, more than half of respondents agreed that the activities were helpful, both generally and for specific aspects such as confidence in public speaking and listening to others (Fig. 5B).

Overall, student responses indicated that they thought the improv activities were a valuable addition to the classroom, with over 80% of respondents ranking the improv

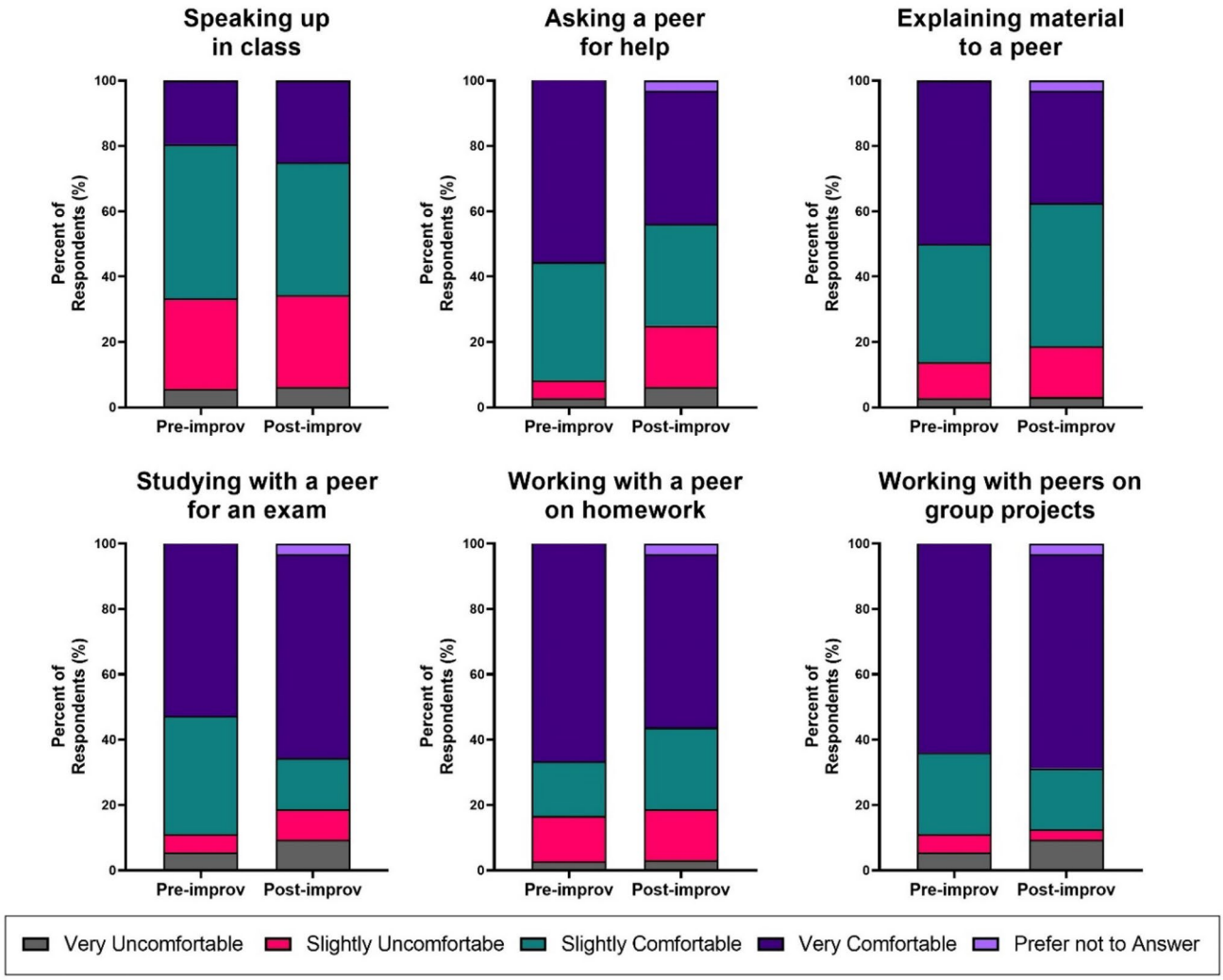

Fig. 4 Percentage of respondents in each category for how comfortable students felt interacting with their peers in different situations before and after participating in the improv activities. 36 responses were collected from the pre-improv survey while 32 responses were collected from the post-improv survey

activities as more valuable than not (Fig. 6A). However, students were more split on whether they would recommend improv to their peers, with only 55% indicating that they would be more likely than not to recommend improv activities (Fig. 6B).

