A Storytelling, Social-Belonging Intervention in an Introductory Computer Science Course

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Abstract

A brief social-belonging intervention was developed for two introductory computer science (CS) courses. This intervention used storytelling to help improve a sense of belonging and establish the importance of persistence in the classroom. In previous experiments using this one-time intervention (Walton & Brady, 2017) there were significant results. The focus of this paper will be on how to incorporate this type of intervention for retention in computer science undergraduate programs in introductory CS courses. First, recent CS graduates were interviewed about their own struggles and failures in their computer science courses. These interviews were videotaped and edited to follow the storytelling pattern of a struggle, followed by an attribution, and concluding with redemption. Interviewees were selected to represent a diverse group of students including both dominant majority and under-represented minority populations. Second, the storytelling videos (as well as control videos) were viewed by approximately 300 introductory-level students during small group recitation-like sessions. Third, survey data was collected that measured student's perception of their own belonging to the field of CS. Additionally, students were asked to respond to mock scenarios, gathering data on their attitudes and beliefs on how much other students belong in CS. This paper focuses on the design and implementation of this type of intervention, including a sample transcript of some of the stories. Preliminary data was collected from the experiment, but response rate was low due to IRB restrictions and low participant incentive. The standard social belongingness survey questions showed no significant difference between the group that had the intervention and the group that didn't. We also asked students to answer questions about another student's belongingness in CS. Both groups of students agreed that if another student struggles on exams, they should continue their pursuit of CS. The group with the intervention was more like to encourage a friend who was struggling on assignments to continue their pursuit in CS than the students without the intervention. However, the intervention group also reported having parents with higher education than the control group, so this result is not conclusive. This quantitative study will be further explored in the second iteration of the experiment that will have a larger response rate. Lastly, narrative responses have been reviewed for themes across participants and summarized, which helps further motivate the need for this intervention.

Motivation

From 2015 AY to 2016 AY, there was an 19% increase in number of students graduating with a bachelor's degree in computer science (Bizot, 2016). However, out of the 17,366 degrees awarded and reported to the Taulbee Survey, less than 18% were awarded to women. Just over 3% of these degrees were awarded to Black or African-American students, despite it being the largest minority population in the United States (an estimated 12.7% of the US population in 2016). Additionally, 7.5% of the degrees were awarded to Hispanic and Latino students, despite it being the largest ethnic minority population (an estimated 18.5% of the US population in 2016, Wikipedia). There are many factors and potential explanations for the lack of diversity in the computer science field. Persistence and belonging continue to be important areas of research in computer science education (Katz, Allbritton, Aronis, Wilson, & Soffa, 2006) to help understand

why underrepresented minority groups are not joining and are not staying. In this paper, we are exploring implementing social belonging intervention intended to help retain underrepresented groups in the computer science major.

Introduction

The way that students experience learning is socially and emotionally complex. However, there is a rich body of research that allows us to see that students learning is affected by both anxiety and how they attribute their failures (and successes).

Anxiety: Math anxiety and testing anxiety are a real barrier for many students (Tobias, 1993). It has been shown that that students with higher math anxiety perform worse in all levels of educations than students who have lower math anxiety (Maloney & Beilock, 2012). There is a lot of evidence that math anxiety robs peoples of working memory (Beilock & Willingham, 2014). The working memory's "space" or capacity is some fixed amount that varies from person to person. It is used to solve problems and reason. If part of the working memory is occupied by anxiety, it is taking away from the fixed capacity that can be used to come up with a solution (Beilock, 2008). There is also neurological data that supports these findings (Young, Wu, & Menon, 2012).

Attribution: How students attribute their failures and successes is also tightly linked to how students perform. A study looked at twelve factors to which most influenced success in a computer programming course (B. C. Wilson & Shrock, 2001). Some of the factors includes attributions where students rated possible reasons for success or failure on the midterm exam to (a) attribution to ability, (b) attribution to task ease/difficulty, (c) attribution to luck, and (d) attribution to effort. They also looked at factors like self-efficacy, previous programming experience, gender, and more. The attributions for success/failure were predictive to performance.

