Controversial Science Argumentation Skills for Teachers in the Digital Clinical Simulation *Discussion Leader*

by

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ABSTRACT

Teaching controversial issues is a critical skill for a continuing democracy and to ensure that the next generation of researchers and designers are well versed in critical analysis skills. Despite this, teachers report that they have received little instruction on how to facilitate a controversial discussion with students and are concerned about possible challenges inside and outside the classroom. To address this need, I have designed a digital clinical simulation of a high school science teacher leading a discussion on the ethics of gene therapy with their class of twenty students using a branching structure on the platform Teacher Moments. In a study with 42 participants, I show that this simulation could be useful in raising teachers' comfort with leading controversial discussions, and that the teacher dialogue choices that experienced teachers make differ from those with less teaching experience. This research shows the usefulness of simulations in preparing teachers to lead controversial discussions with students across a number of discussion skills such as asking open-ended questions and deciding where a teacher's opinion belongs in a discussion. Furthermore, I suggest future design work that could be implemented using machine learning methods to improve the generation of student dialogue and authenticity of simulations about discussions.

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Introduction

My first student-teaching experience was in a charter school in Cambridge, Massachusetts. At this school, I observed in an AP English Language and Composition class, and later an AP Biology class, both for 11th and 12th grade students. Inexperienced and with students older than I was, I often stood in the back and offered essay critiques or help with wet labs. In the AP English class, I worked with my mentor teacher who valued student autonomy and debate of current issues. In one particularly memorable lesson, students read an article written by a parent who believed that recycling should not be taught in schools. He then argued one on twenty with the students, him arguing the opinion of the upset parent. This lively classroom debate was both inspiring and terrifying as a young teacher candidate, and it got me interested in how more teachers could be prepared to lead controversial discussions with their students. This experience, and other moments of my student-teaching career, inspired the work I would go on to conduct at the Teaching Systems Lab on the design of digital simulations that allow teachers to practice leading controversial discussions with students.

This thesis is located at the intersection of educational technology design, teacher education research, and the study of controversy in the classroom. I have used these three fields to design a branching path simulation that allows participants to practice leading a discussion of the ethics of gene therapy with a high school science class. In this thesis, I will first examine the history of simulations and other media for teacher education and analyze how previous work in this area can inform new designs in more interactive technologies, argue for the importance of the inclusion of debate in the K12 curriculum, and describe the design process for the creation of the simulation. I will then analyze the data I collected from participants in a pilot experiment with this simulation by analyzing their teacher dialogue choices throughout the simulation and

describe how I see simulations for practicing facilitating controversial discussions advancing in future research.

Specifically, I am interested in the following research questions:

[1] Can a simulation of leading a controversial discussion make participants more confident in their facilitation skills and act as a tool for reflection on practice?

[2] Can a simulation on leading a controversial discussion act as a tool for reflection on practice?

[3] Are the teacher dialogue choices different among participants with different levels of teaching experience?

The Position of this Thesis: Rapidly Advancing Technologies and a Time of Attack on Teacher Freedoms

I also write this thesis at a moment of time in the United States in which legislatures seek to limit teachers' freedoms and students' exposure to potentially controversial topics. This abhorrent trend, while often fueled by immediate reactions unfounded fears against graduate-level topics like critical race theory, will have long-term effects. Teachers may be more afraid to include the discussion of controversial topics at risk of admonishment from administration, parents, and local government, and students will lack critical opportunities to practice democratic discourse with their peers. Although a digital clinical simulation cannot directly counteract the undemocratic attacks on education, my hope is that through deliberate practice of facilitation skills in low-risk environments, teachers can be confident in their skills to help students gain a voice in discussions so that they might become politically active members of our democracy.

Furthermore, in the design of the content of this scenario, I chose to focus on debates around the future of gene editing techniques in humans. When thinking of a classroom debate,

many would imagine a history or language arts classroom, but I think critical debates can be implemented in any subject, especially in those that have the potential for major ethical and moral considerations, like science and computer science. Gene editing techniques, whether for the treatment of diseases such as cystic fibrosis or in gene editing at the germ cell level, are still being rapidly improved today. It is only very recently that the Telomere-to-Telomere Consortium has announced that they have worked to almost completely map the human genome and are continuing their work to finish mapping the Y chromosome (Nurk et al., 2022). This marks a critical jump in human knowledge of our genetic makeup and will undoubtedly allow the innovation of new genetic treatments that can help patients live longer and easier lives. These new discoveries should be critically discussed in science classrooms so that young students who wish to be the next generation of scientists and researchers can be exposed to important ethical debates in their fields at an early stage in their career.

Thesis Chapters Outline

In chapter one, I explain the history of simulations for teacher education, starting with work done in the early 1960s with projector screens to current technologies today that utilize artificial intelligence or mixed reality to provide spaces for teachers to practice high-impact skills. I also show how we can learn from these past media innovations to improve current teacher education simulations, such as moving away from simulations with definitive answers to work that is more improvisational.