In the last portion of the post-improv survey, students were asked several free-response questions designed to enable less structured feedback on the improv activities. When asked what the most valuable things they took away from the improv activities, many students noted that the activities enabled them to get to know their classmates better and helped them wake up for the early morning (8:30 am) class (Fig. 7A). Of note, 24 of the 32 total survey participants responded to this free-response question. In addition, when asked what improv concepts they could use in the future, several students pointed out that they would be able to continue to use improv concepts such as adaptability and collaboration (Fig. 7B). For this free-response question, 13 responses were collected.

When asked if there were other courses in which improv activities could be used or would be more appropriate, responses were evenly split between STEM-specific courses and non-STEM courses (such as theater, art, or business classes). Several responses also indicated that largely project-based courses, such as engineering senior design, could also benefit from improv activities (Fig. 8A). For this question, 15 responses were collected. Lastly, students were able to provide any other views or opinions they wanted to share about the improv activities in engineering courses (Table 2). Of the 11 responses, roughly 80% expressed positive feedback about the improv activities (Fig. 8B).

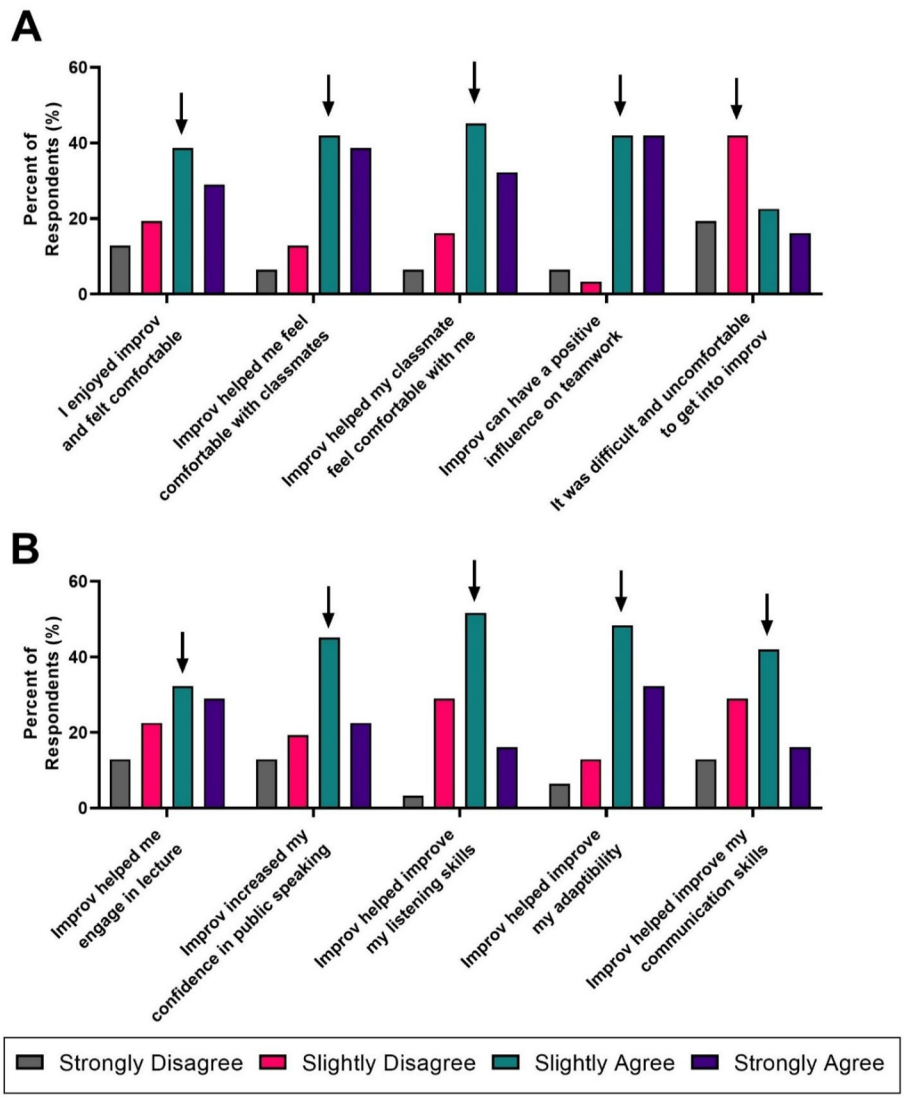

Fig. 5 Student responses to **A** their comfort levels during improv activities and how improv can impact comfort levels with classmates, as well as **B** if improv could help improve communication and teamwork skills. Arrows indicate the rating level that corresponds to the median of all responses; 32 responses were collected for these questions