This proposed intervention is framed by attribution theory. Attribution theory is a phenomenological approach to the study of behavior. It is approach that focuses on how people explain the reasons for their own and others' behavior. The idea is that two students could take a CS exam and both receive Ds. Student A could be very upset and anxious about this performance and might find it difficult to concentrate. On the other hand, Student B shrugs off the poor performance and studies harder for the next exam (T. D. Wilson, Damiani, & Shelton, 2002). The approach focuses on how the students perceive the causes of poor performance, not the actual causes of the behavior. Attribution theory approaches this problem by not targeting behavior or anxiety, but instead trying to change the attributions from pejorative to nonpejorative ones. The well-known growth mindset (Dweck, 1975) is rooted in attribution theory. Therefore, they argue that you should target student's self-theories about intelligence in order to change those attributions (Claro, Paunesku, & Dweck, 2016; Hong, Chiu, Dweck, Lin, & Wan, 1999; Yeager, Romero, et al., 2016).

Attribution theory also centers on the exacerbation cycle. When a student gets a D on an exam, they will blame themselves and might feel it will never get better. The arousal and anxiety, in turn, make it more difficult for them to perform better the next time around leading to even more

pejorative attributions, and the cycle continues. Therefore, some studies have had success with interventions on college students that attribute academic problems to temporary factors (T. D. Wilson & Linville, 1985). This could be as simple as explaining to first year college students that beginning college students tend to experience difficulties, but it gets better with time. In one study, the intervention was interviews of upperclassmen, who spoke about how their grades increased over time (T. D. Wilson & Linville, 1982). The results were significant, in that students who received the intervention had an increased likelihood of staying in college and improved performance in GPA and GRE test score. There have been several other studies replicating this effect (Jesse & Gregory, 1986; Noel, Forsyth, & Kelley, 1987; Van Overwalle, 1989). These studies also show that one-shot interventions have a lasting effect.

It is important for everyone to see themselves as successful and to hear about people similar to themselves who have faced the same barriers (Steele, 2011). This also allows students to adopt an expandable view of intelligence (i.e. you can learn). Other studies have shown that providing narratives can help improve outcomes for a variety of minority populations. One study showed that women who read about the successes of other female mathematicians were able to perform better on mathematics exams than those who did not read the stories (McIntyre, Paulson, & Lord, 2003). While it has yet to be framed in computer science education research in this way, these themes of anxiety and attribution are related to the idea of pluralistic ignorance. Pluralistic ignorance is a situation where the majority of group members privately reject a norm, but incorrectly assume that others accept it. This would be the idea that the majority of students struggle to learn to code, but assume everyone else doesn't. The theory of pluralistic ignorance is common for research relating to college students and heavy drinking (Merrill, Boyle, Barnett, & Carey, 2018) and college students and sexual violence (Kroshus, 2018). Of course, telling stories of these struggles, would help normalize these struggles but also perhaps correct the assumed "norm". Pluralistic ignorance is not the framework of this intervention, however, it has interesting intersections to social belonging in computer science.

Background

The proposed intervention uses storytelling to help improve a sense of belonging and establish the importance of persistence in the classroom for an introductory computer science course. Similar interventions have been used in other contexts to help improve the sense of belonging for students transitioning to college. The social-belonging interventions use carefully written stories from diverse upperclassmen to convey that worries about belonging in a new school are common at first but dissipate with time (Walton & Brady, 2017). In previous experiments using this one-time intervention, there were significant results. In one study (Walton & Cohen, 2011), African American students who received the social-belonging intervention were less likely to respond to daily adversities during the next week with feelings of nonbelonging, engaged in more achievement-promoting behaviors the next week, and earned higher GPAs the next semester than peers. In another study (Walton & Cohen, 2011), African American students who received the social-belonging intervention earned higher grades through senior year, halving the racial achievement gap. The intervention also increased the percentage of African American students in the top 25% of the class. In another study (Yeager, Walton, et al., 2016), the social-belonging intervention increased the percentage of students who stayed full-time enrolled in college in their first year from 32% to 43% and increased the percentage of ethnic-minority and first-generation

college students who completed the first year full-time enrolled by 4%. This type of intervention has not yet been used for the purpose of retention of computer science majors, which is how it was used in the study discussed in this paper.

Methods

This intervention was tested in two introductory computer science courses at a large research university. Recent CS graduates and two CS instructors were interviewed about their own stories of struggle, failure, or anxiety in their computer sciences courses (focused on the introductory level). These interviews were videotaped. Four of these interview transcripts are provided in the following section.

