CHIVE: Classroom Homogeneity In Virtual Environments

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## Overview

As outlined in our proposal for the Amir Lopatin Fellowship, we are interested in the effect of gender ratio in computer science classrooms. We have designed an experiment using Stanford's Virtual Human Interaction Laboratory (VHIL), under the direction of Professor Jeremy Bailenson. In the experiment, non-engineering majors are placed in an immersive virtual computer science classroom surrounded by virtual classmates; the classroom appears identical to one of the discussion sections from Stanford's introductory programming class. The gender ratio of the classmates varies among five experimental conditions, from all-female to all-male. The participant listens to a ten-minute lecture about binary numbers and their importance in computer science, then leave the virtual classroom by removing the headset, and take a post-test regarding their attitude toward computer science, what they learned about binary, and their experience in the virtual world.

We spent the summer of 2012 planning and designing the experiment and developing the instructional materials; programming the virtual world and pilot testing the entire experiment took place during the fall and winter. At this time, we have finished the programming of the classroom and creation of materials such as the lecture and post-test. In addition to ongoing support and feedback from Dr. Bailenson and the rest of the VHIL team, we have also demonstrated the world and received feedback from Dr. Brigid Barron, Dr. Roy Pea, and Dr. Claude Steele. Additionally, we described the world and received feedback from Dr. Stephen Spencer and Dr. Lauren Aguilar, social psychology researchers who have experience with stereotype threat and virtual environments. Their feedback has been overwhelmingly positive as well as helpful in refining both the in-world experience and the subsequent experimental measurements

In the winter, we were able to conduct two pilot runs of the experiment. The first, with four research assistants from the VHIL group, was to practice the experimental script and ensure that the technology worked correctly. The second pilot, with six female communications majors, provided a small amount of data and allowed us to adjust the manipulation to ensure that the maximum number of participants will believe the experience is true.

We will continue the full experiment with 100 participants throughout the spring of 2013 and look forward to analyzing the data and submitting a paper for publication in the summer.

## Introduction

This project investigates the effect of numerical representation as a situational cue for belonging in computer science classes. The core questions are whether being a numerical minority in a class affects students' interest and learning, and whether that effect varies based on the stereotypes of the domain.

Situational cues are one possible cause for social identity threat. Situational cues are indications in the physical environment, such as posters and other decorations, which send messages to the people in the environment. Social identity threat is a feeling people have that their contributions will not be valued or that they will be treated negatively because of an identity they hold. (Murphy, Steele, and Gross, 2007). One example is women in computing. Computing is a masculine discipline, both because most of the people who do it are men and due to its similarity to other masculine disciplines such as math and physical sciences (Correll, 2004; Correll 2001). Women in computing often experience identity threat, since being female is seen as inconsistent with being a good computer scientist (Margolis & Fisher, 2003).

A common example of social identity threat is stereotype threat, in which the risk of confirming negative stereotypes about one's group reduces performance (Steele & Aronson, 1995). Stereotype threat has generally been demonstrated in situations where the participant was a member of a group about whom there is a negative stereotype and where the participant was highly identified with the domain, such as female math majors. Status characteristics theory is a similar theory but has been more broadly applied. It posits that when there are widely-held cultural beliefs ascribing higher competence to one category of an attribute (e.g. men vs. women, adults vs. children) and when the status characteristic is salient, it will affect individuals' performance expectations and their task performance itself (Correll, 2004). Correll describes a model in which gender status beliefs (i.e. "this is a task at which men perform better than women") differentially affect men and women's self-assessment of ability and the performance standards they use, which influences career-relevant choices such as course enrollment. Thus, status characteristics theory suggests that both performance and attitude towards the domain can be affected by gender status beliefs, and that these effects may not be limited to individuals who are highly identified with the domain.

Cheryan et al. (2009) demonstrated that the decorations in a classroom can affect students' sense of belonging and interest in computing. They further tested the design of virtual classrooms (Cheryan, Meltzoff, & Kim, 2011), and found that stereotypically geeky decorations such as a Star Trek poster influenced women's intention to enroll in an introductory computer science class and belief about how well they anticipated doing in it. The results of the 2011 study in a virtual environment were similar to the results of the 2009 study, which took place in real life classrooms. Thus, it is clear that situational cues in virtual classrooms can promote similar responses to real classrooms.

Murphy, Steele, and Gross (2007) tested the hypothesis that numerical representation is a situational cue. They found that for women but not men, a gender imbalanced setting induced a feeling of not belonging. Their experiments were conducted using engineering majors. We intend to extend their work by including students who are not majoring in technical majors.

**Research Questions**

This project aims to investigate the relationship between the gender homogeneity of computer science classrooms and the interest and performance of students. Specifically, we will investigate the impact of different gender ratios on women's and men's interest, performance, and experience in computer science. We want to understand whether minority status affects men and women equally in a male-typed domain, and in this way understand whether the more relevant construct is stereotype threat or tokenism.

