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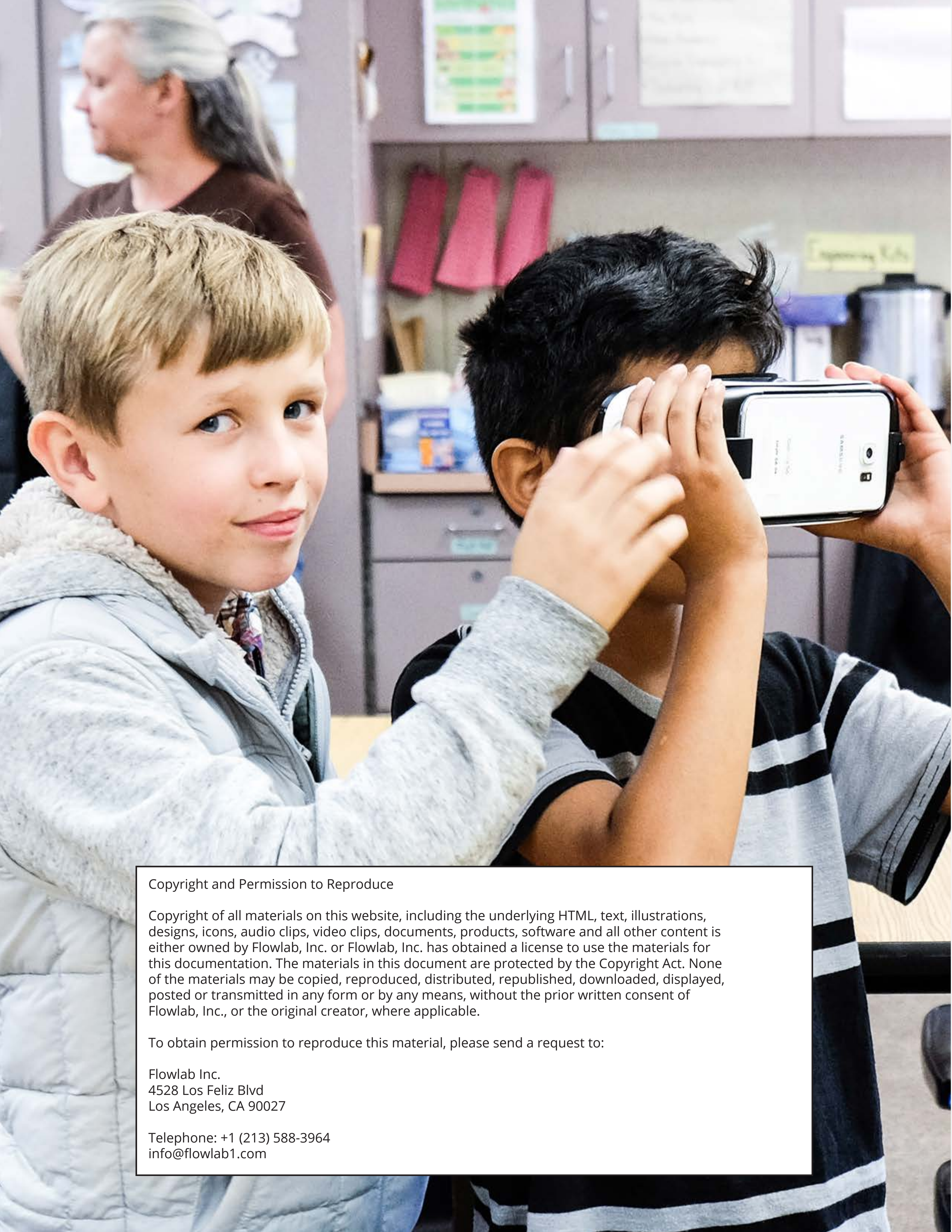
CONTACT INFO:
4528 Los Feliz Blvd
Los Angeles, CA 90027

+1 (213) 588-3964
www.flowlab1.com



IN ORDER TO CHANGE AN EXISTING PARADIGM YOU DO NOT STRUGGLE TO TRY AND CHANGE THE PROBLEMATIC MODEL. YOU CREATE A NEW MODEL AND MAKE THE OLD ONE OBSOLETE.

R. BUCKMINSTER FULLER

WELCOME

We at Flowlab appreciate your interest in this leading-edge initiative. The Focus Room project gives schools the opportunity to re-imagine and apply 21st century technologies to address the educational needs of behaviorally challenged students. As you will discover in this package, the adoption of these tools and practices can position your school's administrators and teachers as thought leaders in the reformation of disciplinary practices currently in use across the US.

The new tools and understandings that these pages describe will gives your teachers powerful new insights that they can use to instruct, inspire and engage students on a level never before possible. In collaboration, we can effectively build a bridge between teachers and students while developing an academic community based on the principles of honesty, mutual respect, tolerance and empathy. By firmly establishing in each of our students these principles for living, we will have laid the foundation for positive transformation and learning. Our mission is to fully engage and empower our students as we introduce each of them to a new world of possibilities.

William J Fort
CEO / CIO
Flowlab, Inc.

WELCOME TO THE FOCUS ROOM™

The Focus Room is a leading-edge project in the field of K through 12 education. The Focus Room takes a revolutionary approach toward improving the academic and social performance of behaviorally challenged students. The Focus Room offers a unique synthesis of traditional educational techniques updated and supported by cutting-edge technology. The result is an integrated system of learning that allows students to develop a comprehensive understanding of the mechanisms of successful interpersonal communication.

Immersive learning is the key to positive behavioral change and emotional resilience for students in the 21st century. The principles of emotional intelligence and mindfulness, and an understanding of personal narratives, must be integrated into the current curricula to help our students become more complete, knowledgeable, and compassionate human beings.

Behavior issues that interfere with teaching and learning have notably worsened, according to an astonishing 62% of teachers who have taught in the same school for five or more years. The results were reported in *Primary Sources: America's Teachers on the Teaching Profession.* The report, recently released by Scholastic and the

Bill & Melinda Gates Foundation, shows that this increased level of behavior problems has been seen across grade levels: Sixty-eight percent of elementary teachers, 64% of middle school teachers, and 53% of high school teachers say the same.

The problem affects the whole classroom. Behavior problems distract other students from learning and require teachers to spend precious instruction time on discipline and behavior management. Over half of teachers wish they could spend fewer school day minutes on discipline.

One elementary educator defined the problem this way: "The time it takes to referee fights and solve bullying issues takes away from academic instruction and keeps students from achieving as much as they could."

Concern about behavior issues was not limited to any particular demographic group. While teachers who worked in schools in low-income areas reported concerns about behavioral issues at a higher rate (65%), teachers who worked in high-income areas were not far behind. In high-income areas, 56% of teachers reported worsening behavioral issues that interfere with teaching and learing.

Teachers are committed to helping all their students succeed, including those with behavioral issues. However, they say that they need help. Overall, 64% of teachers say that they need more professional development and training to meet the needs of students with behavioral issues, while 72% need more tangible school resources. "We have no resources available," reported one middle school teacher, "no school counselors or social workers. A great deal of my time is spent trying to create an environment where students feel safe."

What constitutes a safe educational environment?

Safety has become a growing concern in our public school systems. Practices and policies intended to diminish the impact of behaviorally challenged students on the greater student population have not evolved in decades, and the control systems that are currently in place are completely ineffective. In our efforts to contain and manage troubled students, we have lost sight of education’s greater goal, which is to help every student on their path as they develop into knowledgeable and compassionate human beings.

The very foundations of humanity that allow for academic and social growth have been completely dismissed and replaced by policies that marginalize students who are already struggling with issues of self-worth. To create a safe environment for both students and teachers, these marginalized students must be educated in the principles of emotional intelligence, resilience, and interpersonal communication. They must be taught the value of these principles so that they learn to apply them to the improvement of their own lives, as well as the lives of those around them.

> **“Tell me and I forget, teach me and I may remember, involve me and I learn.”**
>
> **- Benjamin Franklin**

The Process

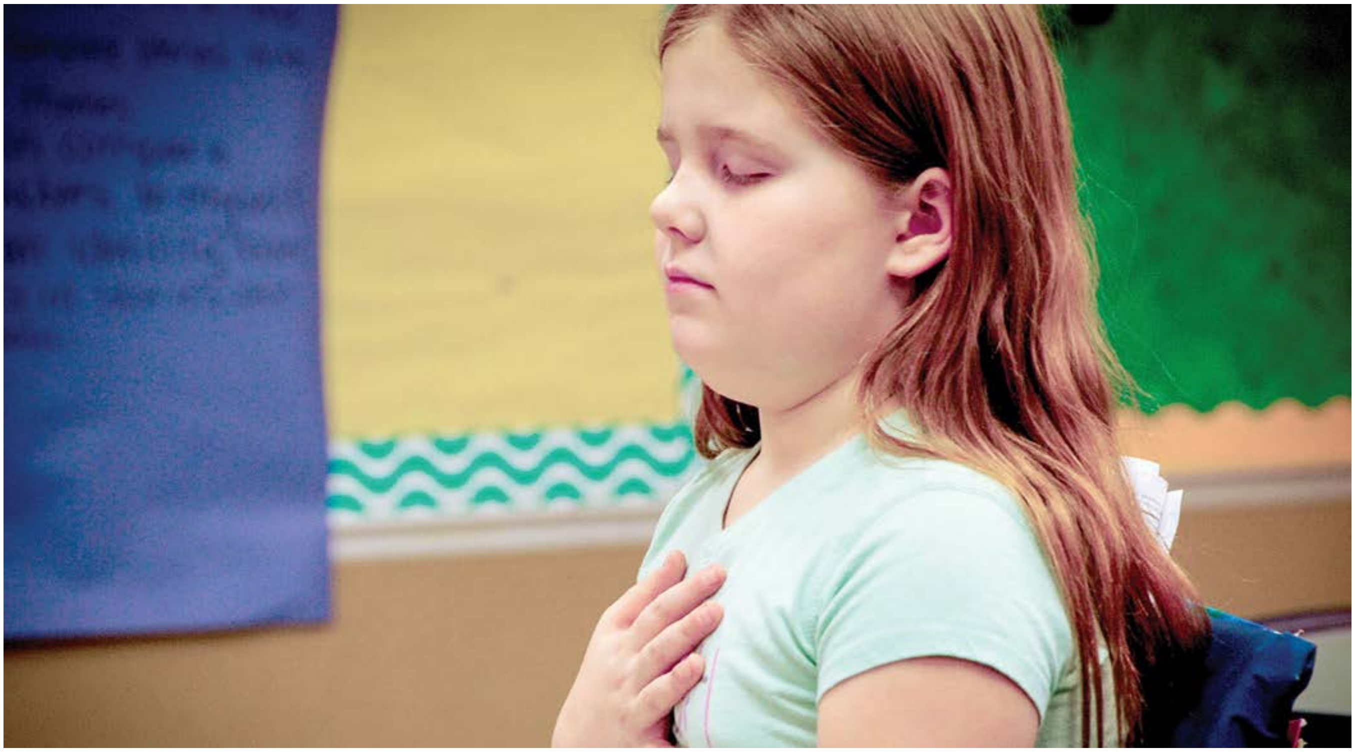
Innovation plays a key role in creating programs that properly inspire behaviorally challenged students to achieve their personal best, both academically and socially. We must engage, encourage, and inspire these students with new tools and technologies that radically alter the process of learning. Neuroscientific discoveries like Neuroplasticity have empirically demonstrated that lasting behavioral change can be achieved through proper conditioning and education. As educators, we must explore these avenues for change and shift the paradigm from processes that work from the outside in to processes that address behavioral issues from the inside out.

Synthesis/The Tools

We live in a multimedia-driven culture. Daily, each of us confronts a constant stream of images and information designed to capture and keep our attention. Advertisers and marketers alike prefer interactive solutions. Video and social media are valued over print because of their statistically proven ability to engage us on an emotional level and to increase our ability to retain information.

The Focus Room takes advantage of this understanding by delivering educational content to students in a language they understand—and that language is media. Social media, video, movies, and music are the most powerful tools of influence in the world today. Each of these tools must be incorporated into all contemporary curricula if we are to successfully capture and manage our students' attention.

The Foundation



The conditions that result in behaviorally challenged students are varied. However, behavioral challenges are primarily a product of the student's home environment. Physical and emotional neglect, addiction, violence, financially stressed parents, and single-parent environments are just a few of the factors contributing to a student's behavioral issues. These conditions do not provide the nurturing environment necessary for proper emotional development. The interpersonal skills that most students develop in their home environments are not present in these marginalized students. So, how do we as educators get through to these troubled children, who have been deprived of guidance during the crucial early developmental stages of their lives?

It is more than apparent that traditional methods do not work with these children. Thus, the individual student must perceive the methods employed as engaging and, more importantly, non-threatening. To foster a non-threatening environment in which younger and older students can comfortably develop emotional skills, we provide content that adheres to the principles of Gamification. Gamification is the concept of applying game mechanics and game design techniques to engage and motivate people to achieve their goals.

Gamification taps into the basic desires and needs of the user's impulses, which revolve around the idea of status and achievement. This is simple enough on the surface, but the behavioral and neurological principles that contribute to the success of this approach go much deeper. Engaging the student with gamified content increases the possibility of neuroplastic change in the brain. Repetition is an essential element of successful conditioning, so students must be intrinsically motivated to engage with the content. In simple terms, the student must choose to be involved in the process. They must feel empowered and sense that some level of autonomy is available to them in the environment. Developing emotional intelligence through gameplay is one example of The Focus Room's safe and sane solution for helping students with behavioral issues.

MEDIADROME

On a weekly schedule, the Mediadrome will deliver motivational videos to the classroom from a variety of speakers who reflect the ethnicity and cultural signposts of specific student audiences. Sports figures, musicians, and thought leaders from various professions will express the principles necessary for their success.