Intervention Stories

Recent CS graduates were interviewed to provide their own stories on failures and struggles in their journey to obtain their CS degrees. They were given the freedom to tell whatever stories they wanted to tell. Here is a sample of what questions they were given to prep for the interview (similar questions were provided about exams and overall courses):

> **Homework/Projects:** Have you ever worked on a CS homework/project and either not finished it by a deadline, done poorly on it, or failed it? Have you even received such a poor grade on an assignment that it made you feel like you did not belong in CS, were not "smart", or something similar? Have you ever lost motivation or felt like giving up after receiving feedback that indicated poor performance on an assignment? Did you ever feel like you needed more help than others and couldn't figure out things on your own? Do you have any stories, general or specific, relating to this?
> **Redemption**: Did it ever get better? Do you have perspective now that would be helpful for students going through it?

These interviewees were provided a template to frame their stories which started with their failure/struggle/anxiety, followed by an attribution, ending with redemption:

TEMPLATE:

> *[Failure/Struggle/Anxiety*] I failed CS103. I felt like I was working many more hours on the homework than my peers, but I wasn't able to finish them and would get low scores, as a result. I felt very discouraged, especially since it seemed like everyone else was doing well. There were times that I thought it meant that CS wasn't for me. However, I stuck with it, merely because I didn't know what else do. I ended up passing it the next time around, but just scraping by. *[Attribution(non-pejorative)]* Looking back, I realize how I did not approach the course right (either time). I feel lucky that I was not too discouraged at the time and that I did not quit. *[Redemption]* Follow up theory courses, like Algorithms, ended up being my favorite. It just didn't click initially.

Interviewees had the most difficult time telling the failure/struggle portion of their story omitting any attribution (as was requested). Since they all ultimately successfully got through these moments and courses, many of them were quite good a properly attributing their failures. It took a lot of coaching to get them to tell the story as it was in the moment (to back when they were attributing their failure to not belonging in computer science instead of something like having the wrong approach to taking exams). Ten different interviewees stories were videotaped and used in the intervention. They were grouped into two categories: (1) stories relating to homework and general approaches to a CS course (2) stories relating to exams. Interviewees 1 and 2 are samples from group 1 and interviewees 3 and 4 are samples from group 2:

Interviewee 1:

My name is [...] and I use he/him pronouns. I am currently a [graduate student] and will be graduating in […]. And fortunately after I graduate in the summer, I'll be working at [...]. When I was in my freshmen year, I was taking my first CS class that delved a lot more deeply into how computer systems worked. One of these assignments that we did was called "binary bomb". And I had been working on this assignment for so long. Literally days. And there was this one day, [the assignment was] probably two days late, my friends walked across the lounge and said, "Hey [...], do you want to get dinner?" and I just remember at that moment, I just had one tear fall and it was so sad. I was just so frustrated. Yeah, eventually, I mean like, I probably finished it and turned it in. The hardest thing for me, that I think I needed to do at that time, was to just be able to like reach out to other people and ask them to help me. I found that often times when I am in a place where I feel like I am so behind that I can't even ask other people for help. But it's definitely something that was really tough for me and I am still trying to improve.

Interviewee 2:

My name is [...]. I'm a queer person who was introduced to programming at a relatively young age. I am currently finishing my [graduate degree in computer science]. When I was taking the [introductory CS] classes here, I got to the last assignment for my class and ultimately had to turn something in that was completely unfinished. It was the first time that I had ever turned in something that just didn't work and that I knew would get a bad grade. I got the assignment back and no surprise, I got a bad grade. I was reflecting back on the experience and realized that it wasn't because I hadn't understood the class, I just didn't give myself enough time. So, I resolved to start my assignments earlier in the future. Since then, I still sometimes don't give myself enough time, but those occasions, sort of, are less dramatic. Even when I don't do very well, I know that it is not a reflection on my ability as a programmer or who I am as a person. It is just a time management thing that I can work on.