In order to understand the role of classroom homogeneity on students, we have two research questions:

1. How does the ratio of same-gender classmates correlate with interest in computing?
2. How does the ratio of same-gender classmates correlate with learning?
3. How do participants describe their experience in classes with different ratios of same-gender classmates?
4. Does gender underrepresentation in a male-typed environment affect women and

men similarly?

We predict that gender homogeneity will have a negative effect on comfort, interest, and learning in computer science classes for women but not for men. We predict that in a condition of high female enrollment, male participants will perform slightly worse but not significantly so, while in a condition of high male enrollment, female participants will perform significantly worse. We further predict that women's performance and interest may improve non-linearly with the percentage of same-sex classmates, with a sharp increase in measures between the 25% and 50% conditions.

## Experiment

### *Design*

This is a 2 (gender of the participant) X 5 (situational cue: gender composition of the class) factorial design. The five conditions for gender composition will be classes that are all male (0% female), 25% female, 50% female, 75% female, and 100% female. These conditions allow us to investigate the effect of different gender ratios, particularly whether gender parity is necessary or sufficient to overcome identity threat.

### *Participants*

The target sample consists of 100 undergraduate students who are not enrolled in computer science or other technical majors. Participants will be recruited through the psychology department pool and will be paid $20 for their participation.

The sample will be gender balanced, and within each gender, participants will be randomly assigned to one of the five conditions, so that 10 women and 10 men will be in each condition.

### *Materials*

A virtual reality environment has been programmed that appears to be a generic classroom with blank walls and windows along one side. There is a central table with students along three sides. Students are obviously male or female. The student agents were tested through an online survey and chosen from those identified as appearing under the age of 35 to closely mirror college students. The participant appears seated at the back of the classroom, to the left of center of the table. At the front of the classroom the instructor, a male avatar, stands at a podium; next to him is a projector screen. The appearance of the classroom can be seen in Figures 1 through 5.