The Program

When approaching the care and instruction of behaviorally challenged students, we must thoroughly understand their model of the world. By doing so, we can create unique combinations of the many tools The Focus Room offers. Our methods go beyond a "one-size-fits-all" approach. The versatility of the modalities and tools we use allows for flexible models that can easily be tailored to the individual. The Focus Room program consists of both online and offline experiences and activities designed to encourage exploration, introspection, and positive expression.

INTAKE

The intake process is a crucial component of the successful integration of students into the Focus Room program. All students will receive a comprehensive personality survey to determine their aptitudes and potential challenges. This process will also help students gain valuable insights into themselves. The intention is that these insights on both sides can organically evolve into discussions between the students and The Focus Room instructors.

MINDFULNESS.

Mindfulness is the ability to pay focused attention to the present moment with kindness and compassion. The practice of this type of meditation is completely non-religious. Mindfulness focuses on the insights that can emerge from silence and the process of quieting the mind. Mindful practice is a simple and effective tool, and can be taught to children at any educational level. Mastery of mindful attention can result in the following benefits.

- Increased attention
- Increased executive function (working memory, planning, organization, and impulse control)
- Decreased ADHD behaviors—specifically, hyperactivity and impulsivity
- Fewer conduct and anger management problems
- Increased emotional regulation
- Increased self-calming
- Increased social skills and social compliance
- Increased care for others
- Decreased negative affect, or emotions
- Decreased anxiety in general and text anxiety in particular
- Decreased depression
- Increased sense of calmness, relaxation, and self-acceptance
- Increased self-esteem
- Increased quality of sleep

Students will be instructed in mindful practice in both group and individual settings. Virtual reality technology will be applied in individual sessions, when students may require a more focused and entertaining experience. The application of this technology gives more seriously challenged students a fun, non-threatening opportunity to absorb the concepts involved in mindful behavior.

THE STATS ARE IN:

97% of Students would like to study a VR course (VR in Education - Cerebrum Inc.)

Education is expected to be the 4th biggest sector in VR investment
(Augmented and Virtual Reality Survey Report)

VR in education is predicted to be a $200 Million dollar industry by 2025.
(Golmand Sachs Report)

Almost 80% of teachers have access to VR devices, but these are used regularly by only 6.87% of teachers
(The State of Technology in Education Report 2016)

93% of teachers said their students would be excited to use virtual reality. (Samsung Survey of U.S. K-12 Educators)

7 out of 10 teachers want to use VR to simulated experiences relevant to the material being covered
(Samsung Survey of U.S. K-12 Educators)

49% of high school teachers would use VR to allow students to visit college campuses to encourage further education
(Samsung Survey of U.S. K-12 Educators)

69% of teachers said that they would use VR to allow students to visit distant locations
(Samsung Survey of U.S. K-12 Educators)

5 INCREDIBLE WAYS THAT VIRTUAL REALITY IS IMPROVING EDUCATION

The VR revolution looks here to stay this time. Gaming and Movies are creating many of the headlines, however the use of VR in classroom is set to take the education sector by storm. Here are five benefits of using Virtual Reality in the classroom:

PUPILS ARE TAKEN TO PLACES THEY WOULD NEVER NORMALLY GET TO VISIT

Imagine visiting the natural history museum in London, without even leaving the classroom? Well trips like this are now made possible with virtual reality. Incredibly useful not only from a cost and time saving point of view, but students who haven't the means to ever go on a field trip, now have the chance to visually experience the wonders of the world in just a click of a button.

IT ENABLES TEACHERS TO ASSESS THE PROGRESS OF STUDENTS

The advance of VR is allowing teachers to assess student comprehension in the moment of learning. This can include real-time assessments and instant polling. It can specifically be used to help teachers consider the emotional impact of their learning activities, assessments and teaching methods.

HELPS STUDENTS PREPARE FOR EMPLOYMENT

Virtual reality can help make a student's time in the classroom more effective in preparation for the job market. For example, it's now possible to take virtual job interviews or learn health and safety on a construction site for example. Technology can even allow medical students to safely prepare infusions for patients without the need of a physical body. Practical engaging learning that will assist in preparation for future employment.

ASSISTS STUDENTS WITH DISABILITIES

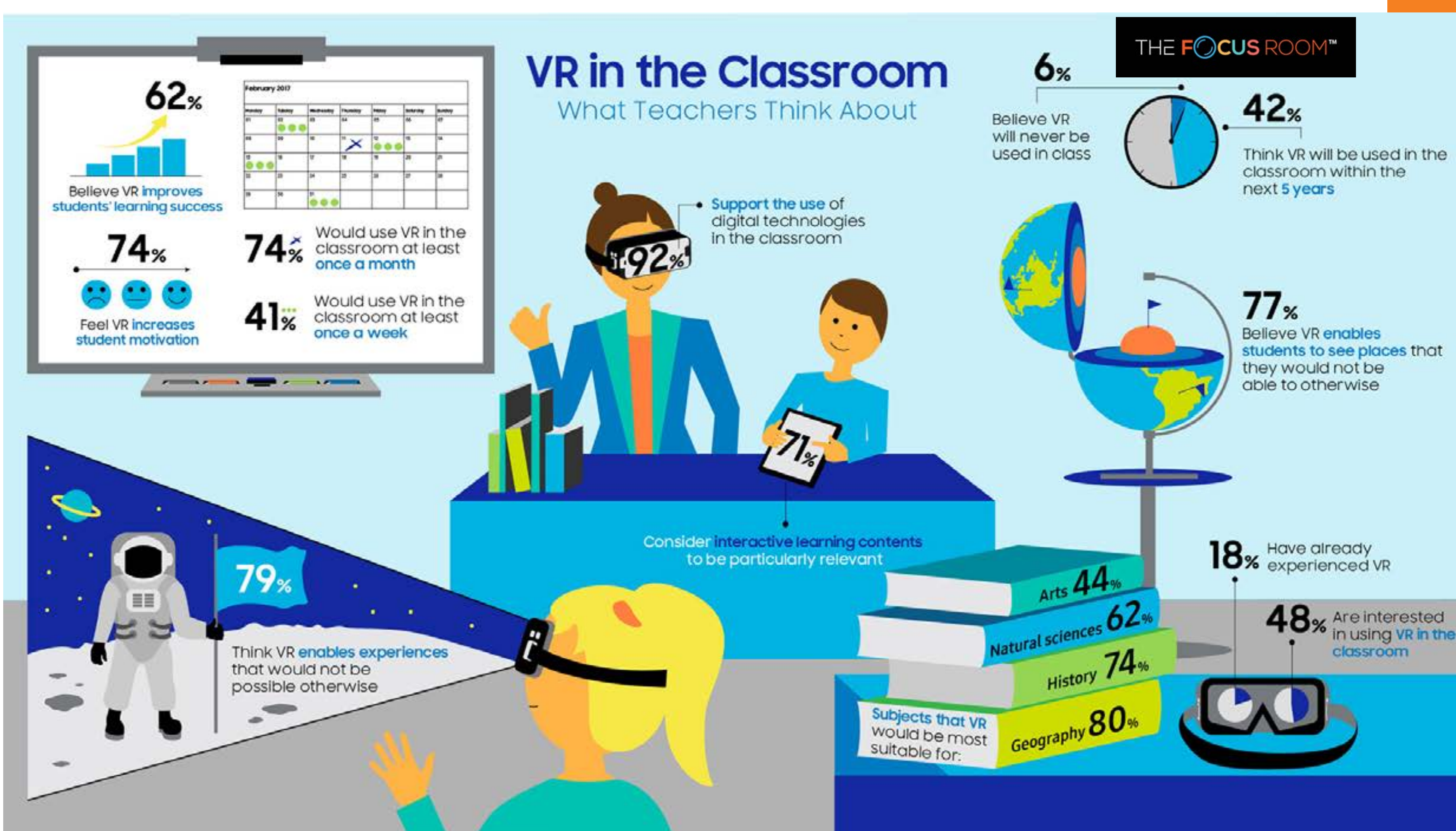
Whether it be a physical or emotional disability, the aid of VR can help them to flourish. There are no physical boundaries with VR. Programmes and apps can be tailored made to assist those whose progress was once slow using traditional teaching methods. It opens up a number of doors of opportunity that was once deemed closed.

IMPROVES STUDENT'S ENGAGEMENT

Let's face it, trying to keep fully engaged whilst a teacher is speaking or writing on the board, can be difficult at the best of times. Research has shown that we remember 20% of what we hear, 30% of what we see, and up to 90% of what we do or simulate. It is scientifically proven that Virtual Reality keeps the user fully engaged and immersed in their new environment. It is an active rather than passive way of learning.

EXPRLORE AND DISCOVER.

The world view of most behaviorally challenged students is incredibly small. Violence, neglect, and other factors contributing to the child's behavior create a type of cultural tunnel vision that often focuses specifically on the more negative aspects of the human experience. Explore and Discover allows students, through virtual reality technology, to explore and interact with the world on a scale never before possible. Students can meet and interact with students from countries around the world. The experiences and autonomous access available to students encourage an atmosphere of curiosity beyond their limited knowledge and experience. The process of opening the students' minds to potential future opportunities is an important part of their rehabilitation.



THE FOCUS ROOM™

Imagine students learning how to control their moods while controlling online games, drones, and holograms with their minds. The Neurosky head-set allows them to do just that, while also giving teachers the brain (EEG) and behavioral data they need. The Neurosky is a revolutionary BCI (Brain Computer Interface) creating fun, engaging experiences that allow students to learn emotional control through gameplay. Repetition is a vital component of effective behavioral conditioning. The Neurosky encourages students, through gameplay, to play again and again, ensuring effective results related to issues of focus, attention, and impulse control.

NEUROSKY GAMEPLAY.

The Focus Room Online

SOCIAL MEDIA

Social media is part of every child's life in the 21st century. On any given day, teens in the United States spend about nine hours using media for their enjoyment, according to a report by Common Sense Media, a non-profit focused on helping children, parents, and educators navigate the world of media and technology. The Focus Room Online gives students the opportunity to not only participate in an online community, but to understand the dynamics of its creation.

About Flowlab

Flowlab works with psychiatrists, psychologists, therapists, media specialists, educators, govermental agencies, and private industry to pursue advancements in wellness and human performance through the use of protocols from the fields of psychology, behaviorism, neuroscience, and state-of-the-art technologies.

Programs are designed and implemented for use in either a clinical setting in our Los Angeles facilities or custom designed for onsite or remote use for organizations. In late 2018, Flowlab will be launching its online streaming platform. The mission of Flowlab is to unlock limitless possibilities that exist in each one of us.

Training

At Flowlab, we understand that even with the application of advanced technologies, it is people who make the difference. Wherever there is a Focus Room, there will be passionate and dedicated staff who oversee its operation. Flowlab selects as trainees the most progressive teachers whose eyes are on the future of education.

In our training, these individuals will learn new tools and communication techniques that enable them to achieve a greater understanding of their students' motivations. They can then apply these new understandings in dynamic new ways. The methods that Flowlab employs for The Focus Room are all based on the tenets of positive psychology. With this in mind, it is our duty, in all our efforts, to find what is right about a child as opposed to focusing on what is wrong.

As educators, we must discover the "diamond in the rough" that exists in every child, and bring that diamond into the light. The Focus Room training addresses a child's deficiencies in inner development. The Focus Room staff will act as guides who empower students by showing them their natural inner potential and demonstrating to the student ways they can harness that potential and use it for positive influence and achievement in the world.

Team Management

WILLIAM JAMAAL FORT

CEO/CIO

Mr. Fort's career in the industries of media, simulator development, and human performance spans over 30 years. Digital Domain, Walt Disney Imagineering, and Showtime Networks are just a few companies where he refined his creative acumen. He segued his media skills into simulator development with Virtual Reality Mariner a division of The Seaman's Church Institute. Mr. Fort's expertise, research, and development of systems and proprietary protocols culminated in the formation of Flowlab, Inc. Mr Fort and the Flowlab team are currently working with the U.S. Navy and Johns Hopkins Applied Physics Lab on programs designed to encourage innovation and improve human resilience.

CAPT. James Fitzpatrick EdD

Director of Education

James Fitzpatrick is an educator and creator of results-driven curricula. He has worked in field of simulation engineering as a developer and trainer. Dr. Fitzpatrick is a full professor at Massachusetts Maritime Academy and specializes in all forms of simulation training. He also consults with U.S. Navy on simulation practicum at Newport Naval Station's Surface Warfare Officers School (SWOS).

Flowlab Inc.
4528 Los Feliz Blvd
Los Angeles, CA 90027

Telephone: +1 (855) 275-7775
info@flowlab1.com

Schools Use Mindfulness to Reform Student Behavior

The Huffington Post

February 22, 2017

Schools Use Mindfulness to Reform Student Behavior

huffingtonpost.com/entry/schools-use-mindfulness-to-reform-student-behavior_us_58ae03e6e4b01f4ab51c75d5

Linda Novick O'Keefe , Contributor Founding Chief Executive Officer, Common Threads February 22, 2017

“It’s not what you look at that matters, it’s what you see.” - Henry David Thoreau

In today’s fast-paced, interconnected world, how we deal with stress is becoming a top priority for improved overall health. The Mayo Clinic, American Psychological Association and American Heart Association have thoroughly documented the destructive power of chronic stress and its associated increased rates of depression, heart disease, high blood pressure, weight gain, memory impairment, sleep problems, digestive problems, muscle pain, anxiety and a myriad of other health issues.

Many of America’s top corporations and their executive leadership have put employee wellness on the front burner and with good reason. Dustin Moskovitz, co-founder of Facebook and Asana, has said, “Mindfulness has helped me succeed in almost every dimension of my life. By stopping regularly to look inward and become aware of my mental state, I stay connected to the source of my actions and thoughts and can guide them with considerably more intention.”