Interviewee 3:

Hi, my name is [...]. I graduated from [...] in spring […] with a computer science major. I am originally for North Dakota. I now work as a software engineer at a company called [...]. I struggled the most during my winter quarter, sophomore year. I was taking a lot of CS classes. I was very overcommitted. To the point where I remember during the midterm, I was looking at the test and I literally didn't know how to answer any of the questions. I started guessing all over the place. Ended up failing the exam. It was a really tough quarter for me. I wasn't really doing that well. And looking back on it, I was really comparing myself to some of my peers who were taking more advanced computer science courses. Over time, I started to realize that [my school] does a really good job of getting everyone to the same point in spite of everyone coming from really different backgrounds. And I was comparing myself to people who had completely different stories. And that was not something I should have been doing.

Interviewee 4:

Hi, my name is [...]. I am a current Masters student, [...], in computer science. Currently, [I am involved in teaching and assisting with] the introductory CS courses. I took [an introductory course] when I was a freshman. I really liked the class. I had a lot fun with the projects. But when the final exam came around, I was really unhappy with what ended up happening. I ended up getting stuck on a problem and spending way too much time on it. I came out of the exam just really questioning whether or not computer science is the subject I should be studying or not. And this was something that happened on future introductory class exams, as well. But one of the things that I realized at my time at [my school], especially after [...] helping teach that introductory class, is that exams are really not a measure of whether or not you belong in computer science. They are really testing this one specific instance of whether or not you were able to figure out what the solution to that specific problem was. As long as you are still enjoying the material and excited about what you are learning, you can still be a great computer scientist.

Additionally, each of the interviewees was also asked to tell a story about their favorite CS project or topic, which was also videotaped and used as the control video. These stories were edited such that, in total, the intervention video (and control video, as well) took about 10 minutes of class time. This required using the video editing technique called jump cutting. This also helped keep each story to the template which started with their failure/struggle/anxiety, followed by an attribution, ending with redemption. Most interviewees were not able to stick to the template using a single take on video.

The videos were shown to the students during their weekly problem-solving session run by a team of teaching staff trained to show the video and open up a dialogue to comment or ask questions about the videos. Therefore, approximately half of the students saw the control videos and half of the students saw the intervention videos. The control videos consisted of the same interviewees, but they were talking about their favorite thing about computer science or their favorite computer science project. During the last few weeks of classes, the instructors of the courses sent out a web-based survey. At the end of the survey, students were asked if they

recalled seeing either of the two types of videos in their problem-solving sections, which was used to categorizes students into the intervention group or control group.

Survey

There were 377 students enrolled in the introductory courses. Half of the students were part of the intervention group and the other half were part of the control group. The students viewed the intervention and control videos during Week 2 and Week 5 of course the course. The survey was sent out during Week 7 (Week 8 was the last week of the course). The survey was sent out by email to the entire group of enrolled students (Table 1 shows the questions in the survey that are discussed in this paper) and 57 students responded. Out of the students who responded, 28 students met the IRB age requirements.

Our response rate was quite low for many reasons. This first iteration of this intervention was a preliminary one, intended not to disrupt the class as much as possible. The authors ran this intervention with the cooperation of the instructors of the two courses. The instructors agreed to the intervention, as long as it required no more than 10 minutes of class time. As a result, surveys were distributed by email and there not a good enough incentive for students to participate. Also, these courses were during the summer, which means that there was a large population of high school students enrolled. These conditions were known a priori, however, the goal of this experiment was to develop the intervention so that when it was run during the regular academic year, it would be a successful experiment.

#	**Question**	**Answer selections**
Q1	"What is the highest level of education completed by your parent(s) or guardians(s)?"	1 is grade school… 5 is graduate school.
Q2	"Overall, how much did you enjoy the course?"	1 not at all… 5 is a lot.
Q3	“For me, learning to program has been”	1 is extremely difficult… 6 is extremely easy
Q4	"When something bad happens, I feel that maybe I don't belong in computer science."	1 is strongly disagree… 6 is strongly agree
Q5	"Many different kinds of people can be successful computer programmers."	1 is strongly disagree… 6 is strongly agree
Q6	"It's easy to know if someone is going to be good at computer science or not."	1 is strongly disagree… 6 is strongly agree
Q7	"Which picture best represents how well you feel you fit in and belong in computer science?"	1 is does not fit at all… 4 is does fit very well.

Table 1: Survey question and answer options (standard social belongingness survey).