Figure 1: 50% female condition, looking toward the right side of the classroom


Figure 2: 50% female condition, looking toward the left side of the classroom

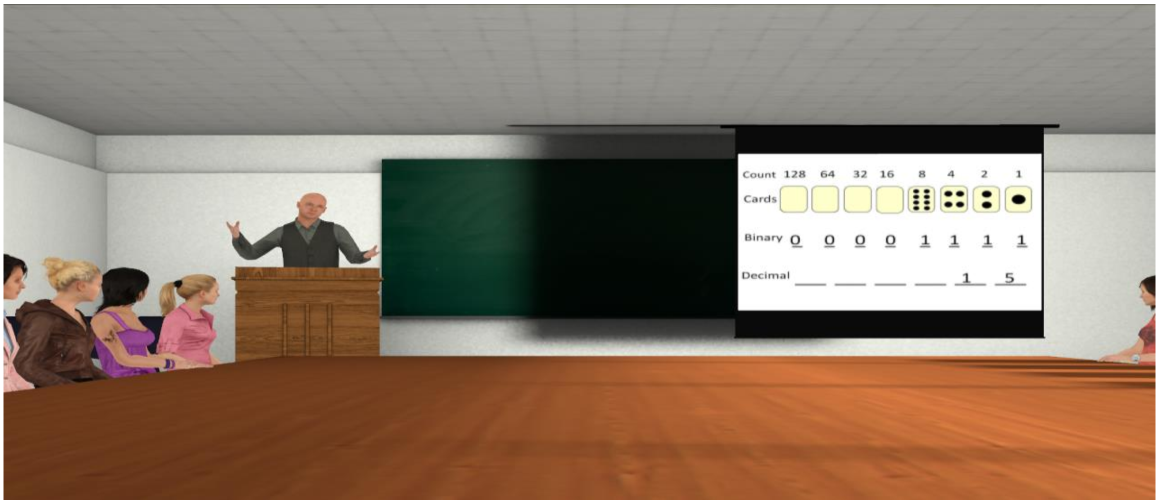

Figure 3: All-female condition, looking at front of classroom

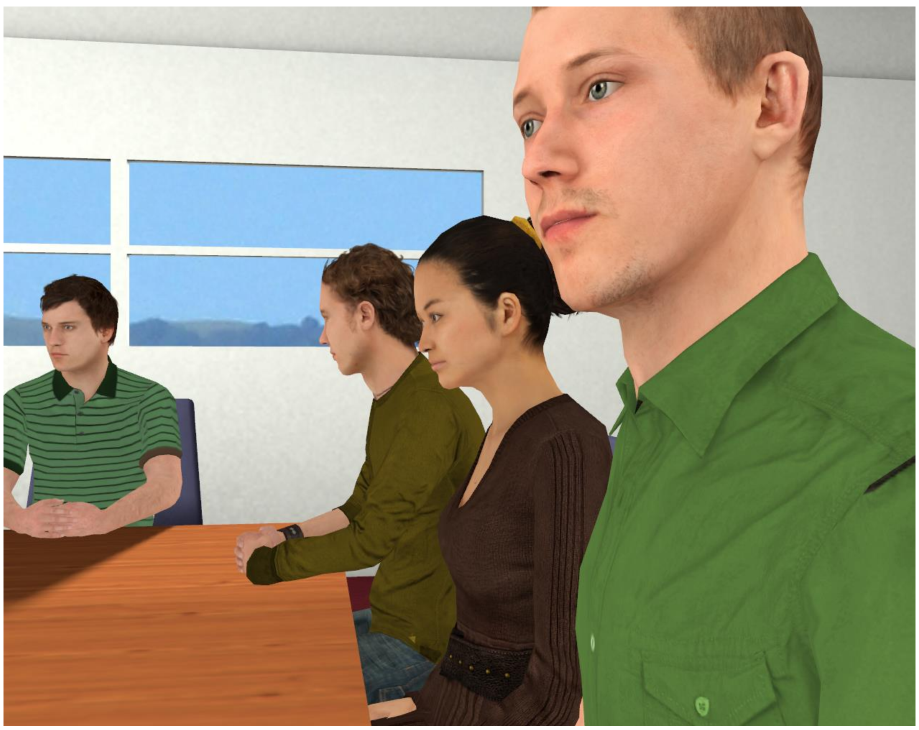
Figure 4: 25% female condition, looking to participant's right

Figure 5: All-male condition, looking to participant's left.

The instructor avatar moves freely while the audio recording of the lesson plays – he gestures with his hands and looks around the class. The student avatars can move their heads but are otherwise immobile. Early tests demonstrated that the male and female agents had different behaviors and that these could be quite distracting, for example female avatars looked at their watches while male avatars banged on the table. Removing the body motions removed these problems and avoided any gender-specific behaviors.

The computer science lesson is about binary numbers. There is a ten-minute audio recording and accompanying set of slides delivered by the instructor. The lesson is based on and established curriculum by Computer Science Unplugged (http://www.csunplugged.org) The lesson used in this project is available at http://www.youtube.com/watch?v=mR3g83_9Sus&feature=youtu.be

*Procedures*

Participants are told that the experiment is testing a new virtual reality implementation of university classes, one of many experiments in online learning being conducted by the university. To ensure that the participants' virtual experiences closely mirror real world experiences, they will need to believe that the other students are real people – while the other students will be completely virtual, participants are told that these other students are avatars for other real participants in the experiment.

Before entering the virtual reality classroom, participants complete a short questionnaire asking about interest in computing and experience, as well as two binary conversion questions to check for prior knowledge.

After completing the questionnaire, participants are instructed that they will be placed in a simulated classroom and asked to listen to a short lecture. They are told that other students are participating in the same class using a variety of technologies, and that avatars have been chosen for everyone that look approximately like them. They are directed that they will complete a test after the lesson and should pay close attention but do not need to take notes. Following this explanation, participants are placed in the headset, as shown in Figure 6.

Figure 6: Participant in virtual environment

Participants are told to look around for a couple of minutes while other students connect. After two minutes, an assistant knocks at the door and the researcher explains that there are connection problems, and asks the student if s/he can see certain other students shaking their heads, and to look at the instructor and shake his/her own head. After a short delay, the "problem" is fixed and the tests are repeated successfully (this time the other students can be seen to shake their heads). At that time, the lesson commences.

Following the lesson, the participant takes an online survey testing ability to convert numbers and attitude towards computer science as described in the measures section. The post-test concludes with a manipulation check to ensure that the participant believed the story that this is a test of an online course.

The experiment takes less than one hour.

*Measures*

*Learning*: A short quiz measures how much of the material presented in the lecture is retained and whether it can be applied to a novel situation. Participants are asked to convert from decimal to binary and binary to decimal, using both numbers demonstrated in the lecture and numbers not demonstrated in the lecture. Additionally, participants are asked to convert between ternary (base three) and decimal, a new task that uses the same logic as explained in the binary lesson.

*Attitude and Interest:* Participants are asked about their attitude towards computer science and their interest in taking computer science classes in the future and having a career in computing. Questions for this were taken from the Stanford Survey on Interest, Access and Experience with Technology.

*Actions:* The position and orientation of the participant's head and hands are continuously tracked throughout the VR experience. Prior work has shown that subject's body language can be an indicator of engagement and / or learning.

**Implications**

This experiment will provide insight as to whether gender ratio is a situational cue for belonging in a highly-stereotyped environment. It provides the opportunity to test learning as well as attitude and the effect of status characteristics threat on both, for students who do not highly identify with the stereotyped domain.

By creating a virtual environment that is a small-classroom setting, we hope that our results would be able to be generalized or tested in a variety of settings – small classes at colleges, high school and middle school classes, and discussion sections for larger university courses. The university is unlikely to modify enrollment choices by its students in major courses. However, small discussion sections accompany most introductory computing courses. If the gender ratio of classes affects student learning and attitude, it would be fairly straightforward to assign students to discussion sections using gender balance as a criterion (along with each student's time preferences and other criteria currently under consideration.)

**References**


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