The post-improv survey for the course instructor focused on gathering feedback about how improv activities impacted student engagement in the classroom as well as the logistics of implementing the activities. The instructor had largely positive reviews of the in-class improv activities, pointing out several details they noticed throughout the experience. Namely, they thought that the activities facilitated a space for everyone to participate with very little pressure to be "correct". They also noted the activities engaged important teamwork and communication skills, enabling students to practice these valuable "soft skills". When asked about if there were any noticeable changes in student engagement as improv activities were introduced, the instructor commented that after a couple weeks of improv activities, students appeared to be less hesitant to ask and answer questions in class. Furthermore, a higher number of students consistently interacted (asking and answering questions) during lectures than in previous offerings of this course. In addition, the instructor noted that students seemed more socially engaged before class and during in-class discussions upon implementing the improv activities compared to both before the activities started and to previous course offerings. When asked about the logistics of including improv activities in the course schedule, the instructor remarked that the improv activities were very easy to implement and did not require a large time commitment. They did note that implementing improv activities could be hindered

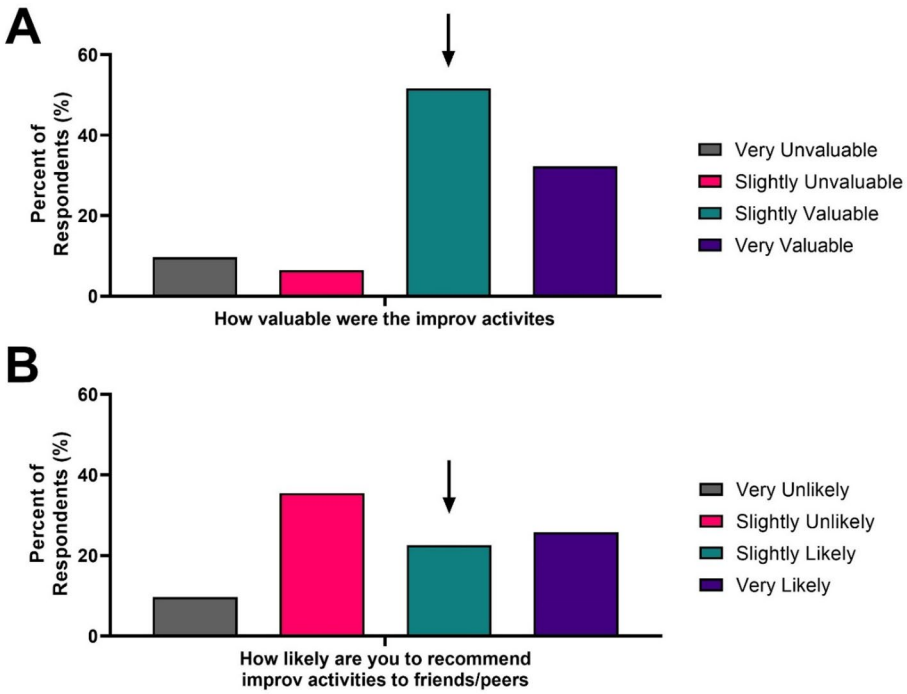

Fig. 6 Student responses to **A** how valuable they felt the improv activities were and **B** whether they would recommend improv to their peers. Arrows indicate the rating level that corresponds to the median of all responses; 32 responses were collected for these questions