Building a culture of mindfulness leads to powerful outcomes. Aetna’s employees decreased stress levels by one third after doing just one hour of yoga every week, which reduced the company’s healthcare costs by an average of $2,000 a year, according to Financial Times. And, after General Mills instituted a seven-week employee meditation program, 83 percent of participating employees said they took time to optimize their daily productivity, a 60 percent increase from before taking the course.

Mindfulness techniques, also referred to as heart work, continue to be integrated into wellness frameworks across sectors as a way to promote the power of reflection, manage stress and support long-term brain health. Formal meditation (visualizations, breath work, forgiveness and reconciliation practices) and body awareness exercises (body scans, walking meditation, mindful yoga and movement) encourage constant awareness of our emotional state and surrounding environment. Simply put, the tone of the voice in our heads can change our relationship to stress by the second and allow us to better soak in the vibrant and catalyzing moments.

“I’ll tell you what freedom is to me: no fear.” - Nina Simone

Considered the “Godfather of Mindfulness,” Jon Kabat-Zinn founded The Center for Mindfulness in Medicine, Health Care and Society at the University of Massachusetts Medical School, which has had more than 22,000 people complete the school’s Mindfulness Based

Stress Reduction Program (MSBR), and more than 6,000 medical doctors and healthcare professionals refer their patients to the program to date. Participants reported a 38 percent reduction in medical symptoms, a 43 percent reduction in psychological and emotional distress and a 26 percent reduction in perceived stress.

"How you think and how you act can transform your experience with stress," explains Kelly McGonigal, a health psychologist from Stanford University, who has devoted her career to studying stress and our attempts to alleviate it.

In her TED Talk, McGonigal refers to a Harvard study in which participants were subjected to the "social stress test," a series of nerve-racking tasks designed to produce the physical symptoms of stress: faster heartbeat, heavier breathing, more sweating, and so on. The results showed that participants who reframed their perceptions of stress prior to the tests could actually improve their performance and demonstrate improved cardiovascular functioning, urging us to consider the possibility that there may be a real link between a mindful approach to stress and reduced risk of heart diseases.

Supporting McGonigal's claims is a recent study from Penn State University, which found that "how you perceive and react to stressful events is more important to your health than how frequently you encounter stress." Another recent study conducted by Professor Willem Kuyken at England's University of Exeter found that mindfulness therapy was similarly effective as antidepressant medication in preventing relapses among participants suffering from depression. The National Center for Biotechnology Information conducted a review of 209 studies related to the effects of mindfulness-based therapy. It concluded that mindfulness "is an effective treatment for a variety of psychological problems, especially reducing anxiety, depression and stress."

"Intelligence is the door to freedom and alert attention is the mother of intelligence." – John Kabat-Zinn

Stress can be especially detrimental to children, whose stress-response systems are not fully developed. This makes their brains and bodies more vulnerable to the effects of stress, especially for those in underserved communities who are exposed to violence, abuse, neglect and instability. These children face more stress on a day-to-day basis from hunger, lack of access to healthy food, often toxic home life, and living in less safe, more crime-ridden areas. A symposium at Columbia University's Mailman School of Public Health revealed that children who grow up in poverty are more susceptible to stresses that can "alter the architecture of a child's brain, impairing cognitive function, attention span, and the ability to regulate emotions."

Bringing mindfulness into schools gives children a chance to learn self-awareness and healthy habits, instead of falling into patterns of destructive behavior that could have potentially devastating consequences for their long-term health. Early adopting schools have already seen promising results.

Visitacion Valley Middle School in San Francisco, who along with its nonprofit partner, the Center for Wellness and Achievement in Education (CWAE), introduced Quiet Time in 2007, a program offering students two 15-minute periods of quiet rest and relaxation each school day to reduce stress and enhance social, emotional and cognitive development.

Over the next three years, 17 studies of the program revealed that Academic Performance Index and STAR standardized test scores improved for Quiet Time participants, especially among students whose grades had previously been below proficiency. Average GPAs, attendance and graduation rates rose while suspension rates declined. Students reported higher self-esteem, confidence and resilience, plus lower levels of stress and anxiety among a number of other improved psychological health factors.

“We have observed and teachers have told us that students seem calmer and happier during school,” said Jeff Rice, the CWAE’s Director of Operations. “They seem more motivated to sit down and focus on classroom lessons and absorb material, and they also appear to have better, more supportive relationships with their peers and with their teachers. Students have echoed that they have a better rapport with their instructors, who seem happier and more relaxed as well.”

Since inception, the Quiet Time program has helped over 10,000 children in the Bay Area. CWAE’s work has caught the attention of the U.S. Surgeon General, Dr. Vivek Murthy. He has visited Visitacion Valley and performed a TED Talk in which he shared the program’s ability to craft such a simple solution to substantially increase’ students happiness in a difficult environment.

“We believe the four pillars of good health are diet, exercise, sleep and meditation,” explains Rice. “Kids can’t learn meditation if they are hungry or don’t have enough energy to concentrate and stay focused.”

Rice isn’t alone. With a focus on positive outcomes, more schools and nonprofits have intentionally incorporated health and nutrition into their educational and curricular framework to create a more comprehensive health culture.

In Baltimore, the Holistic Life Foundation currently operates its Mindful Moment program in 17 local schools, serving 5,000 students per week. It has woven 15 minutes of meditation into the structure of every school day, and also created the “Mindful Moment Room,” a safe space for students who are being disruptive in class or just feeling stressed. There they have the opportunity to take about 20 minutes to relax, discuss the problem with a trained staff member and come up with mindfulness techniques to address similar situations in the future. HLF staff are uniquely qualified to help these at-risk students because staff members went through the program themselves.

“Our staff inspires me,” said Ali Smith, Executive Director and Co-Founder of the Holistic Life Foundation. “About half are former students of ours. These were kids who were getting in fights, in detention regularly and dropping out of school, but they were able to pull themselves back to center and share their experiences with other kids. They're amazing teachers because they can connect to other kids going through the same things they did."

The program has been initially successful in improving student behavior. During the 2013-14 school year, there were zero suspension of students in preK-fifth grade at HLF schools. At Patterson Park High School, the number of suspensions decreased by about 50 percent. Beyond those numbers, Smith says when he goes to observe schools, he can see a tangible difference in student behavior.

"We pay attention to how the school feels when we walk through it," Smith said. "You see a lot of situations with the potential for negative or violent behavior, and we're seeing a lot more of those interactions become positive…That self-awareness and self-accountability increase students' self-esteem and allow them to care more about how their actions affect themselves and their peers so they can start to aspire beyond just their neighborhood and dream about what is possible for them."

"All that is important is this one moment... Make the moment important, vital and worth living. Do not let it slip away unnoticed and unused." – Martha Graham

At the Creative Challenge Community School in Denver, the school's 300 students participate in two 15-minute mindfulness sessions each month, where the school's mindfulness program director and instructor, Melissa Kaufmann, who has been practicing yoga and mindfulness techniques herself since 2004, leads them in exercises to heighten their awareness of their thoughts, emotions and surroundings.

"The biggest behavioral change I have seen is the kids' ability to self-regulate," said Kaufmann, who left the fast-paced tech startup world to slow down her mind to be able to focus on her true passions. "They have the ability to access mindfulness tools they have learned like breathing, listening, expressing gratitude and generosity, and use them based on their present moment…The students are more kind to each other. They are able to be empathic and caring in the classroom, in the hallways, and on the playground."

The Erikson Institute, a graduate school in childhood development, received funding to study the effects of mindfulness in more than 30 underserved Chicago public schools over the next four years. They have implemented their Calm Classroom program in 16 low-income schools, with 14 additional schools being studied as a control group with no mindfulness learning involved. While data from the study will not be available until 2019, Amanda Moreno, an assistant professor at Erikson, says anecdotal results have been extremely promising.

"Many teachers tell us that outbursts and tantrums are down, and instructional minutes are up, due to the fact that mindfulness breaks make transitions go much more smoothly," Moreno said. "One assistant principal told us that he felt the program was responsible for that year's test score improvements, because they all did mindfulness techniques at the beginning of the testing sessions."

She says the sessions are not only easy to accommodate in the school day schedule, but they also help students find strategies to address their own social and emotional needs. One of the major advantages of using MBSR strategies is that after completing initial training in the techniques, students can access mindfulness tools at any time without the need for schools to invest in other resources or special environment conditions.

Early evidence points to the effectiveness of mindfulness techniques in reducing stress and increasing happiness in children and adults alike, but where does it go from here?

“There is a lot we still don’t know about mindfulness in children,” Moreno said. “If we want a comprehensive approach to social-emotional development within school walls, we need a way to extend mindful culture to the ocean of relationships we are always swimming in. Some programs, including ours, are testing innovative ways of doing this, such as including civic/greater good activities. We have developed an aspect to our program called Calm Community, in which children and teachers more publicly share how they apply mindful activities to the everyday challenges of school, so that everyone can have a good day.”

“Sometimes when people are under stress, they hate to think, and it’s the time when they most need to think.” – Bill Clinton

Mindfulness can sometimes be misinterpreted as trying to use meditation and yoga to reach a zen-like emotional equilibrium, an inner peace free of anger, worry or fear. Rather than shy away from life’s stressors by trying to control or suppress negative feelings, educators and children who participate in mindfulness programs glean insights about their own internal processes and behavior patterns, as well as a heightened awareness of their emotional state in each and every moment, pleasant or unpleasant.

These programs provide a toolkit to help children master how to intentionally reprogram their responses to challenging or uncomfortable situations, how to let go of negative thoughts and how to declutter their minds and pay attention to what is in front of them while leaving room for curiosity and course correction. With more data showing the benefits of addressing the needs of the whole child, we will hopefully see ignited interest in the integration of MBSR-based programs into a layered programmatic strategy in schools that helps children and adults build resilience and live with more ease and well-being.

The Use of Immersive Virtual Reality in The Learning Sciences: Digital Transformation of Teachers, Students, and Social Context

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The Use of Immersive Virtual Reality in the Learning Sciences: Digital Transformations of Teachers, Students, and Social Context

Jeremy N. Bailenson and Nick Yee
Department of Communication
Stanford University

Jim Blascovich and Andrew C. Beall
Department of Psychology
Stanford University

Nicole Lundblad
Department of Symbolic Systems
Stanford University

Michael Jin
Department of Computer Science
Stanford University

This article illustrates the utility of using virtual environments to transform social interaction via behavior and context, with the goal of improving learning in digital environments. We first describe the technology and theories behind virtual environments and then report data from 4 empirical studies. In Experiment 1, we demonstrated that teachers with augmented social perception (i.e., receiving visual warnings alerting them to students not receiving enough teacher eye gaze) were able to

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Correspondence should be addressed to Jeremy N. Bailenson, Department of Communication, Stanford University, 450 Serra Mall, Stanford, CA 94305-2020. E-mail: bailenson@stanford.edu

spread their attention more equally among students than teachers without augmented perception. In Experiments 2 and 3, we demonstrated that by breaking the rules of spatial proximity that exist in physical space, students can learn more by being in the center of the teacher's field of view (compared to the periphery) and by being closer to the teacher (compared to farther away). In Experiment 4, we demonstrated that inserting virtual co-learners who were either model students or distracting students changed the learning abilities of experiment participants who conformed to the virtual co-learners. Results suggest that virtual environments will have a unique ability to alter the social dynamics of learning environments via transformed social interaction.

INTRODUCTION

Many researchers have investigated the viability of *virtual environments* (VEs), digital simulations that involve representations of teachers, students, and/or content, for learning applications. In this article, we describe how VEs enable *transformed social interaction* (TSI), the ability of teachers and students to use digital technology to strategically alter their online representations and contexts in order to improve learning. We present evidence from a series of empirical studies that demonstrate how breaking the social physics of traditional learning environments can increase learning in VEs. Of course immersive virtual reality currently is not yet an easily acquired technology in classroom settings. Nevertheless, VEs are becoming more common place, and it is important to understand how this digital technology will aid the basic learning process.

In this Introduction, we first provide a discussion of the taxonomies of VEs in general and previous implementations of learning systems in VEs. We next provide an assimilation of the literature on learning in VEs, focusing on the unique affordances provided by VEs not possible in face-to-face settings, including explicating our theory of TSI. Finally, we provide an overview of the current experiments.

Definitions and Taxonomies of VEs

VEs are distinct from other types of multimedia learning environments (e.g., Mayer, 2001). In this article, we define VEs as "synthetic sensory information that leads to perceptions of environments and their contents as if they were not synthetic" (Blascovich et al., 2002, p. 105). Typically, digital computers are used to generate these images and to enable real-time interaction between users and VEs. In principle, people can interact with a VE by using any perceptual channel, including visual (e.g., by wearing a head-mounted display [HMD] with digital displays that project VEs), auditory (e.g., by wearing earphones that help localize sound in VEs), haptic (e.g., by wearing gloves that use mechanical feedback or air blast systems that simulate contact with object VEs), or olfactory (e.g., by wearing a nosepiece or collar that releases different smells when a person approaches different objects in VEs).

An *immersive virtual environment* (IVE) is one that perceptually surrounds the user, increasing his or her sense of presence or actually being within it. Consider a child's video game; playing that game using a joystick and a television set is a VE. However, if the child were to have special equipment that allowed him or her to take on the actual point of view of the main character of the video game, that is, to control that character's movements with his or her own movements such that the child were actually inside the video game, then the child would be in an IVE. In other words, in an IVE, the sensory information of the VE is more psychologically prominent and engaging than the sensory information of the outside physical world. For this to occur, IVEs typically include two characteristic systems. First, the users are unobtrusively tracked physically as they interact with the IVE. User actions such as head orientation and body position (e.g., the direction of the gaze) are automatically and continually recorded, and the IVE, in turn, is updated to reflect the changes resulting from these actions. In this way, as a person in the IVE moves, the tracking technology senses this movement and renders the virtual scene to match the user's position and orientation. Second, sensory information from the physical world is kept to a minimum. For example, in an IVE that relies on visual images, the user wears an HMD or sits in a dedicated projection room. By doing so, the user cannot see objects from the physical world, and consequently it is easier for him or her to become enveloped by the synthetic information.