In addition to the above standard, validated survey questions used in social belonging studies, students were asked to read two hypothetical stories about someone else’s belongingness. The survey questions can be found in Table 2. The stories are found below.

Story 1: Remy just completed [your course] at [your university]. During the [term], Remy was not able to finish two assignments and received low grades, (in the - bucket) on each. Remy will be taking [the next CS course] the next quarter and is looking forward to it.

Story 2: Riley took [your course]. Riley was able to do all the assignments, typically earned a score of a [B]. However, Riley did poorly on the final exam and received a failing grade, but did earn a passing grade in the course. Riley really wants to take [the next CS course], but is nervous they aren't cut out for it.

#	**Question**	**Answer selections**
Q8	"If Remy was your friend and asked for your advice, you would encourage Remy to continue with their pursuit of a degree in Computer Science and take [the next CS course]."	1 is strongly disagree… 6 is strongly agree
Q9	If Remy was your friend, you would *believe* that Remy should continue with their pursuit of a degree in Computer Science."	1 is strongly disagree… 6 is strongly agree
Q10	"If Riley was your friend and asked for your advice, you would encourage Riley to continue with their pursuit of a degree in Computer Science and take [the next CS course]."	1 is strongly disagree… 6 is strongly agree
Q11	"If Riley was your friend, you would *believe* that Riley should continue with their pursuit of a degree in Computer Science."	1 is strongly disagree… 6 is strongly agree

Table 2: Survey questions and answer options (new, not validated).

Lastly, the lead author of this work was on the teaching staff of one of the courses. In the conclusions, some informal observations will be discussed from this experience to help other CS educators get more perspective on this intervention.

Preliminary Results

Social-Belonging Survey Results and Discussion

Table 3 summarizes the responses from the some of the survey questions. The statistics are separated into two groups: S1 is the group of students who had the intervention and S2 is the group of students who did not have the intervention. The most significant differences between the two groups responses is with Q1. The S1 group had, on average, parents with higher levels of education. There were not significant differences in the remaining responses to questions.

Question	Mean (S1) n=17	Mean (S2) n=11	p-value
Q1	4.265	2.955	0.00300
Q2	4.588	4.364	0.223
Q3	3.764	3.636	0.383
Q4	2.706	2.545	0.388
Q5	5.118	5.182	0.428
Q6	3.941	4.000	0.465
Q7	2.647	3.091	0.057

Table 3: Preliminary statistical results for validated social belonging survey questions, where S1 is the group of students who had the intervention and S2 is the group of students who did not. The p-value was calculated using an independent t-test.

The statistical results from the questions asking the students to think about the belongingness of someone else are summarized in Table 4. The results from these questions indicate that students from the S1 group were more likely to encourage their friend who struggled with completing programming homework assignments to continue with their pursuit of computer science than the S2 group. However, given the statistical difference on Q1, this is not a conclusive result. It is also showing that students from both groups would encourage a friend who scored below average on CS exams to continue with computer science, which should be encouraging for more educators.

Question	Mean (S1) n=17	Mean (S2) n=11	p-value
Q8	4.353	3.364	0.0417
Q9	4.235	3.455	0.118
Q10	5	5.273	0.204
Q11	5	5.091	0.387

Table 4: Preliminary statistical results for hypothetical story responses, where S1 is the group of students who had the intervention and S2 is the group of students who did not. The p-value was calculated using an independent t-test.

Narrative Responses

We asked students at the end of the course to tell us "their stories" on experiences with failure and struggle. There were 19 narrative responses received. These were broken up into themes and there were six that described struggles and failures relevant to this study. The other themes found were describing what they liked about the course (5 responses), critiquing the course (3 responses), describing why didn't have any struggles or why they did well (3 students), and giving tips to future students on how to succeed (2 students). The six narrative responses below were chosen because they were the only stories where students described failures or struggles that they were not able to overcome complete by the end of the course.

Student 1 (from S2): I believe I understand most of what is going on in the class as well as the assignments. In fact, I do fairly well on them, given that I am able to constantly check the output and make amendments to my code as I go along. However I struggle greatly during exams because I am unable to check the output of my code and I fail to visualise what goes in my code in an abstract manner. Once, I asked a friend to help me debug one of codes. I told him "I don't understand what is going on here." I was flustered at that point. He looked at me reassuringly and told me "Some people are not gifted to code well", looked away and continued "I think you are one of them". I guessed that made me question if my lack of ability to visualise my code in an abstract manner significantly hinders my ability to be a good coder. Perhaps I was never a very good coder myself or perhaps this is all new to me. Learning a new 'language' has always been difficult to me, for that I am dyslexic. But till today, I am still not confident that I have the abilities to code well, as I see my peers soaring through the course somewhat effortlessly?"