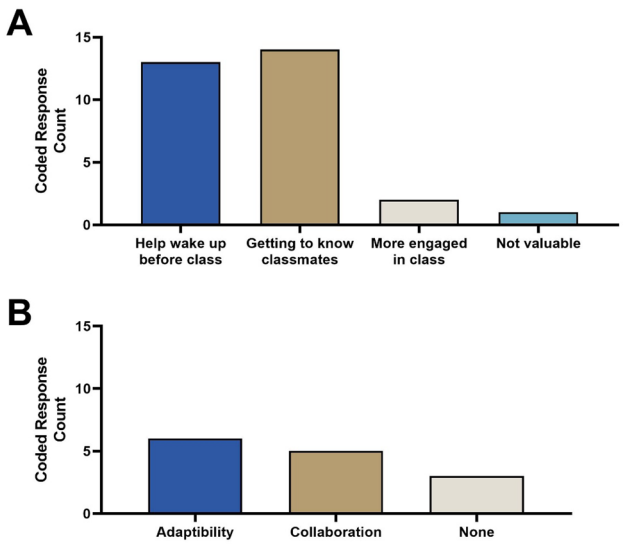

Fig. 7 Student response counts as coded categories for **A** what the most valuable things they got from the improv activities, and **B** what improv concepts they could use in the future

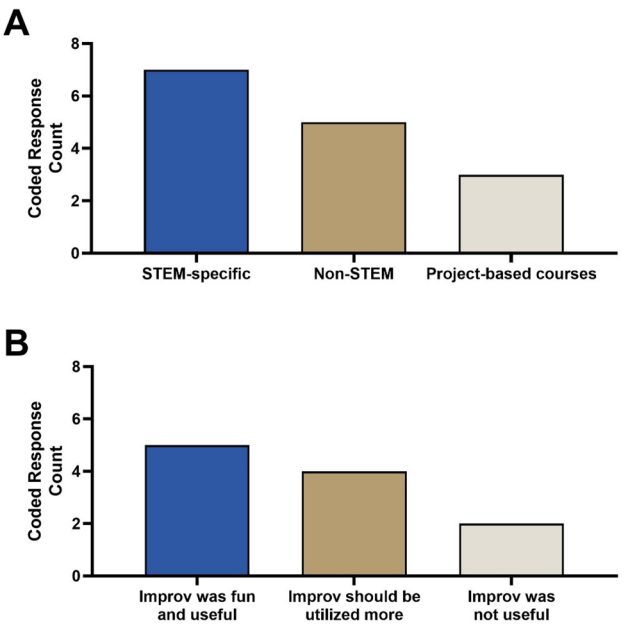

Fig. 8 Student response counts as coded categories for **A** what other courses improv activities could be used in or more appropriate for, and **B** any other feedback about the improv activities in engineering courses

by logistical challenges related to the number of students and classroom space, but these challenges are also encountered in facilitating small-group discussions and are not limited to improv activities. Finally, the instructor indicated that they would be open to incorporating similar activities in future courses but may moderate the frequency to a consistent weekly activity, as opposed to every lecture period.

Discussion

When designing this study, we set out to gather relevant data on how implementing improv activities into

Table 2 Example responses to the post-improv survey question regarding any other feedback students would like to share about the activities

Theme	Example responses
Improv was fun and useful	"Doesn't make it [feel] as "upper-level" and I feel like learning is more playful than work, which I think learning should have." "I think it was a nice change. Sometimes high level [STEM] courses can feel very stiff and stressful. Doing the improv made me feel a bit more comfortable"
Improv should be utilized more	"I think that these should be done more often at the beginning of every class." "I think classes need to do this at least once a week because making people uncomfortable seems to build classroom comradery."
Improv was not useful	"I believe that it is beneficial to foster a collaborative environment within higher education, but I believe that improv is the wrong way to approach it."

engineering courses can impact student communication skills, teamwork, and in-class engagement. Since several studies in other fields have shown that improv activities can improve student participation, engagement, and communication, we expected our results to corroborate these findings when applied to a biomedical engineering classroom. Adapting our post-improv surveys from previous studies enabled us to directly compare our results to studies across several disciplines.

When surveyed prior to the improv activities, engineering students expressed moderate to high levels of confidence in their communication skills and participation levels in the classroom (Fig. 2). We speculate that this may in part be from the population of students involved in this study, as the specific course in this study is an upper-level undergraduate or graduate level course. In future studies, it would be valuable to determine if student level plays a role in the effectiveness of improv activities in increasing engagement. For example, this question could be addressed by extending the study to introductory courses composed of first- or second-year undergraduates, or to higher level courses with primarily graduate students. Another major takeaway of our first survey was the student feedback about practices that instructors have used to help students feel more comfortable in the classroom (Fig. 3). Students overwhelmingly indicated that facilitating small-group discussions and being personable were among the most significant ways instructors can create a welcoming classroom environment. Notably, the improv activities fit into both practices, as the class is split into smaller groups of students for each activity, and the instructor participation enables a more personable experience compared to traditional classroom settings.