There are two important features of IVEs that will continually surface in later discussions. The first is that IVEs necessarily track a user's movements, including body position, head direction, as well as facial expressions and gestures, thereby providing a wealth of information about where in the IVE the user is focusing his or her attention, what he or she observes from that specific vantage point, and what are his or her reactions to the environment. The second is that the designer of an IVE has tremendous control over the user's experience and can alter the appearance and design of the virtual world to fit experimental goals, providing a wealth of real-time adjustments to specific user actions.

Of course there are limitations to IVEs given current technology. The past few years have demonstrated a sharp acceleration of the realism of VEs and IVEs. However, the technology still has quite a long way to go before the photographic realism and behavioral realism (i.e., gestures, intonations, facial expressions) of *avatars*—digital representations of one another—in IVEs approach the realism of actual people. Moreover, although technology for visual and auditory IVEs steadily develops, systems for the other senses (i.e., haptic) are not progressing as quickly. Consequently, it may be some years before the technology rivals a real-world experience. And finally, some users of IVEs experience simulator sickness, a feeling of discomfort resulting from the optics of particular technological configurations. However, a recent longitudinal study has demonstrated that simulator sickness is extremely rare today, given the speed of current tracking and graphics systems, and also that the effects for a given user tend to diminish over time (Bailenson & Yee, 2006).

Collaborative virtual environments (CVEs) involve more than a single user. CVE users interact via avatars. For example, while in a CVE, as Person A communicates verbally and nonverbally in one location, the CVE technology can nearly instantaneously track his or her movements, gestures, expressions, and sounds. Person B, in another location, sees and hears Person A's avatar exhibiting these behaviors in his or her own version of the CVE when it is networked to Person A's CVE. Person B's CVE system then sends all of the tracking information relevant to his or her own communications over the network to Person A's system, which then renders all of those movements via Person B's avatar, which Person A can see and hear. This bidirectional process—tracking the users' actions, sending those actions over the network, and rendering those actions simultaneously for each user—occurs at an extremely high frequency (e.g., 60 Hz).

Traditionally, researchers have distinguished *embodied agents*, which are models driven by computer algorithms, from avatars, which are models driven by humans in real time. Most research examining learning in VEs has utilized embodied agents (as opposed to avatars; see Bailenson & Blascovich, 2004, for a discussion). One reason for this disparity is that readily available commercial technology allowing individuals to create digital avatars that can look and behave in real time like the persons they represent has emerged only recently. Previously, producing real-time avatars that captured the user's voice, visual features, and subtle movements was quite difficult. Consequently, understanding the implications of the visual and behavioral veridicality of an avatar on the quality of interaction is an important question that has received very little empirical attention.

As the technological barriers to creating CVEs have decreased, a growing number of researchers have created CVEs specifically as educational platforms. For illustration, we discuss three implementation approaches with case studies. The first approach leverages observations that online games are highly engaging and attempts to create CVEs that reward activities performed offline. One well-known educational example is Quest Atlantis (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005), wherein students engage in a variety of "quests"—mostly offline tasks that vary in duration, domain, and complexity. Quests may require students to interview family and friends, research community problems, or produce advocacy media. By completing quests, students earn points and gain status in addition to privileges in the VE. In this sense, Quest Atlantis is a mixed platform—the VE provides a reward structure for tasks that largely need to be performed offline.

Another approach is to embed both the task and reward within the VE. An example is the River City project (Clarke & Dede, 2005), a multi-user VE for learning scientific principles and hypothesis testing built using design-based research. In River City, students interact with one another and the town's inhabitants via avatars using typed chat as they investigate and develop hypotheses regarding one of three strains of illness in the town. The researchers identified several experiences that exemplified "neomillennial learning styles" (p. 4). First, the environment created an immersive experience that allowed students to become shapers of a scientific experience rather than passive observers. Second, River City allowed students to shed an identity of a "'student failing science' and take on the identity of a scientist" (p. 5). And finally, the immersive experience also encouraged critical thinking by actively engaging students. It is worth noting that these three features would not be present in systems using the first approach, because the reward structure in and of itself does not provide these features.

A third approach has been to leverage existing online environments instead of creating them from scratch. For example, researchers from the University of California at Los Angeles collaborated with developers of the children's online environment Whyville to engineer a virtual pox epidemic in an attempt to increase awareness of and learning about epidemics and vaccinations (Foley & La Torre, 2004). The pox was spread by proximity and interaction. Vaccinations could be used to immunize against the pox, but a vaccination shortage (modeled from flu vaccine shortages in the real world) made it impossible for every user to be immunized. Users infected with the pox would occasionally sneeze (thereby replacing some of their typed chat), and spots would appear on their avatars' faces. Researchers found that the event led to a dramatic increase in users exploring the medical libraries in Whyville, and science topics in chat and message boards increased by 2000%. This comparatively informal approach illustrates how VEs could be used to increase interest and inquiry in specific topic areas.

Unique Affordances of VEs for Learning

Researchers in many disciplines (e.g., the learning sciences, computer science, psychology, communication) have studied the use of VEs for learning. The strongest case for VEs as learning modules stems from their ability to implement contexts and relationships not possible to achieve in a traditional learning setting. In this section we review a number of the unique learning opportunities VEs provide.

Embodied agents that teach and learn. One paradigm used in learning sciences seeks to create intelligent virtual agents who teach a learner about a specific domain (see Badler, Phillips, & Webber, 1993, for an early example; or Moreno, in press, for a recent review). For example, Rickel and colleagues have explored the use of virtual agents in teaching users how to perform complex mechanical tasks (Rickel & Johnson, 1998) as well as how to respond to crises in which both emotional and cultural factors have to be considered (Hill et al., 2003).

The latter study is noteworthy for implementing a natural language processing interface as well as producing agents that can behave and react with a wide range of emotional tones. A similar use of virtual agents that employ natural language processing can be found in work by Graesser, Wiemer-Hastings, Wiemer-Hastings, and Kreuz (1999), who created a virtual tutor for teaching the fundamentals of hardware and operating systems.

Work in this area has also explored virtual agents that encourage the construction rather than consumption of knowledge. For example, Cassell (2004) implemented a digitally augmented dollhouse that encourages children to tell stories as a way of promoting literary competencies. It is also worth noting that the virtual agent in this dollhouse is presented as a young boy, and thus this approach provides a learning paradigm whereby the user perceives the agent as a same-age playmate rather than an authoritative teacher. Similar work by Schwartz, Pilner, Biswas, Leelawong, and Davis (in press) has shown that when agents encourage students to teach them, learning improves as students process the information while teaching the agents. Virtual agents not only allow a user to enter into a learning experience at his or her own convenience, but they can also provide personalized one-on-one learning experiences tailored to the individual that would be prohibitively expensive otherwise (Baylor & Kim, 2005).

Co-learners. Although virtual teachers allow users to learn any time any where, one trade-off is that oftentimes users must give up the contextual environment of the classroom as well as other students. From a communities of practice point of view (Wegner, 1998), the absence of a social group of peers is a significant drawback to the typical individualized learning environments with virtual teachers. Indeed, students learning in social conditions (whether cooperative or competitive) outperform students in individualistic conditions (Johnson, Johnson, & Skon, 1979). And students studying with a partner remember more factual material than when studying alone (Wood, Willoughby, Reilly, Elliot, & DuCharme, 1995).

However, it is possible to populate a virtual learning environment with virtual co-learners (Kim & Baylor, 2006; Lee et al., in press). Moreover, research in interactive agents (Reeves & Nass, 1996) has suggested that people may respond to behaviors of a virtual co-learner similarly to how they respond to human co-learners in a virtual classroom. Thus, the aforementioned benefits of co-learners could conceivably be harnessed in VEs. And finally, virtual co-learners can be programmed to behave specifically to enhance each user's learning, something that cannot be done as easily with real students in a classroom.

Of course, it may be argued that much of the benefit from co-learners is due to dialogue or shared reasoning, an experience that is hard to create with virtual agents. However, some research has shown that co-learners can improve learning through their behaviors alone. In a study of virtual co-learners (Ju, Nickell, Eng, & Nass, 2005), it was found that varying a co-learner's behavior can enhance a user's performance. In Ju et al.'s study, users learned Morse Code alongside a co-learner. Users next to a high-performing co-learner performed significantly better themselves than users next to a low-performing co-learner. Thus, virtual learning environments provide unique opportunities to leverage the benefit of co-learners, whether through highly interactive agents that can provide a shared reasoning and dialogue experience, or via behaviors alone in a simpler system.

Visualizations. VEs can provide enhanced visualizations and a range of perspectives into complex information (Salzman, Dede, Loftin, & Chen, 1999). For example, the ability to create, alter, and rotate an architectural, engineering, or chemical structure in real time three dimension can make it easier to understand abstract concepts (Perdomo, Shiratuddin, Thabet, & Ananth, 2005).

In addition to providing visualizations of complex information, VEs also provide the ability to take on multiple perspectives of the same scenario. Studies have shown that different perspectives make salient different aspects of the same environment (Ellis, Tharp, Grunwald, & Smith, 1991; Thorndike & Hayes-Roth, 1982). For example, in Thorndike and Hayes-Roth's study on knowledge acquired from maps as opposed to navigation, it was found that maps allowed people to make better judgments of relative location and straight-line distance between objects, whereas navigation allowed people to more accurately estimate route distances. VEs can easily provide users with multiple perspectives on the same situation—central, peripheral, bird's-eye view, and so on—to make different aspects of the situation salient.

Finally, VEs can provide not only visual cues but, with the integration of other technologies, haptic and auditory cues. These additional cues can benefit learning in several ways. First of all, additional sensory cues provide a more realistic and engaging learning experience (Psotka, 1996). But more important, the addition of haptic cues allows users to acquire proficiency in activities that require eye–hand coordination, such as surgical skills. For example, a virtual training tool in surgical drilling with haptic feedback helped users perform an analogous task in a physical environment (Sewell et al., 2007).

Synthesis of archived behaviors. One of the great advantages of digital VEs is that every single action that is rendered (i.e., shown to the users) must be formally represented in order to appear to the users. Consequently, all actions performed by every single student or teacher, ranging from microbehaviors such as nonverbal gestures to macrobehaviors such as performance on an exam, can be constantly recorded over time. By storing and assimilating this data, VEs promise to provide a tool to create behavioral profiles and summaries on a scale not possible face to face.

For example, Rizzo and colleagues (2000) automatically collected the gaze behavior of students in a virtual classroom via head-tracking devices and used patterns of attention and gaze to diagnose deficits in attention among children. In a more complex and naturalistic learning environment, researchers utilized a network methodology to track the interaction among students and teachers over a 1-week period (Barab, Hay, Barnett, & Squire, 2001) and provided a framework for using historical data to map out the relationships between actions, conceptual understanding, and context. Finally, other researchers have utilized digital video as a way of archiving and tracing learning patterns through collaborative groups (see Roschelle, Pea, & Sipusic, 1989, for an early example). As the behavioral tracking systems become more elaborate, the ability to use this information to track student performance and consequently improve learning systems should become a major advantage of using virtual classrooms.

Presence, immersion, and learning. The construct of *presence* has often been used as a metric to evaluate the utility of a VE. Although there is no consensus on an exact definition of presence, the general notion concerns the degree to which the user actually feels as if he or she is present in the VE (as opposed to present in the physical world). Attempts at capturing the subjective experience of presence in an objective manner have proceeded along several different lines, including questionnaire ratings (Heeter, 1992; Held & Durlach, 1992; Short, Williams, & Christie, 1976; Witmer & Singer, 1998), physiological measures (Meehan, 2001), and behavioral measures (Bailenson, Blascovich, Beall, & Loomis, 2003; Mania & Chalmers, 2001; Welch, 1999). Despite broad research on the topic of presence, reliable measures are still lacking, and much debate as to how to quantify the construct exists (for various viewpoints, see Heeter, 1992; Lombard & Ditton, 1997; Loomis, 1992; Slater, 1999; Zahorick & Jenison, 1998).

One argument for using VEs in the classroom is that learners can feel more psychologically present in a virtual simulation than is possible in other types of traditional learning venues (Kafai, 2006; Kafai, Franke, Ching, & Shih, 1998). For example, researchers are demonstrating that when students actually experience learning material in an interactive video game context, they learn in unique manners (e.g., Barab et al., 2005). Similarly, by using IVEs, students can feel present in a virtual body that is not their own (Lanier, 2001). For example, work by Yee and Bailenson (2006) demonstrated that college-age students who are forced to take on the first-person visual perspective of a senior citizen in a VE develop more empathy toward elderly adults than students who take on the perspective of a young person. Finally, by using virtual technology to bring together large groups of students in the same virtual class (see Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004, for a plausible short-term design strategy for such an environment), students may collaboratively experience course material in a way not possible from lectures, movies, or interactive problem-solving tasks.

Simulation of dangerous or expensive lessons. There is also a line of research using VEs to teach lessons that are either too expensive or too dangerous to conduct in physical space. For example, Stansfield, Shawver, Sobel, Prasad, and Tapia (2000) designed and tested fully immersive systems to train emergency response workers such as firefighters and bioterrorist response units. By using realistic virtual depictions of dangerous crises, learners can experience the chaos and affective stressors that are typically accompanied with actual crises. Similarly, there have been a number of studies that have used virtual simulations to train surgeons (see Sutherland et al., 2006, for a systematic review of this work). The advantage of virtual surgery training simulations is that cadavers, a natural alternative, are extremely rare and expensive, whereas virtual patients, once built, are extremely cheap to duplicate.