In chapter two, I further describe the challenges and importance of teaching controversy. I also discuss the need for context specific practice in teaching controversial issues, and how simulations may be a way for teachers to rehearse addressing common issues in a controversial

discussion, such as students who want to know a teacher's options or dealing with misinformation.

In chapter three, I describe the design decisions that went into building the latest version of *Discussion Leader*. I show how the evolution of the *Discussion Leader* suite of practice spaces informs the current version, describe the content that participants saw across the five student groups in the discussion, and show examples of teacher dialogue choices they can make in the simulation.

In chapter four, I detail demographic information about the participants in the study who completed the simulation, the types of data I collected for analysis from participants' choices in the simulation, and overall path use.

In chapter five, I show the results of the simulation runs, including teacher dialogue choices, survey data, and text response analysis. I present each of the five student discussions in this chapter separately and stratify the data by the amount of teaching experience that the participants had.

In chapter six, I discuss implications for the results of this pilot study in regards to how this simulation could help novice teachers feel more confident in their intuition about discussions and explore different teacher moves they could enact in discussion. I also cover areas of future research about analyzing the effects of simulations on teaching practice and ways to improve simulation authenticity and scope using machine learning methods.

Chapter One

History of Simulations for Teacher Education

In this chapter, I discuss the evolution of how teacher-preparatory programs and teacher educators used different forms of technology to prepare new teachers for common and difficult problems in teaching. I also describe how the implementation of technologies for teacher education can meet the need for repeated, focused practice of critical teaching skills. Through this historical lens, I argue that simulation developers of today should design scenarios that are more open-ended so that teachers can explore different ways to react to difficult moments in teaching. I end this section with suggestions for how teacher education technologies can improve to be more responsive by utilizing natural language processing techniques to provide personalized feedback.

Introduction to Teacher Education

Teacher education consists largely of three strands of education for pre-service teachers (PST): educational theory and child development, content-related work related to the teacher's subject matter, and practicum, but pre-service teachers may struggle to connect this instruction in theory to practice (Darling-Hammond et al., 2005). In a pre-service teacher's practicum, also called student teaching, a PST works with a more experienced teacher to take over the responsibilities in their classroom. This apprenticeship model gives PSTs exposure to classroom responsibilities, but rarely offers the ability to focus on one element of teaching at a time. This educational trial by fire can be difficult for college students who are introduced to teaching their own class late in their undergraduate experience. For instance, student-teachers in Massachusetts are evaluated on their ability to perform in several areas of teaching and classroom management simultaneously (603 CMR 35.00: Evaluation of Educators - Education Laws and Regulations,

2017). This measurement metric leaves little room for new educators to develop the discrete skills needed for teaching. However, prior work has shown that pre-service teachers often struggle to connect educational theory with how they actually teach in their practicums, and that simulated field experiences may help to bridge this gap (Livingston & Borko, 1989).

To focus on the difficult elements of teaching, simulations were first developed first by teacher-educators and educational psychologists (Cruickshank, 1988). Currently, there are simulations that provide the opportunity to teachers to practice moments like parent-teacher conferences, bringing concerns to a principal, and managing difficult discussions (Dotger et al., 2018; Self, 2016; Reich et al., 2018; Wang et al., 2021). Simulations in teacher training can be traced to in-person simulations, board and card game type experiences, and digital simulations in the form of web applications and augmented/mixed/virtual reality.

However, prior to these simulations came the idea of microteaching, a type of teacher education based on "teach, critique, reteach" that allows educators to get immediate feedback on their teaching from their professors and peers (Allen & Eve, 1968; Remesh, 2013). This is a valuable aspect of teaching simulations. Making a mistake in an actual classroom with real students has consequences that stretch beyond that moment. Simulations allow for student teachers to make mistakes in a low-risk environment and allow student teachers to explore new teaching methods safely (Grossman et al., 2009). I argue that a combination of the immediate feedback of microteaching with the lens of critical teaching moments of simulations would be a better approach. Simulations allow for teachers to practice difficult professional tasks, but can lack the immediate feedback needed for participants to reflect thoughtfully on their performance. Teachers may be able to improve on their ability to act in critical moments and feel more

confident facing difficult classroom issues when they receive embedded, immediate feedback systems in teacher education simulations.

Shifts in Teacher Education and Simulations

Though rapid technology advancements have allowed for an increase in available technologies for teacher education, teacher training is thought to have begun with the creation of Normal Schools, or schools where students were taught by teachers-in-training who then received feedback from teaching experts (Edwards, 1865). In the early 1900s, the Normal Schools began to utilize what was called “visual instruction” through film strips and other forms of media such as stereoscopes (Starnes, 1937, as cited in Betrus & Molenda, 2002). Moving into the mid-1900s, as media advanced to include color TV and easier access to educational film strips, these teacher education programs shifted to teaching pre-service teachers how to operate these technologies, so that they may use new forms of media in their instruction (Betrus & Molenda, 2002).