Comparing students' comfort level interacting with their peers from before and after the improv activities, there were no drastic changes for any of the topics (Fig. 4). Since our approved IRB protocol did not allow collection of identifying information, we were not able to match pre- and post-survey responses, which is a limitation. It is also worth noting that the total number of responses gathered did change between Survey 1 and 2, making it more difficult to correlate the findings. While there were slight changes to the distributions of students' comfort levels before and after the improv activities, students generally indicated they felt more comfortable than not across all situations. This is interesting because in a later survey question where they were asked more directly about the impact of the improv activities, most students indicated that the improv activities helped them feel more comfortable with their classmates and helped them improve various communication skills (Fig. 5). One might expect these results to parallel each other, but they instead show slightly different conclusions. However, compared to previous studies in software engineering and geoscience courses, our results showed very similar distributions in the student responses. Specifically, most students felt comfortable during the improv activities and thought that these exercises can help to improve various communication skills [19, 21]. Importantly, the results of Fig. 5 strongly support our hypothesis that communication skills and teamwork abilities would be improved for at least half of respondents. This implies that improv activities can successfully enhance communication and teamwork in the biomedical engineering classroom.

In a more general question, a vast majority of students indicated that they found the improv activities to be more valuable than not (Fig. 6A). This response is important because it is not focused on specific topics we thought to ask about, and instead enables students to provide feedback on the overall impact of the improv activities. Despite indicating that the improv activities were valuable, students were more split on whether they would recommend the activities to a friend or peer (Fig. 6B). This may indicate that while students felt comfortable participating in the activities in a facilitated environment, they would be less comfortable personally recommending improv to their friends. Comparing this study to previous literature, Rice-Bailey asked these same questions in a study on improv activities in technical communication courses [20]. In terms of the value of improv

activities, our results agreed, with a majority of students finding the improv activities to be valuable. However, in our study, students were more hesitant to fully recommend these activities to friends or peers than in the Rice-Bailey study. This discrepancy potentially highlights the importance of the instructor's role in the classroom. Students may not feel it is their role or responsibility to facilitate a positive classroom environment as a leader, and instead depend on the support of the instructor.

In the free-response questions on the post-improv survey, student responses followed several main themes. Overall, students indicated that the improv activities helped them become more comfortable with their peers, which is an important step in creating an inclusive and engaging classroom environment. In addition, students also said that being adaptable and collaborative were the major improv concepts they could use in the future (Fig. 7B). These are critical "soft skills" that can be difficult to teach in traditional classroom settings, and here we show that introducing improv activities may offer a way for students to gain experience with these principles. Importantly, these principles also directly tie into ABET student outcomes, specifically: Outcome 3 "an ability to communicate effectively with a range of audiences" and Outcome 5: "an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives". The ability of improv activities to help support students in achieving these outcomes further highlights the benefits improv can bring to the STEM classroom.

Another interesting observation in the free-response questions was that students noted that the activities helped them to wake up for the early morning (8:30am) lecture (Fig. 7A). While this may not be vital for classes later in the day, these activities can still help engage students and mitigate general learning fatigue. Finally, while we did not receive as many responses to these questions as other questions on the survey, students did indicate that they thought the improv activities were a useful addition to the classroom and could be implemented in a variety of courses both within and outside of STEM (Fig. 8). Several students thought that the discussion sections of engineering classes and project-based courses, such as the senior design capstone course, would be good candidates for the addition of improv activities. Notably, these responses align well with themes from previous studies of improv in STEM classrooms [19–21]. Briefly, students appreciated how improv enabled them to become more comfortable with their peers and added a fun, higher energy learning activity to the classroom. As these studies take place across a range of disciplines within the STEM field (geoscience, software engineering, and technical communication) our results strengthen the evidence that improv activities can be valuable addition to the STEM classroom.