TSI. Recent research in the learning sciences has stressed the importance of understanding the social aspects of digital learning environments (Allmendinger, Troitzsch, Hesse, & Spada, 2003; Bielaczyc, 2006; Enyedy, 2003). Because CVEs render the world separately for each user simultaneously, it is possible to interrupt or distort the normal physics of social interaction and to render the interaction differently for each participant at the same time. In other words, the information relevant to a CVE participant is transmitted to the other participants as a stream of information that summarizes his or her current movements or actions. However, that stream of information can be transformed on the fly and in real time for strategic purposes. The theory of TSI (Bailenson, 2006; Bailenson & Beall, 2006; Bailenson, Beall, Loomis, Blascovich, & Turk, 2004) describes the potential of these real-time transformations. We discuss three dimensions for transformations during interaction: self-representation, social-sensory abilities, and social environment.

The first dimension of TSI is *self-representation*, the strategic decoupling of the rendered appearance or behaviors of avatars from the actual appearance or behavior of the humans driving the avatars. Because CVE interactants can modulate the flow of information, thereby transforming the way in which specific avatars are rendered to others, rendered states can deviate from the actual state of the interactant. For example, in a virtual learning paradigm, it could be the case that some students learn better with teachers who smile and some learn better with teachers with serious faces. In a CVE, the teacher can be rendered differently to each type of student, tailoring his or her facial expressions to each student in order to maximize that student's attention and learning.

The second dimension is transforming *social-sensory abilities*. These transformations complement human perceptual abilities. One example is to render *invisible consultants*, either algorithms or humans whose information is only visible to particular participants in the CVEs. These consultants can either provide real-time summary information about the attentions and movements of other interactants (information that is automatically collected by the CVE) or scrutinize the actions of the users themselves. For example, teachers using virtual learning applications can utilize automatic registers that ensure they are spreading their attention equally toward each student.

The third dimension is transforming the *social environment*. The contextual setup of a virtual meeting room can be optimally configured for each participant. For example, while giving a speech in front of an audience, the speaker can replace the gestures of distracting students with gestures that improve the ability of that speaker to concentrate. Furthermore, by altering the flow of rendered time of the actions of other interactants in a CVE, users can implement strategic uses of "pause," "rewind," and "fast forward" during a conversation in an attempt to increase comprehension and productivity.

Overview of Experiments

We report results from four preliminary experiments designed to demonstrate the utility of CVEs for studying learning sciences. All four studies utilized the paradigm of TSI to improve learning.

In Experiment 1 we utilized a transformation of social-sensory abilities, manipulating whether participants teaching a room of virtual students received cues warning them when any of the virtual students had been outside of the teaching participants' visual field of view. We predicted that teachers with this augmented perception would be able to more uniformly spread their mutual gaze than teachers with normal perception.

In Experiment 2 we utilized a transformation of social environment, specifically the location in a virtual classroom where participants sat while being presented with a verbal lesson from a virtual teacher. Because the CVE can be transformed differently for multiple learners simultaneously, it is possible for each of two students to both sit in the same place in a virtual room (i.e., an optimal location for learning) while believing he or she is the only student in that spot. Participants received two learning passages, one directly in the center of the teacher's visual field of view and one in the teacher's periphery. We predicted that students would learn the passage better when sitting in the center.

Experiment 3 was a replication of Experiment 2, manipulating the distance between student and teacher instead of the angle. We predicted students sitting closer to the teacher would learn better than students sitting farther away.

In Experiment 4 we transformed social environment by inserting virtual colearners around a participant listening to a verbal lesson from a virtual teacher. The co-learners were either model students, paying attention to the teacher enthusiastically, or alternatively were distracting students who did not pay attention to the teacher. We predicted that students would conform to the behaviors of the co-learners and would learn more in the model student condition than the distracting student condition.

In all four of our studies, the learning process was operationalized as a teacher transmitting information via lecture to students who were tested on recall shortly thereafter. There has been much discussion concerning the ability of students to learn from traditional lectures delivered by an instructor (i.e., *telling models*; Smith, 1996) compared to a more active learning process in which students interact with people and materials (i.e., *constructivist models*; Cobb, 1994). As a whole, the field currently leans toward the constructivist model as the more optimal learning paradigm (see Baylor & Kitsantas, 2005, for a recent discussion). However, some researchers have been reconsidering the role of delivering information in the classroom. For example, Schwartz and Bransford (1998) provided evidence that telling via lecturing can be effective if the students have preexisting, well-differentiated knowledge about a given domain. Their results demonstrated that when students were trained to form sufficiently developed categories within a topic, they utilized lecture material effectively. More recently, Lobato, Clarke, and Ellis (2005) proposed that telling can be reformulated if researchers focus on the function of telling rather than the form, the conceptual content of telling rather than the procedural aspects, and the relationship of telling to other actions instead of telling in a vacuum. Their key insight was that telling can act as a mechanism to initiate other actions and consequently can result in effective learning if formulated properly.

In the current work, our goal is not to imply that the fundamental activity in teaching and learning is lecture and recall. Instead, we envision the telling process as merely a common component of many teaching approaches, including some that also include constructivist processes. By isolating components of teaching and learning, we are best able to test our theories of TSI in virtual reality. Ideal learning environments of the future are likely to blend both real interactions with virtual ones, as well as telling processes with active/constructive ones. However, before arriving at the optimal combination of component processes, we are beginning to test one individual component in the current work.

EXPERIMENT 1: AUGMENTED SOCIAL PERCEPTION AND EYE GAZE

Design

Participants in this study acted as teachers interacting in a virtual classroom with nine virtual students, each of whom exhibited prerecorded head movements. Two between-subjects variables were manipulated. The first variable was augmented social perception; a teacher either did or did not receive real-time information about his or her gaze behavior via the opacity of each student's digital representation. The opacity level of each student was directly related to the amount of gaze provided by the teaching participant, such that students would become increasingly translucent while out of the teacher's field of view. The second variable manipulated was requirement to lecture; participants either had to talk to the students during the length of the study, or they did not.

Participants

Forty undergraduate students (20 men and 20 women) participated in the study for course credit or pay. There were 10 participants in each of the four between-participants conditions resulting from crossing augmented social interaction (present vs. absent) with requirement to lecture (required vs. not required).

Materials

The virtual setting. The immersive, three-dimensional virtual classroom contained a long, slightly curved table behind which nine virtual student agents were seated, and a podium behind which the teacher (i.e., the participant) was standing (see Figure 1). Participants could see the student agents as well as their own torsos (if they looked straight down). We avoided using student agents whose faces were extremely attractive or extremely unattractive according to previously a pretested database (Yee & Bailenson, 2007).

Head movements of virtual students. We conducted a pilot study to collect realistic-looking head movements for the nine virtual students used in this study in order to ensure that the gazes of the students would be appropriate for the exact seat location setup of the room. In the pilot study, 36 undergraduate students (14 men and 22 women) listened to a recorded virtual teacher give an 8-min lecture about the pharmaceutical industry in the same virtual learning environment as was used in Experiment 1. Each participant was randomly assigned a seat in the classroom (out of the nine possible seats). The other eight student agents exhibited previously recorded realistic head movements. In the pilot study, 36 participant head movement sessions of 8-min in length were recorded: four different recordings for each of the nine seat positions. For the main study, we randomly selected one of the recordings from the pilot study for each of the nine seating positions so that the participant teaching the lesson could see realistic head movements of the student agents.

Apparatus

Figure 2 depicts a person wearing the HMD, which allows the participant to see and interact in the virtual world. The HMD contains a separate display monitor for

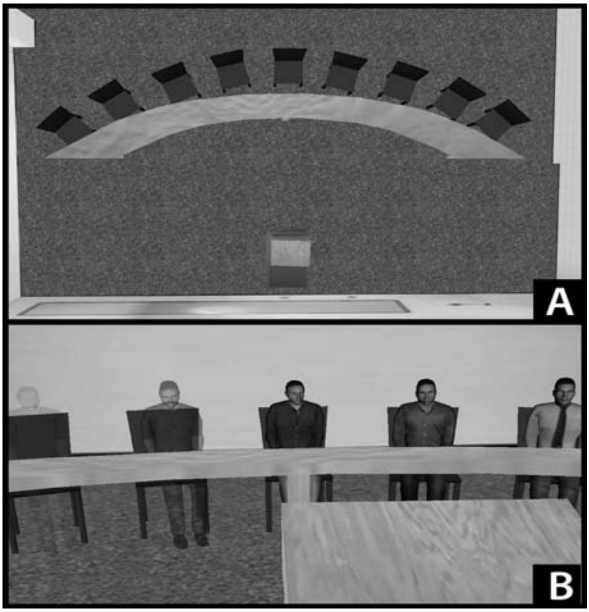

FIGURE 1 A bird's-eye view of (A) the virtual learning environment and (B) the specific viewpoint of a participant as he or she teaches the virtual class.

FIGURE 2 A simulated participant wearing the equipment: (1) head orientation tracking device, (2) rendering computer, (3) head-mounted display, (4) game pad used to record responses.

each eye (50° horizontal × 38° vertical field of view with 100% binocular overlap). The graphics system rendered the virtual scene separately for each eye (in order to provide stereoscopic depth) at approximately 60 Hz. That is, the system redrew the scene 60 times per second in each eye, continually updating the simulated viewpoint as a function of the participants' head movements, in order to reflect the appropriate movements. The system latency, or delay between a participant's movement and the resulting concomitant update in the HMD, was less than 45 ms. The orientation of the participant's head along the *x*, *y*, and *z* planes was tracked by a three-axis orientation sensing system (Intersense IS250, update rate of 150 Hz). The software used to assimilate the rendering and tracking was Vizard 2.53. Participants wore either a nVisor SX HMD that featured dual 1,280 horizontal × 1,024 vertical pixel resolution panels or a Virtual Research HMD that featured dual 640 horizontal × 480 vertical pixel resolution panels.

Procedure

When participants arrived at the laboratory, they were given paper instructions to read that differed according to the experimental condition to which they had been randomly assigned. Participants required to lecture were told they would have to lecture verbally and nonverbally with nine virtual students for 8 min, teaching them about certain topics, whereas participants not required to lecture were told they would only have to interact nonverbally with the nine students. Participants in the augmented social perception condition were told that students would fade in and out according to how much the participants looked at them. Participants in all four conditions were instructed that they should attempt to spread their eye gaze equally between all nine students:

> We are using this virtual reality simulation to examine how teachers use eye gaze to engage students while teaching. Given that students learn better while receiving eye gaze, it is helpful for teachers to spread their gaze among all of the students in a class. In this experiment, we want you to do your best to move your head around often in order to spread your eye gaze equally between all nine students.

After participants finished reading the paper instructions, they were shown how to wear and adjust the HMD. Once comfortable with the HMD, participants found themselves in a classroom, standing behind a podium in front of nine empty chairs placed behind a long, slightly curved desk (see Figure 1). When the participant indicated that he or she was ready begin, the experimenter began the experiment. At this point, the empty chairs were filled with the virtual students. At any given moment, participants could only see about a third of the virtual students due to the field of view of the HMD. If the participant had been assigned to teaching conditions, then prompts concerning different topics of discussion appeared in the top of the field of view and changed every 30 s. The participant was required to discuss each prompt with the students in the class. If the participant had not been assigned the conditions to teach, then no prompts appeared. If the participant had been assigned to the augmented social perception conditions, then the student agents changed opacity according to how much they were looked at by the participant, with a student degrading linearly from fully opaque to fully translucent in 15 s if kept out of the participant teacher's field of view. Although the students turned translucent, the chairs the students were sitting in remained opaque in order to ensure the teacher knew a student was supposed to be sitting there. If the participant had not been assigned to the augmented social perception conditions, then all of the students remained opaque the entire time. At the end of 8 min, participants removed the HMD and were thanked for their participation.

Results and Discussion

The main dependent variable was *gaze inattention*, or the amount of time students were completely kept out of the teacher's field of view. Figure 3 shows the percentage of time students were ignored as a function of the nine seats for the augmented social perception condition and the nonaugmented social perception condition. We collapsed the nine seats into the location variable: center seats (the five seats in the middle) and periphery seats (the set of four seats defined by the two on the outside left and the two on the outside right). We then ran an analysis of variance (ANOVA) with location as a within-subjects variable, augmented social percep-

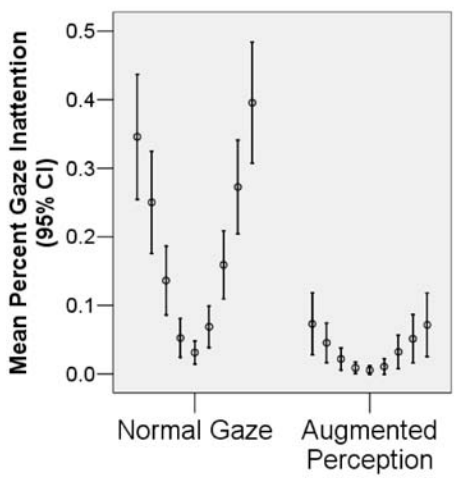

FIGURE 3 Mean percent inattention by the nine seat locations for each condition in Experiment 1 for the participants with and without augmented social perception. Higher numbers on the *y* axis indicate more inattention. CI = confidence interval.

tion and requirement to lecture as between-subjects variables, participant gender as a covariate, and gaze inattention as the dependent variable.