Student 2 (from S2): I got mostly good scores on the homeworks but there were two assignments I couldn't finish / figure out. I studied hard for the exams but it always took a long time for things to actually *click* and so I often didn't finish in time or was not able to implement the actual code (versus pseudo code). When I couldn't figure out an assignment, I felt pretty bad and like I was dumb or not good enough for programming. The week before the final, I reached out to a friend who graduated in CS at a different school. She came over and we worked on some practice problems together and she reviewed difficult concepts for me that I was too embarrassed (or felt like it was too late) to ask in the class (on Piazza). She encouraged me that I was actually better than I thought (that I was understanding the logic and stuff but just had difficulty with getting it all written out) and that she had some of the same struggles when she was a student. Though I don't think I will pursue programming as a career, I no longer think I'm too dumb for it and I believe if I continued to practice and apply it, things would start coming more naturally.

Student 3 (from S1): I have enjoyed the class and the assignments a lot. It was great to have [help center] to support us through the assignments. I was very excited with the class until shortly after the midterm exam, when I learned that I scored below average. At that point I felt that I was not good at computer science and became discouraged. I have continued to enjoy the classes and the assignments, and I am happy that I have learned a lot. However, now I very nervous about the final exam.

Student 4 (from S1): I work slower than my peers in my opinion. I always have. I get accommodations for double time on tests. I put in a lot more time compared to my peers in my opinion to be sure I do well on assignments. It's hard to have the time for all the extra time things take but I do my best. I was very surprised by how much time coding took for this class, even while having a partner help. I definitely felt discouraged at many points throughout the course and I even now question whether CS is right for me and my career. I will continue to stick with it though. Watching those videos about others failures in CS definitely made me feel comforted that I'm not alone. It made me realize that CS is just hard, for everyone, not just me. And that each person has different things in CS that they are good at and bad at. For CS to be the right fit for a person, I think that person just has to be mindful of their skills and try not to judge themselves. I hope employers are okay with differences in CS abilities of their employees. I think as long as a person enjoys it and is decent, CS could be a good fit for them. Despite this, I'm still hesitant about myself and my future in CS. I'm definitely comfortable asking help. I've

learned this early on that asking for help is the only way to ensure I get better without wasting so much of my time trying to ignorantly/naively figure it out myself.

Student 5 (from S1): I think taking it over the summer definitely had an impact on my experience -- I lived off-campus and rarely attended lectures (instead watched them online) and did all of my homework solo (with the exception of the [help center]). It was pretty solitary, and at times I really wished for a peer that I could go to for questions on days where I couldn't go to the [help session]. I loved the work, but I had to spend a ton of hours to learn the material. I don't think I would have gotten the grade that I did if this hadn't been my only class. I am definitely pursuing [the next CS course in the sequence], but I still feel a bit like an imposter in the CS major because of how long it takes me to grasp the concepts. I'm assuming taking the class on campus with peers will make a huge difference.

Student 6 (from S1): I really enjoyed the course, but had difficulty managing it at times due to a full-time job, attrition on my team at work during the course period and an overlapping job hunt of my own. As an [online] student who had over-allocated myself during the course period, I was a bit more removed than I would've liked from interaction with the course staff. I relied on being able to utilize the background I have to figure out as much as possible on my own, which was good and bad. I definitely got nervous before both exams and feel I did not perform up to my abilities on them (particularly on the final) due to not being well-rested enough since I was trying to juggle too many things. That said I really enjoyed the course and would love to continue my CS education at [school] in the […] program for now and hopefully in the MSCS program down the line.