Feedback from the instructor was an important aspect of this study as it provided a more external perspective on how improv activities can influence student behavior in the classroom. The instructor noted several points that the students may not have explicitly been aware of. For example, as everyone (instructor included) participated in the often silly and challenging activities, traditional student-teacher power dynamics were suspended for a brief time. This dynamic could enable students to become more comfortable interacting with instructors in a classroom setting.

One limitation to the current study is the small scope of the improv activities and relatively small sample size. Implementing the activities took place in one engineering class over the course of 4 weeks. Thus, the results of the study are not necessarily directly generalizable to a broad population of engineering students at this stage. However, our approach could serve as a model for performing similar studies in varying contexts (e.g., fields, student levels, and course types) within engineering higher education. In addition, the short time between the start of the semester and the implementation phase complicated the collection of a baseline for how students interact in the classroom. For example, it may just take a little time for students to feel comfortable in a new class and start participating, regardless of the improv activities. The instructor's feedback does lend support to the value of improv activities, as they noted qualitative changes in engagement and participation even compared to previous offerings of the course. Furthermore, despite these limitations, taken together with previous studies in STEM [19–21], business [9–13], and health science [14–18] classes, our results provide further evidence that improv activities are a valuable addition and should be implemented throughout higher education classrooms.

In the future, continuing this work both in the same course and expanding it to other biomedical engineering courses would help to further strengthen the conclusions drawn from this study. Heavily project-focused courses that require high levels of creative problem-solving, brainstorming, and teamwork may especially benefit. In addition, collection of more information such as student education level and demographics could facilitate understanding of potential relationships between these characteristics and how students react to improv activities, although care must be taken to preserve student anonymity. For example, first-year students may find the in-class improv activities to be more beneficial in meeting new peers than upper-level students, who may have already established collegial relationships with a group of peers. To further emphasize the impact of the improv activities on student communication, comfortability, and confidence levels, a debriefing session after each new activity may also be helpful. This session could take the form of small-group discussions where students can reflect on the dynamics and skills that were used throughout the

improv activities. Furthermore, tailoring the improv activities to a course's technical topics may help to benefit not only students' comfortability and communication skills, but also course-specific learning goals. Examining the relationships between in-class improv activities and student learning performance could be an interesting assessment in future studies. However, care would need to be exercised to preserve student anonymity, and proper control groups would need to be established in order to accurately interpret results.

Conclusion

Overall, the results of this study suggest that implementing improv activities into biomedical engineering courses can have a positive impact on communication, teamwork, and student engagement. Taken with other work in the field, this study continues to provide evidence that improv can help to inspire student confidence and comfortability, which could lead to a more welcoming and inclusive classroom environment. The improv activities were logistically easy to implement and did not detract from class time dedicated to learning material. Furthermore, participating in improv activities could lead to benefits outside of the classroom; students may be able to apply their improved concepts of communication, engagement, and inclusivity to all aspects of life.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s43683-023-00129-z.

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Author Contributions RJW: Conceptualization, Methodology, Formal analysis and investigation, Writing—original draft and editing. KSW: Methodology, Investigation, Writing—review and editing, Supervision.

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Data Availability Surveys are available in supplementary information. Other data are available upon request.

Code Availability Not applicable.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethical Approval Surveys and methodology for this study were approved by the University of Iowa's Human Subjects Office/Institutional Review Board under the Exempt status.

Consent to Participation Informed consent was obtained prior to participation in all surveys.

Consent to Publication Not applicable. All data were collected as anonymized, and no identifying information is found in the manuscript.