There was a significant main effect of location, $F(1, 35) = 44.69$, $p < .0001$, $\eta^2 = .53$. As one can see in Figure 3, students in the periphery were ignored more than students in the center. There was also a main effect of augmented social perception, $F(1, 36) = 46.22$, $p < .0001$, $\eta^2 = .51$, such that teachers with augmented perception ignored students less than teachers without augmented perception. In addition there was an interaction between location and augmented perception, $F(1, 36) = 35.90$, $p < .0001$, $\eta^2 = .43$; as Figure 3 shows, augmented perception reduced inattention more in the periphery than in the center. Finally, there was an interaction between augmented perception and requirement to lecture, $F(1, 36) = 5.89$, $p < .02$, $\eta^2 = .07$, such that students were ignored most in the no augmented perception, no lecture condition, most likely due to the extreme boredom resulting from no task or change in visual stimuli.

In this study we demonstrated that alerting participants to shortcomings in their own gaze behavior while teaching virtual students results in a more even distribution of gaze than a simulation without augmented perception. The classroom shape chosen in the current study lent itself to ignoring students in the teacher's periphery. However, when augmenting the rendering of the students to include information about mutual gaze, the teachers ignored students in the periphery much less than teachers without augmented social perception. In other words, the additional social cues increased the ability of the teacher to maintain joint attention through eye gaze (i.e., Clark, 1996) with the students in the classroom. Given that a prerequisite of any substantive communication is to establish common ground (Clark & Brennan, 1991), it is essential to engage students using gaze as a tool to increase their attention (Argyle, 1988) and to increase teachers' ability to monitor all students' degree of attention simply by including those students in their field of view.

Although we demonstrated that the gaze of the teachers changed dramatically in the current study as a function of augmented social perception, we did not attempt to demonstrate that this change in gaze actually would make teachers more effective with real students in a CVE. The goal of the current study was to demonstrate that augmenting a teacher's perception with social information about his or her eye gaze results in better distribution of gaze in a classroom. It could be the case that the specific algorithm we chose to make the virtual students transparent resulted in head movements by the teacher that actually were not conducive toward better learning (e.g., perhaps the movements were excessively fast or jerky). The current study demonstrated that it is possible to change a teacher's nonverbal behavior while he or she is delivering a lecture to a class using TSI in a virtual classroom. By determining optimal nonverbal strategies for various learning scenarios, researchers can provide teachers with the tools to increase their ability to engage students.

EXPERIMENT 2: TRANSFORMED PROXIMITY

Overview

CVEs allow experts to remove many of the physical constraints of social interaction. For example, in the physical world, a presenter can only maintain eye contact with one person at a time, whereas in a CVE, because every audience member sees his or her own rendition of the shared space, it is possible to render separate versions of the presenter, one who appears to maintain eye contact with each audience member at the same time. We call this transformation *augmented gaze*. Eye gaze enhances persuasion (Morton, 1980) and teaching effectiveness (Fry & Smith, 1975; Ottenson & Ottenson, 1979; Sherwood, 1987) and leads to physiological arousal (Wellens, 1987). In a previous study in which a presenter read a persuasive passage to two listeners using augmented gaze, we found that the transformation enhanced agreement and attention (Bailenson, Beall, Loomis, Blascovich, & Turk, 2005; Beall, Bailenson, Loomis, Blascovich, & Rex, 2003).

In Experiment 1, we demonstrated that, in the normal teaching condition without augmented social perception, students on the periphery received less eye gaze from the teacher than students in the center of the room. In this study, we wanted to explore the use of technology and space (see Bielaczyc, 2006, for a review of this concept). Specifically, we explored the idea of changing a student's seat virtually and examined the effect of seat change on learning. In other words, given normal teacher behavior, there may be a *privileged seat*, or a seat that optimally engages the student, in any given classroom. Using TSI it is possible to have two students sitting in one single privileged seat simultaneously (and each of them believing the other student is sitting somewhere else). In the current study, we examined this use of *transformed proximity* by having the same participants learn passages in the center of the room and in the periphery, and then examined the differential learning in each spot.

Design

Participants in this study were students in the exact same virtual classroom as used in Experiment 1. Each sat in one of the learning spots, either right in the center or on either the extreme left or right end (see Figure 4). The shape of the virtual seating arrangement was intentionally created to keep the distance between the teacher and students the same in the two positions while varying only the angle between the front-on position of the teacher and the student. Within subjects, we manipulated seat location; participants sat in either the center or periphery (half of the participants sat in the left periphery seat, and half sat in the right). There were two separate learning passages, one on how the human body fights fevers created by Okita and Schwartz (2006), and one on the pharmaceutical industry. Participants re-

FIGURE 4 A participant's view of the virtual classroom from (left) the periphery and (right) the center.

ceived one passage from the virtual teacher in each seat, and across participants we counterbalanced which seat they sat in first, which passage was received first, and which passage was paired with each seat in a Latin Square design. The volume of the audio from the teacher was kept constant at all seat locations.

Participants

Participants were 32 Stanford University students (16 women) who received $10 for their participation in this study.

Materials

There were two passages delivered verbally by the teacher. The gender of the teacher always matched the gender of the participant, and each of the two passages was recorded in both a male and female voice. Both the fever passage and the pharmaceutical passage were approximately 4 min long, and each had a series of multiple choice questions relating to the verbal content of the passage. The passages as well as the multiple choice questions are listed in the Appendix.

The virtual teacher utilized prerecorded idling movements (i.e., generic "default" behaviors preprogrammed to look realistic) in terms of his or her arms, posture, and head, which were designed to model those of a typical teacher. Furthermore, as the virtual teacher spoke, the lips were synchronized with the volume of the recorded passage. The other eight seats in the classroom were filled with virtual student agents who used the same idling head movements that were collected in the pilot study of Experiment 1. The apparatus and virtual world were identical to those described in Experiment 1.

Procedure

When participants arrived at the laboratory, they were given paper instructions to read based on the experimental condition to which they had been assigned. The instructions indicated that they would be hearing two separate verbal passages by a virtual teacher and would be answering questions about those passages. The experimenter then instructed the participant on how to put on the HMD and use the game pad to answer the questions (see Figure 2). When the participants indicated that they understood the instructions, they put on the HMD and hit a button to begin the first lesson. After the virtual teacher finished delivering the first passage, the teacher and the students disappeared while the participant used the game pad to answer the multiple choice questions about the passage. The questions appeared one at a time. After the participant finished answering questions about the first passage, he or she switched seats in the virtual room, and then the teacher and the students reappeared. The same process then repeated itself with the second passage.

Measures

Learning. We used scores for each of the multiple choice tests after each passage and report scores as percent correct. The mean score of the fever passage was 52% ($SD = 22\%$), and the mean of the drug passage was 74% ($SD = 23\%$). It is important to note that these scores should not be interpreted in the absolute sense, in that there is no norm for performance given this learning material.

Gaze. We computed the percentage of the total time that the students kept the teacher within their field of view. On average, students kept the teacher within their field of view (i.e., some part of the teacher's head was visible to them) 55% of the time ($SD = 17\%$).

Results and Discussion

We ran an ANOVA with learning as the dependent variable; seat (center or periphery) as a within-subjects factor; and order of seat location (center first or second), order of passage (fever first or second), and participant gender as covariates. There was a significant effect of seat location, $F(1, 28) = 4.51$, $p < .05$, $\eta^2 = .14$, with students in the center ($M = 68\%$, $SEM = 4\%$) performing better than students in the periphery ($M = 58\%$, $SEM = 4\%$). There was also a significant effect of gender, $F(1, 28) = 13.55$, $p < .001$, $\eta^2 = .33$, with men ($M = 73\%$, $SEM = 4\%$) performing better than women ($M = 52\%$, $SEM = 4\%$). No other main effects or interactions were significant, all Fs < 1.3, all ps > .25.

We next ran an ANOVA with gaze as the dependent variable; seat (center or periphery) as a within-subjects factor; and order of seat (center first or second), order of passage (fever first or second), and participant gender as covariates. The only significant effect was an interaction between seat and order of seat, $F(1, 28) = 4.94$, $p < .03$, $\eta^2 = .15$. As Figure 5 shows (as well as post hoc examinations of 95% confidence intervals of the estimated marginal means), students ignored the teacher most when moved to the periphery seat after sitting in the center compared to the other three cells. None of the other main effects or interactions were significant, all Fs < 2, all ps > .15.

In this study, we demonstrated that students learn better when sitting in front of the teacher than when sitting in the periphery. Furthermore, there was a contrast effect, such that students sitting in the periphery after being first put in the privileged seat looked at the teacher less often than students in all other conditions. The results from this study are similar to our previous work showing the power of teacher gaze in virtual simulations in which we transformed teachers' gaze behavior by redirecting the gaze of a single teacher directly at the eyes of two students simultaneously, thereby demonstrating more social influence for teachers who transform their gazes than teachers who can only look at a single student at one time (Bailenson, Beall, Blascovich, Loomis, & Turk, 2005). In this study, however, we demonstrated that by keeping the teacher's gaze constant, but reconfiguring the spatial geometry of the room, a set of students can learn better if they are all sitting in the center. This strategy of transforming proximity may be more effective than using algorithms to automatically transform and redirect a teacher's gaze because the latter technique involves making head movements and gaze behavior artificial. In contrast, transformed proximity allows a teacher to use natural, realistic head movements but simply increases learning by allowing a number of students to be in the privileged spot to receive those head movements simultaneously.

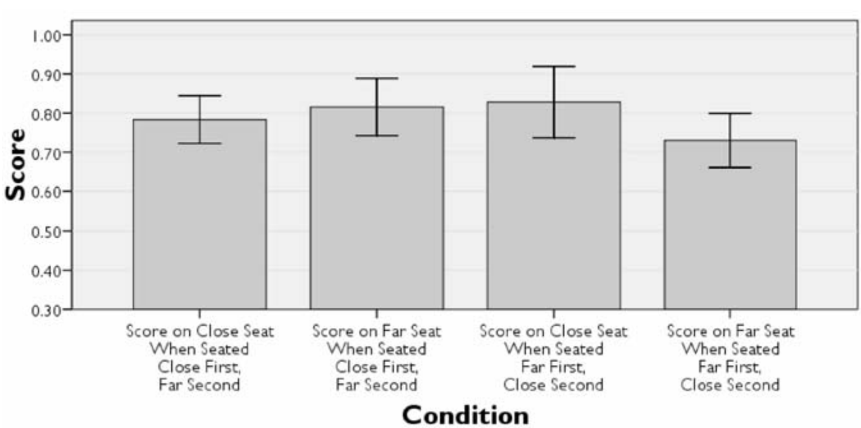

FIGURE 5 Mean gazes and 95% confidence intervals toward the teacher by seat location and seat order in Experiment 2.

We also demonstrated a main effect of gender, such that male scores were approximately 20 points higher than female scores. We did not predict this difference, so our explanation is necessarily ad hoc. This effect may have occurred because, culturally, men tend to have much more experience using video-game-like interfaces (Cassell & Jenkins, 1998; Yee, 2006) and consequently may have felt more comfortable using the IVE system in the experimental setting.

EXPERIMENT 3: TRANSFORMED PROXIMITY—DISTANCE

Overview

In Experiment 3, we sought to replicate the results of increasing learning from transforming spatial proximity via seat location from Experiment 2 by varying the distance between the student and the teacher instead of the visual angle from the front of the teacher. In this study, the angle between the students and the teacher was kept constant while we manipulated the distance between the persons.

Design

Participants performed as students in the virtual classroom depicted in Figure 6. We manipulated two variables in this study. The first, seat location, was manipulated within subjects; participants sat in two different virtual seats close (2.5 m) to the teacher and two different virtual seats far (8.5 m) from the teacher. The 8-min learning passage on pharmaceutical drug companies was broken into four segments. Participants received each learning segment at one of the four seats. Order of seat location, learning passage, and pairings between the two were varied via a Latin Square design. Each of the four learning segments was paired with specific test questions based on the content from that portion of the passage. The second variable, classroom population, was manipulated between subjects; either the other virtual seats were full of virtual students exhibiting the same recorded idling behaviors used in the previous studies, or the classroom was empty except for the participant and the teacher. Figure 6 depicts a bird's-eye view of both conditions.

Participants

Participants were 44 Stanford University students (20 women) who received $10 for their participation in this study.

Procedure

The procedure was very similar to Experiment 2, with the only difference being that the complete 8-min passage on pharmaceutical companies was broken into

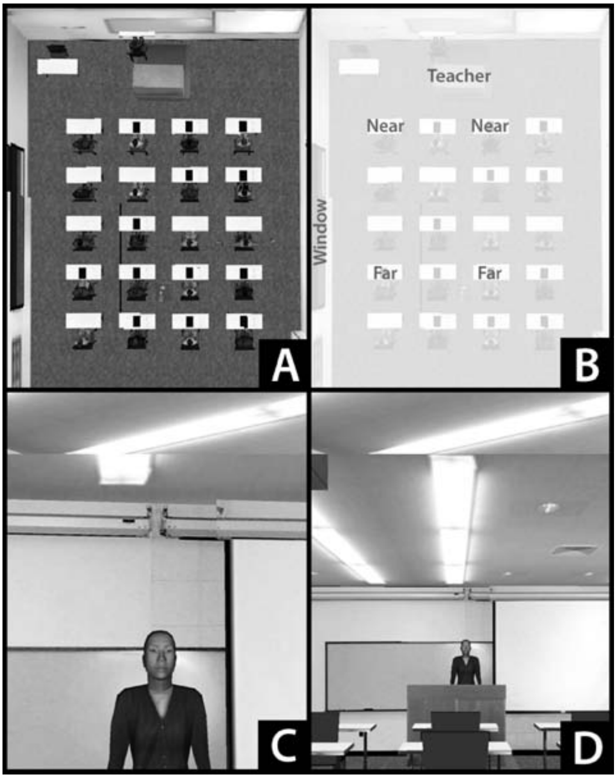

FIGURE 6 Different viewpoints in the virtual classroom: (A) a bird's-eye view of the room layout, (B) the locations of the teacher and participants in the two distance conditions, (C) the participant's viewpoint from the near position, (D) the participant's viewpoint from the far position.

four, 2-min clips, and participants switched among the four seats between clips. Participants answered questions about the passages after hearing all four of the clips.