It is really interesting to read the stories from Student 1 and Student 2, since they both did not receive the intervention. Student 1 had an experience quite detrimental to their sense of belonging that could have possibly been quite alternated by the intervention. Student 2 luckily experienced the intervention naturally in their own friend group and indicated that it did just what it was intended to do. Student 3 indicated that they experienced some failures, but did not indicate that the videos helped them cope with those struggles (however, it appears that they have coped somewhat well). Student 4 is the poster child for this intervention, describing exactly the types of emotions and thoughts that this intervention is designed for. They are also able to demonstrate that this is a complex issue that is never "fixed", even if a student does complete a computer science degree and start working as a software engineer. These feelings of not fitting in and not being good enough will likely always been something to cope with. Student 5 (as well as a few other students) demonstrated this idea of pluralistic ignorance that they felt they were the only one who took a long time to figure out the projects, assuming the majority of students finished them without any problems. Finally, Student 6 was an example of a student who experienced some struggles but was able to attribute to something that could be changed rather than not belonging. Some of the other themes of these stories were students who "critiqued the course" or "gave advice to future students". These stories differed from Student 6 because they never described explicit struggle or never admitted to struggle, but perhaps hinted at it by indicating what did not work in the course structure or by discussing a skill/habit they developed that worked well.

Conclusions

This paper describes a social-belonging intervention in an introductory computer science classroom. In all previous work, this intervention has been effective in retention of college students, particularly in underrepresented groups. The purpose of this paper is to provide other CS faculty with some details on how an intervention like this one can be implemented for improving retention of underrepresented groups majoring in computer science. The template for framing the stories on struggles/failures is provided, as well as, four sample stories from CS graduates who were interviewed (and details of how to get interviewees to tell the stories using the template). Additionally, the proposed approach of videotaping the interviews makes it so they can be viewed by students in a variety of settings. They could be shown during lecture as a break from content. They could be showed during small group discussions, recitations, or labs sessions. They could also be assigned as homework and watched at home. This makes this invention easy to integrate and not invasive in terms of taking away from class time. However, it is also flexible in that it could be integrated in way that allows for students to take time to discuss or do reflective writing if the luxury of time is available. Lastly, we provided a design of this intervention that allows it to be used intentionally during specific times during the semester. For example, the first intervention video (themed around challenges with programming assignments/courses in general) was shown after students have experienced the first few challenging projects. The second intervention video (themed around exam anxiety or poor exam performance) was shown after the students' midterm exam.

Some preliminary statistical results are presented; however, sample sizes were small and results are not conclusive. Therefore, we are not able to make many conclusions about how effective the videos were in terms of improving a students' sense of belonging. On the other hand, the preliminary data does indicate that perhaps there is some sense of improved attitude about who belongs in computer science from students in the intervention group. It is certainly worth further exploration. However, we were able to provide some narrative comments from students, to demonstrate how this intervention got them to reflect on their own experiences.

The lead author of this work was on the teaching staff of one of the courses. Therefore, informal observations in the classrooms and discussions with other teaching staff can offer an additional perspective on the intervention. During some video observations, students in the classroom did comment and discuss the video. Students were discussing that it was nice to see successful people from their race or ethnicity group in CS. Other students mentioned it was a relief to see that successful CS graduates also struggled with exams, especially since the videos were shown immediately after taking their first exam (this was intentional). While videos were being shown, students were incredibly engaged and completely consumed with the video (not appearing bored, distracted, or uninterested in anyway). One initial concern is that these videos would "scare off" students. While we have no data on this, of course, discussions following the videos did not indicate that these videos increased fear, but instead that students were relieved and felt comforted. The lead author also had a large number of teaching assistants voluntarily reach out after showing the videos to say that they thought they were very useful and that they wished they had seen them before they started their CS journey.

Future Work

This initial implementation of this social-belong intervention was primarily used to understand how this type of intervention fits into the computer science classroom. Since this type of intervention is new, we chose to test during the summer term because there is more time and flexibility for experimentation. However, the summer term comes with its own limitations, such as having a smaller percentage of students who are meeting IRB age requirements. Therefore, our next step will be to do a follow up study during the regular academic terms in the authors' own classes. This will likely lend itself to higher participation among students (in our experience, having the author as the instructor is enough incentive for participation), and give us better data on how this type of intervention is working.

After the first iteration of testing out this intervention, we are running the experiment in a course for two consecutive terms taught by the same instructor. This allows us to better control which students have experience the intervention and which students are part of the control group. This second iteration will have a much larger sample size because it eliminated the issues with the IRB age restriction and lack of incentive.

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