References

1. Berk RA, Trieber RH. Whose classroom is it, anyway? Improvisation as a teaching tool. J Excell Coll Teach. 2009;20(3):29–60.
2. Rossing JP, Hoffmann-Longtin K. Improv(ing) the academy: applied improvisation as a strategy for educational development. Improve Acad. 2016;35(2):303–25. https://doi.org/10.1002/tia2.20044.
3. Spolin V. Improvisation for the theatre: a handbook of teaching and directing techniques. 3rd ed. Evanston: Northwestern University Press; 1999.
4. Casteleyn J. Playing with improv(isational) theatre to battle public speaking stress. RIDE-J Appl Theatre Perform. 2019;24(2):147–54. https://doi.org/10.1080/13569783.2018.1552129.
5. Seppanen S, Toivanen T, Makkonen T, Jaaskelainen LP, Anttonen M, Tiippana K. Effects of improvisation training on student teachers' behavioral, neuroendocrine, and psychophysiological responses during the trier social stress test. Adapt Hum Behav Physiol. 2020;6(3):356–80. https://doi.org/10.1007/s40750-020-00145-1.
6. Felsman P, Gunawardena S, Seifert CM. Improv experience promotes divergent thinking, uncertainty tolerance, and affective well-being. Think Skills Creat. 2020;35:14. https://doi.org/10.1016/j.tsc.2020.100632.
7. Schwenke D, Dshemuchadse M, Rasehorn L, Klarholter D, Scherbaum S. Improv to improve: the impact of improvisational theater on creativity, acceptance, and psychological well-being. J Creat Ment Health. 2021;16(1):31–48. https://doi.org/10.1080/15401383.2020.1754987.
8. Neel N, Maury JM, Heskett KM, Iglewicz A, Lander L. The impact of a medical improv curriculum on wellbeing and professional development among pre-clinical medical students. Med Educ Online. 2021;26(1):5. https://doi.org/10.1080/10872981.2021.1961565.
9. Huffaker JS, West E. Enhancing learning in the business classroom: an adventure with improv theater techniques. J Manag Educ. 2005;29(6):852–69. https://doi.org/10.1177/1052562905277311.
10. Balachandra L. The improvisational entrepreneur: improvisation training in entrepreneurship education. J Small Bus Manag. 2019;57:60–77. https://doi.org/10.1111/jsbm.12486.
11. Moshavi D. "Yes and…": introducing improvisational theatre techniques to the management classroom. J Manag Educ. 2001;25(4):437–49. https://doi.org/10.1177/105256290102500408.
12. Rocco RA, Whalen DJ. Teaching yes, and … improv in sales classes: enhancing student adaptive selling skills, sales performance, and teaching evaluations. J Market Educ. 2014;36(2):197–208. https://doi.org/10.1177/0273475314537278.
13. Robson K, Pitt L, Berthon PR. "Yes, and …": what improv theater can teach service firms. Bus Horiz. 2015;58(4):357–62. https://doi.org/10.1016/j.bushor.2015.02.002.
14. Grossman CE, Lemay M, Kang L, Byland E, Anderson AD, Nestler JE, et al. Improv to improve medical student communication. Clin Teach. 2021;18(3):301–6. https://doi.org/10.1111/tct.13336.
15. Watson K. Perspective: serious play: teaching medical skills with improvisational theater techniques. Acad Med. 2011;86(10):1260–5. https://doi.org/10.1097/ACM.0b013e31822cf858.
16. Boesen KP, Herrier RN, Apgar DA, Jackowski RM. Improvisational exercises to improve pharmacy students' professional communication skills. Am J Pharm Educ. 2009;73(2):8. https://doi.org/10.5688/aj730235.
17. Kaplan-Liss E, Lantz-Gefroh V, Bass E, Killebrew D, Ponzio NM, Savi C, et al. Teaching medical students to communicate with empathy and clarity using improvisation. Acad Med.

2018;93(3):440–3. https://doi.org/10.1097/acm.0000000000002031.
18. Shochet R, King J, Levine R, Clever S, Wright S. 'Thinking on my feet': an improvisation course to enhance students' confidence and responsiveness in the medical interview. Educ Prim Care. 2013;24(2):119–24. https://doi.org/10.1080/14739879.2013.11493466.
19. Haroldson EL. Improv games in geoscience courses. J Geosci Educ. 2022;70(2):195–207. https://doi.org/10.1080/10899995.2021.1945404.
20. Rice-Bailey T. The benefits of improvisational games in the TC classroom. Tech Commun Q. 2021;30(1):63–76. https://doi.org/10.1080/10572252.2020.1754466.
21. Bottcher A, Worch N, Kamper A, Trescher R, Ieee. Using improvisational theater in team-based teaching activities. IEEE Global Engineering Education Conference (EDUCON). Tech Univ Berlin, Berlin, Germany: Ieee; 2013. p. 356–61.
22. Morales-Almazan P. Improv practices in mathematics active teaching. Primus. 2022;32(9):1013–28. https://doi.org/10.1080/10511970.2021.1978604.