Materials

The virtual classroom. The virtual setting approximated a standard classroom. Students were arranged in four rows of five seats each (and desks were left unoccupied in the empty condition). The teacher was located at the front of the classroom behind a desk. Behind the teacher was a blackboard. To the right of the blackboard was a screen for projections. A window that showed several red-brick buildings in a campus-like setting was located to the left of the students (see Figure 6).

Measures

The learning score was based on how well participants did on questions designed to test the specific content from the 2-min segments for each seat. We generated four questions for each of the two segments, and we computed a percentage correct for each participant based on his or her results from close seats and results from far seats. The questions are listed in the Appendix. The average learning score was .77 (SD = .13).

Results and Discussion

We ran a repeated measures ANOVA with distance (close vs. far) as a within-subjects factor, occupancy of the classroom (full vs. empty) as a between-subjects factor, participant gender and order of seat location (close first vs. far first) as covariates, and lecture score as a dependent variable. There was a main effect of distance, $F(1, 40) = 6.80$, $p = .01$, $\eta^2 = .13$. Participants learned more information from the lecture when they were close to the teacher ($M = .77$, $SE = .04$) than when they were far from the teacher ($M = .74$, $SE = .04$).

There was also a significant interaction between order of seat location and distance, $F(1, 40) = 5.36$, $p = .03$, $\eta^2 = .10$, as illustrated in Figure 7. Again, we observed a contrast effect such that students learned better when sitting close to the teacher (i.e., the privileged seat) after they had sat in the far seat. None of the other interactions were significant, Fs < .70, ps > .45. In sum, although there was a small main effect of distance of about three percentage points, this difference became magnified after students contrasted a seat position with their previous position;

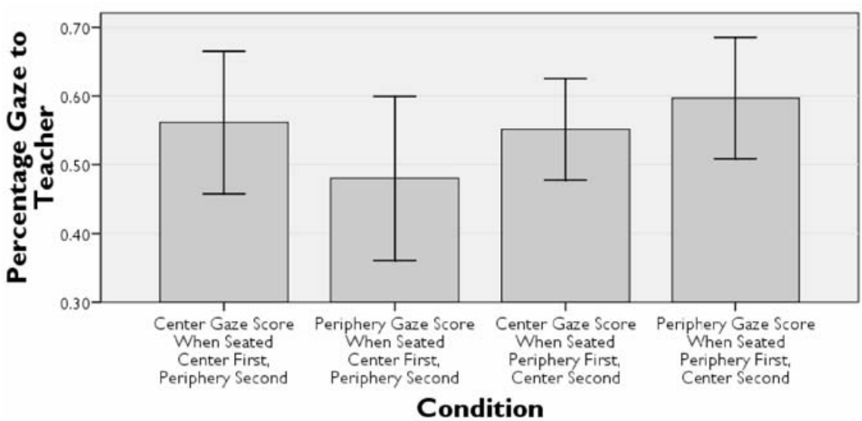

FIGURE 7 Mean test scores and 95% confidence intervals by seat and seat order in Experiment 3.

specifically, performance improved most when they moved from the far seat to the close seat.

The results of both Experiments 2 and 3 were surprising, given that our manipulations occurred within subjects. Conventional wisdom indicates that students tend to select their spot in the classroom; some like the back of the room, some like the front. In the current studies, we demonstrated that, on average, students do learn better in specific privileged seats. The possibilities of transforming proximity during learning via CVEs are not negligible—even with relatively small effect sizes. Considering a class of 100, if each student can occupy the privileged seat, then small shifts in percentages may make considerable differences in terms of the group as a whole.

EXPERIMENT 4: TRANSFORMED CONFORMITY

Overview

Conformity is one of the most powerful aspects of social influence (Asch, 1955; Festinger, 1954). Previous research in CVEs (Blascovich et al., 2002; Swinth & Blascovich, 2002) has demonstrated that participants conform to the behaviors of other people in immersive virtual reality, regardless of whether they are avatars (representations controlled by other people) or agents (representations controlled by the computer). In the current study, we examined the effect of populating a virtual classroom with co-learners (Ju et al., 2005) who exhibited either positive or negative learning behaviors and then examined the change in behaviors by the participants. The goal of the study was to determine if presenters are able to accomplish social influence goals by creating a specific type of audience via transformed conformity.

Design

According to a between-subjects design, participants were randomly assigned to a classroom in one of three conformity conditions: (a) positive, (b) negative, or (c) empty (control). In the positive condition, other agents in the classroom were attentive and focused their gazes on the teacher. In the negative condition, other agents in the classroom appeared distracted and did not pay attention to the teacher. In the control condition, there were no other virtual students. The participants listened to a teacher present a 4-min passage about pharmaceutical companies and then completed a test on the material presented.

Participants

Eighty-two undergraduate students participated in the study for course credit or for pay. Participants were split equally in terms of gender as well as assignment to the three conditions.

Materials

The virtual classroom. The room in this study was identical to the one used in Experiment 3 (depicted in Figure 6). We also added an intermittent distracting event to the setting. Four times over the course of the lecture, cars of different colors, which were visible through the classroom window, drove past outside the classroom. When a car appeared, it was accompanied by the sound of a car engine. In order to see the car, participants had to turn their gazes away from the teacher to see the distracting event (cf. Rizzo et al., 2000).

Virtual co-learner behaviors. In the positive conformity condition, virtual students in the classroom cycled through a set of animations interspersed with periods of neutral idling behavior. This set of animations included (a) looking at the teacher, (b) nodding, (c) taking notes, and (d) not turning their heads toward the distracting event outside the window. In the negative conformity condition, the agents cycled through a different set of animations that included (a) looking at their watches, (b) shaking their heads in disagreement, (c) allowing their gazes to drift around the classroom, and (d) looking outside when the distracting event occurred.

Apparatus. The apparatus used in this experiment was the same as that described for the previous studies.

Procedure

After receiving appropriate experiment descriptions, participants were told by an experimenter that they would be placed in an IVE to listen to an instructor's short presentation in a classroom setting. Participants were also told that they would be answering questions about this presentation later on in this study. The experimenter then showed the participant how to wear the HMD.

After participants adjusted their HMDs for optimum focus and height, the experimenter triggered the start of the study and participants found themselves seated in a classroom as described earlier (always the seat marked with the *X* in Figure 8). The virtual teacher began the prerecorded passage on the pharmaceutical industry, using the same nonverbal behaviors as in the previous studies.

At the end of the passage, participants were taken out of the VE and asked to answer the multiple choice questions on a computer via a Web-based format. Answer choices were selected using the mouse in the form of radio.

Measures

Lecture score. We calculated a learning score based on the number of questions participants answered correctly. Overall, the average accuracy ratio was .70 ($SD = .17$).

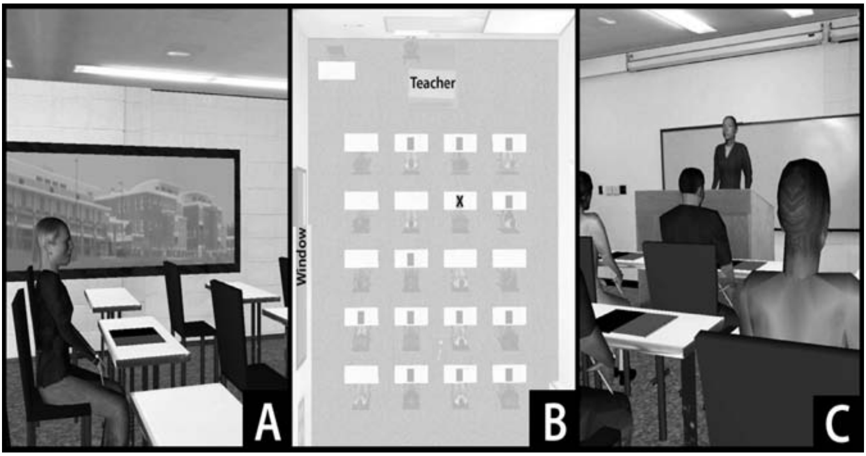

FIGURE 8 (A) The participant's view out the window. (B) A bird's-eye view of the classroom with an *X* denoting the student location. (C) The participant's view of the teacher.

Room score. Participants were also asked about minor details of the virtual setting as a way of ascertaining their spread of attention. There were three multiple choice recognition questions about different aspects of the VE: color of the cars, location of the clock, and how many times cars went by. Overall, the average accuracy ratio was .60 (SD = .25).

Gaze. We calculated the percentage of time participants had the teacher agent in their field of view. The mean gaze percentage was .65 (SD = .16).

Results and Discussion

We conducted a repeated measures ANOVA with memory type (room details vs. lecture details) as a within-subjects factor, conformity condition as a between-subjects factor, participant gender as a covariate, and learning score as the dependent variable. As Figure 9 illustrates, the interaction between memory type and conformity condition was significant, $F(2, 76) = 3.41$, $p = .04$, $\eta^2 = .09$. A comparison of the 95% confidence intervals revealed that in the empty condition, participants learned significantly more details about the lecture (M = .74, SE = .03) than they did about the room (M = .56, SE = .07; $p < .05$); this was also the trend in the positive conformity condition. In the negative conformity condition, the opposite trend was observed: Participants learned more information about the room than they did about the lecture. No other main effects or interactions were significant, all Fs < 1.5, all ps > .25.

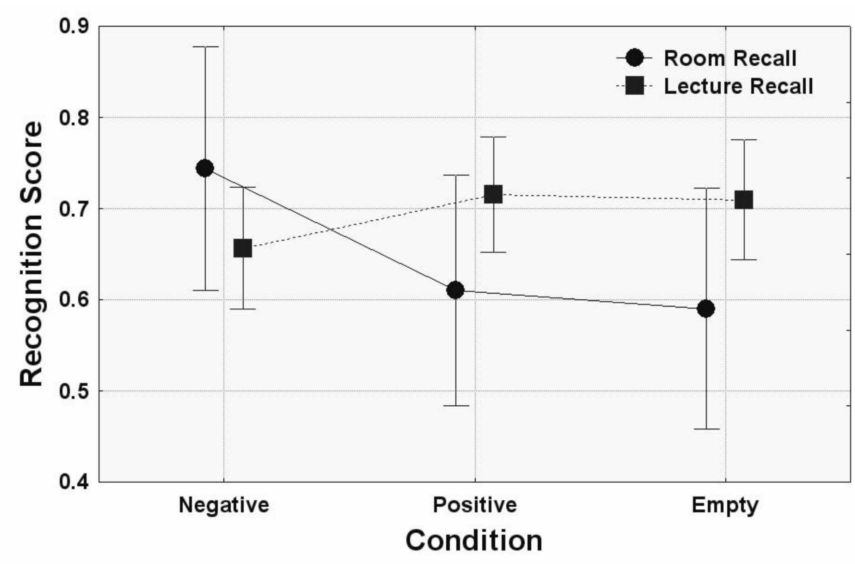

FIGURE 9 Mean learning scores of room and lecture details by condition in Experiment 4.

We next ran an ANOVA with gaze as the dependent variable, conformity condition as a between-subjects factor, and participant gender as a covariate. There were no significant main effects or interactions, all *F*s < 1.5, all *p*s > .25.

In this study, we demonstrated that the behaviors of virtual co-learners change the pattern of learning by participants in the virtual classroom. However, the strongest improvement in memory for lecture material occurred not from populating the room with idealized students, but instead from emptying the room. This suggests that an effective transformation in a CVE scenario may be simply not rendering other students in the room. In other words, by giving every student in a class of 100 the perception that he or she is receiving a one-on-one tutorial by the teacher may lead to the best learning overall as a set. There may be contexts in which having co-learners is essential, for example in collaborative problem-solving tasks or during test taking, when social facilitation effects might occur. However, within the very basic “telling” paradigm of learning examined in the current study, transforming social context to actually remove other learners from the classroom may have been optimal.

GENERAL DISCUSSION

These initial studies demonstrate that using digital transformations of teachers and learners in CVEs can increase learning compared to no transformations in the same environments. In Experiment 1, we demonstrated that teachers are better able to spread their gazes among students when receiving real-time visual feedback about which students they have been ignoring. In Experiments 2 and 3, we demonstrated that transforming the spatial configuration of a virtual classroom changes how much students learn. Specifically, sitting in the center of the teacher's field of view results in more learning than sitting in the periphery, and sitting in the front of the room results in more learning than sitting in the back. Moreover, in both of these studies we observed contrast effects, such that the transition from the privileged seat to the worse seat is particularly detrimental for learning and attention. Finally, in Experiment 4, we demonstrated that transforming the social behaviors of virtual co-learners results in differential learning; emptying the room of other students results in the most learning of course materials and the least learning of non-course-related details compared to other transformations of co-learners.

In general, we believe there are two important advances based on the current work. First, we demonstrated that in VEs, social behaviors such as head movements, spatial proximity, and the presence of virtual others all have an impact on learning. Given that the lecture material delivered by the virtual teacher was completely unrelated to any of the nonverbal social behaviors manipulated, it is notable that the relationship between the social cues and learning was so strong, sometimes more than 10 percentage points. A compelling argument can be made that social information during a lecture helps most when it is meaningfully linked to the information delivered in the lecture (e.g., using hand movements to approximate shapes, or using facial expressions to accent negative or positive statements). In the current work, we demonstrated that even when the information delivered by the virtual teacher is completely unrelated to the transformed social behaviors, learning improves simply by designing social cues to optimally engage students. Previous researchers have pointed out that it is crucial to attend to the social affordances of digital environments by leveraging the ability to monitor social cues (Kreijns, Kirschner, & Jochems, 2002). The current data demonstrate how critical those affordances can be. Moreover, the current findings provide support for the notions that in physical, face-to-face instruction contexts, the seating arrangement and level of eye contact between teacher and student may be extremely important.

Second, we demonstrated that digital transformations of learning environments (i.e., Pea, in press) can result in more learning. By having multiple students sit in a privileged virtual seat simultaneously, optimizing behaviors or physical presence of co-learners, or by augmenting perceptions, student nonverbal behaviors, attention, and learning can be altered. Consequently, the possibility for teachers to augment themselves with digital transformations deserves consideration, especially in larger groups in which tailored social cues from a physical teacher are not possible.

There are a number of limitations to the current study. First, here, we did not implement the constructivist learning tasks that learning science as a field deems the most worthwhile. Although testing memory for verbal content was a logical place to begin for CVEs due to the ease of implementing the materials in that manner, we agree that this one learning component in no way approximates the entire holistic learning process. In future studies, we plan to test various combinations of learning components—mixing physical and digital environments as well as passive and active learning processes—in order to slowly isolate the optimal pattern of learning components that exist in a world that includes learning via digital media. Similarly, we need to test the various components by examining different types of learning content; different types of nonverbal gestures and social behaviors; and different types of social contexts, ranging from the formality of the learning environment (Bransford et al., in press) to the physical shape configuration and size (Sharon, 2003) of the virtual classrooms. The utility of our various learning components may vary drastically as a function of these larger contexts. Also, our studies did not take into account students' natural preferences for seating locations. An intriguing question is whether students who naturally prefer the less optimal locations would learn more or less when forced to be in the more optimal locations. It is also important to point out that our studies relied on short-term, single-trial tasks and that different patterns quickly emerge over time. Finally, given the novelty of using IVEs, the findings from the current studies may not generalize to learning environments that are not so reliant on extravagant technology. A thorough examination of the theoretical constructs examined in the current work using technology that is more accessible for classrooms is essential. Moreover, the small and unrepresentative sample size of the current study should be addressed in future work before generalizations are made.

The potential for future work examining the effects of TSI in CVEs is striking. The possibility of both teachers and students to transform their appearance and behaviors, their perceptual abilities, and the social context of a classroom present promising opportunities. In previous work we demonstrated that, in CVEs, one person can automatically and implicitly mimic the nonverbal behaviors of others (Bailenson & Yee, 2005), and by doing so can capture the attention of an audience and become more persuasive. In a virtual learning scenario, a teacher who differentially mimics each student in a class of 100 simultaneously should be extraordinarily effective. The ability to filter in real time, appearance, behaviors, contexts, and even the fundamental aspects (i.e., race, gender, etc.) of peoples' identity should provide learning scientists with tools that were difficult to imagine decades ago (Loomis, Blascovich, & Beall, 1999).

Of course, one must consider the ethics and morality of such a research paradigm. It is a fine line between strategic transformations and outright deception. In face-to-face scenarios, teachers must often mask their emotions; for example, smiling at students when they are in fact extremely upset or praising students who deliver less-than-stellar responses. TSI is not qualitatively different from putting a mask over the true expressed emotional state of the teacher. However, the quantitative deviation from physical reality via TSI does provide a substantial quantitative difference from putting on a smile or nodding encouragingly.

In previous work we examined the ability of people to detect TSI in digital interactions, ranging from the exchange of simple digital photographs (Bailenson, Garland, Iyengar, & Yee, 2006) to more elaborate CVE contexts (see Bailenson, 2006, for a review). Over dozens of studies, a similar result occurred: People are very poor at detecting transformations of appearance and behaviors during the exchange of digital information. Consequently, the possibility for abuse in these manipulations is real, and learning scientists should openly discuss the pros and cons of engaging in such a research paradigm.

In sum, the practical implications of the current work are clear: Digital transformations through media can increase students' learning in some contexts. Of course, students across the world are not all going to don HMDs anytime in the near future; however, the possibilities of using other types of digital media—video games, Web pages, and others—are growing. The theoretical findings from the current article should extend to any digital media in which avatars interact in learning contexts.

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APPENDIX

Pharmaceutical and fever passages with corresponding multiple choice questions. Answers are italicized.

Pharmaceutical Passage

I'm going to be talking to you about something that I think almost all Americans are concerned about these days: the pharmaceutical industry and, in particular, the high prices it charges and the justifications it gives for charging those high prices. This year Americans will spend about $250 billion on prescription drugs, making them the fastest-growing component of our health care bill, which itself is growing very rapidly. The skyrocketing expenditures on prescription drugs are partly a matter of greater overall use —more people are taking more drugs—but it's mainly a matter of increasing prices. New drugs are almost always priced higher than old ones, and once on the market, for the drugs that are most commonly used, the prices are jacked up, usually at about three times the inflation rate, so it's unsustainable. Most Americans have insurance that covers at least part of drug costs, but not everyone. Medicare, for example, does not have a prescription drug benefit yet (and I'll say more about that benefit later) so that Medicare recipients who do not have supplementary insurance have to pay for their prescription drugs out of pocket. And, in one of its more perverse practices, the pharmaceutical industry charges much more for people who don't have insurance than they do for people who have large insurance companies to bargain for lower prices or rebates. In 2002, senior citizens paid, on average, $1,500 per year for the drugs that they took, and if they took six drugs, which is not rare for an older person, they had a bill of $9,000 a year. Not many senior citizens have such deep pockets. In fact, a recent survey showed that one-third of senior citizens either did not get their prescriptions filled in the first place, or if they did get them filled, didn't take the full dose but played out the dose to make the drugs last longer. In recent years there has begun to be a public outcry about this, probably stimulated in large part by the knowledge that you can buy exactly the same drugs in Canada for about half the price. This has caused people to look very carefully at the pharmaceutical industry. Still, the industry has been remarkably successful in dampening any serious move toward price regulation. Witness, for example, the Medicare prescription drug benefit that Congress passed late last year; it will go into effect in 2006. That bill actually contains a provision that explicitly prohibits Medicare from using its bulk purchasing power to bargain for lower prices with drug companies. That's quite a provision. It makes, first of all, prescription drugs unique in the Medicare system. Medicare does regulate doctors' fees, Medicare does regulate hospital payments—but prescription drugs are off the table. Drug companies can continue to charge whatever the traffic will bear, and it will bear quite a lot. How does the pharmaceutical industry justify its high prices? What it says, what it would like you to believe, is that the high prices are necessary to cover their high research and development costs, which implies that they spend most of their money on research and development and that afterwards they have very little left over—enough for modest profits but not much more than that; they're just getting by. They also make the argument that they are a highly innovative industry and they need the high prices as a spiritual incentive for their innovation. They say that any form of price regulation would choke off the stream of miracle drugs that they are turning out, so don't mess with us. A part of this argument is the implication that this is somehow a peculiarly American industry, that the pharmaceutical industry is an example of the success of our free enterprise system. Other countries have drug price regulation; we don't, and therefore this industry is an American industry that is especially innovative and successful because there is no price regulation. That's implied—it's not stated exactly, but it's implied. What they are saying with these arguments is, You get your money's worth. Just shut up. Pay up. You get your money's worth—is that true? Do you get your money's worth? The reality of this industry is very different from the image it tries to portray in its public relations. There is a huge rhetoric reality gap.

1) According to the speaker, increases in prescription drug spending are primarily based on increases in:

people taking drugs
drugs available
drug prices
the aging population

2) According to the speaker, prices charged by the pharmaceutical industry vary.

People without health insurance pay less for drugs than people with insurance.
Insurance companies pay more for drugs than individuals without health insurance.
The pharmaceutical industry charges people without insurance more for drugs.
People without health insurance bargain for lower prices or rebates.

3) According to a survey cited by the speaker, one-third of senior citizens:

do not get their prescriptions filled or take less than a full dose to make the drugs last longer
take six drugs which can cost up to $9000 per year
buy their drugs from Canada in order to pay lower prices
rely on Medicare to subsidize their drug purchases

4) According to the speaker, buying drugs in Canada:

is illegal
substantially decreases the incentive of US pharmaceutical companies
can cut costs of the drug by half
is encouraged by a bill passed in Congress

5) According to the speaker, the Medicare prescription drug benefit:

encourages Medicare to bargain for lower drug prices
prevents Medicare from using its bulk purchasing power
prevents low income seniors from spending over $300 a month on drugs
encourages drug companies to lower prices for Medicare recipients

6) According to the speaker, the pharmaceutical industry claims that high prices for drugs are necessary in order:

to enable the effective marketing of new innovative drugs
to compensate shareholders for their investments
to pay the pensions of an increasing number of retired workers
to cover high research and development costs

7) According to the speaker, the American pharmaceutical industry claims that it is especially innovative and successful

because it employs graduates from America's best research universities
because prices are not regulated by the government
because of superior technology
because of a collaborative mentality

8) According to the speaker, the profit history of pharmaceutical companies demonstrates that the risk of this industry is:

higher than other industries in the US
comparable to other industries in the US
lower than other industries in the US
highly variable and hard to compare with other industries

Fever Passage

Many people worry when they get a fever. But, a fever can be a good thing. It means the immune system is working to kill an infection. A fever means the body is hot, and the heat helps to kill *pathogens*. Pathogens include things like bacteria and viruses. The brain has a region called the *hypothalamus*. The nerve cells inside the hypothalamus create a *set point* that determines how hot the body gets. When the set point rises, it causes the body to get hotter. The set point rises when pathogens invade the body. The way this works is that a person's immune system can detect when there are unusual organisms in the blood. The immune system releases *macrophages* that attack the pathogens. The macrophages are cells that float in the blood. Macrophages also produce a chemical called, *IL-1*. When IL-1 reaches the hypothalamus, it causes the set point to rise. IL-1 tells the hypothalamus that the body is in a state of emergency, and that the temperature must be raised a few degrees to kill the pathogens. This causes the body to run a fever. What processes cause the body to increase its temperature? One process involves *vascularization* near the skin. Vascularization means the veins (blood vessels) shrink. When veins shrink it means that less blood can get near the skin, and therefore, the blood cannot release as much heat through the skin. Vascularization helps explain why people can have a fever but still feel cold in their hands and feet. There is less blood near the skin. A second process involves shivering. Shivering makes the muscles move. When muscles move, they produce heat. Shivering can make the body produce more heat than normal. A third process is *piloerection*. Pilo means hair, and erection means stand up right. Piloerection causes the small hairs on the body to stand up. Piloerection closes the pores in the skin and makes the hairs stand up. This means less heat can escape through the pores. It also means that less sweat can escape through the skin. This is important because sweating is a cooling mechanism and fever is the body's way of increasing the temperature, not decreasing it. Piloerection also helps explain why a fever causes a person's skin to feel tender. The little hairs get rubbed and irritate the skin. The hypothalamus also releases a chemical called the *thyrotropin releasing hormone* (TRH). TRH, in turn, causes the release of another chemical called the *thyroid stimulating hormone* (TSH). TSH increases the metabolism of various tissues in the body. A higher metabolism means that tissues use up energy faster, and this causes them to produce more heat. The higher metabolism helps to explain why people have rapid breathing and a rapid heart rate when they have a fever. The tissues with an increased metabolism need more blood and oxygen than usual. If the body gets too hot, it will begin to kill its own cells. How does the body stop from getting too hot? When the body temperature reaches the set point in the hypothalamus, all the processes reverse. Blood goes to the skin, shivering stops, piloerection ends, and the hypothalamus stops the production of TRH. Aspirin and Tylenol help reduce a fever by blocking IL-1 from reaching the hypothalamus. This helps to bring down the set point, so the body stops trying to heat up. The good part of aspirin is that it makes one feel better. The bad part is that there is less fever to help kill the pathogens.

1) According to the passage, your hands and feet get cold when you have a fever because

your veins shrink
there is more blood near your skin
of the effects of IL-1
the small hairs on your body stand up
none of the above

2) Which of the following is *not* a process that causes the body to increase its temperature?

piloconstriction
vascularization
macrophage-activation
shivering
both a and c

3) What does Aspirin/Tylenol do?

increase a fever
block IL-1 from reaching the hypothalamus
increase the set point so the body stops trying to heat up
reduce vascularization
both b and d

4) When you have a fever …

your body's cooling mechanism shuts down
heat production kicks in
your skin feels tender
all of the above
none of the above

5) According to the passage, how is the brain involved with a fever?

The hypothalamus produces IL-1
The brain releases macrophages
The brain attacks the pathogens
The hypothalamic nerve cells create a set point
Both a and b

6) What is the relation between TRH and the TSH?

TRH causes the secretion of TSH
TSH causes the secretion of TRH
TRH blocks the effect of TSH
TSH blocks the effect of TRH
None of the above

7) Which of the following is a way that the body stops from getting too hot?

Muscles controlling hair follicles contract to use up energy
Shivering begins to use up heat
Blood goes to the skin
Macrophages block IL-1 signaling
Both c and d

8) Birds do not have hair and they do not sweat. But, piloerection also helps them have a fever. How?

Piloerection creates heat by activating hair follicle muscles.
Piloerection traps body heat.
Piloerection signals the hypothalamus to increase the set point.
Piloerection causes tender skin, which makes fevers more likely.
Both a and b

9) Imagine that there are no pathogens in your body and your body temperature is normal. What will happen if you take an aspirin?

Your body temperature will increase in anticipation for a fever.
Your body temperature will stay the same.
Your body temperature will decrease.

Your body temperature will increase, and then decrease.
Your body temperature will decrease, and then increase.

10) Here is a common situation: People wake up all sweaty and they are finally cured from their flu. Does the sweating help them to cure their flu?

Yes, it helps rid the body of pathogens.
Yes, it increases the effect of vascularization.
No, it is a by-product of the body's increase in temperature.
No, it is a direct effect of TRH.
It cannot be determined.

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Contact Us At:

Address:
4528 Los Feliz Blvd
Los Angeles, CA 90027

Phone: +(213) 588-3964
URL: www.flowlab1.com

Email: info@flowlab1.com

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