Nearly 100 years after the start of the Normal Schools, this movement helped to legitimize teaching as a profession and allowed for the study of the “Science of Education" in colleges as a method of training new teachers (Robarts, 1963). Work in the sixties highlighted a need for teachers to receive feedback on how they worked with students in their classrooms and their ability to deliver lessons (Allen & Eve, 1968; Amidon & Rosenshine, 1968). These programs, called microteaching and interaction analysis, focus on two parts of teaching: the abstraction of a smaller lesson with the intent to receive expert feedback, and analysis of how teachers engaged students in dialogue. In microteaching, a PST may give a mini-lesson in their college class to receive feedback on their performance, and then reteach the lesson (Allen & Eve, 1968). This focus is good for refining lecture skills, as the immediate feedback from experts is a

critical element of learning, but it can be said that practicing teaching to a classroom of your college-aged peers is much different than delivering that lesson to your K12 students while balancing managing a real classroom. While microteaching is much closer to the modern digital teaching simulation, interaction analysis provides a useful starting framework for analyzing how teachers talk to their students such as being open to their ideas or asking probing questions (Amidon, 1968), which is a critical element of positive relationships in the classroom. These tasks are not without criticism, largely around a lack of authenticity from the actual classroom environment (He & Yan, 2011).

However, teacher education has moved largely into colleges in such a way that some PSTs get limited time to reflect on their classroom practice (Darling-Hammond et al., 2005), even if they complete their required practicum hours which are often 300 hours or more (*603 CMR 7.00: Educator Licensure and Preparation Program Approval Regulations - Education Laws and Regulations*, 2021). This shift of teacher education from actual classrooms to university lecture halls has bolstered the need for "reflection in context" or experiences that allow PSTs the ability to reflect on specific, complex instances of teaching (Beauchamp, 2015). Some teacher education programs have relied on role-play for practicing teaching a lesson or classroom management. While this provides a low-stakes environment for PSTs to practice certain teaching skills, it has similar logistical problems to that of teacher education in the Normal Schools. Namely, the amount of in-person set up and facilitation required. For teacher education, simulations that are based on in-person role-play require an actor who has memorized a limited script and often need a specific room with materials for the simulation to occur. Additionally, these environments may also lack authenticity, especially in university classes where student-teachers practice classroom management techniques on their classmates. This is

not to say that role-playing does not have a place in teacher education as it may offer the one-on-one support that novice teachers need to practice a skill, such as reflecting on misconceptions in science (Dotger et al., 2018).

It was not until the 1960s that teacher-educators began to use technologies such as video recording and projectors to simulate the classroom environment to teach new teachers (Kersh, 1962). In the later 20th century, teacher educators began to use desktop computers and other programs to model classroom environments (Cruickshank, 1988). Currently, teacher education simulations exist in digital web apps and altered reality experiences (Reich et al., 2018; Thompson et al., 2019; Wang et al., 2021). These simulations require little facilitation and be scaled up to larger contexts, allowing more PSTs and in-service teachers to receive less costly professional development training, though web apps and altered reality simulations do have different affordances.

In the next section, I describe in more detail these changes in technology for simulations of teacher education, address some of the broader criticisms of education simulations, and how these past technology designs can help designers create new, more adaptive simulations.

Technology Advancements: Scripted Videos to VR to AI

One of the first digital simulations for teacher education was the Classroom Simulator which came out of the Center for Teaching Research in Oregon in the early sixties (Kersh, 1962; Cruickshank, 1988). In the Classroom Simulator, a student teacher would stand in the middle of several projection screens controlled by an expert teacher that showed a short event in a classroom. The student teacher would then act out what they would do in that situation and the expert teacher would select another clip to show that shows the student teacher the outcome of their actions. Many different classroom scenes were available, and the scenarios could be

repeated. This setup allowed for the possibility of correct and incorrect teaching actions, a metric of evaluation often not seen in modern teaching simulations, but it is a consideration that designers of teacher education simulations should consider depending on the focus of the simulation.

Video remained a popular method in teacher training throughout the sixties and seventies (Cruickshank, 1971, 1988). In Cruickshank's video training simulations, the learning goal for student teachers was not getting to a "correct" teaching action, but to encourage discussion with their peers the identification of the problem, often student behavior, and what they could do to solve it in their classroom. Specifically, student teachers focus on what they do not know from the short video clip and discuss with other student teachers what they would like to know before choosing a course of action. This model, a joint simulation in which many student teachers experience the same events followed by discussion of what is missing from the classroom context, highlights a valuable shift in simulations for teacher education. First, this model moves from the one-on-one method to the one-for-many method of simulation design. This decreases the human capital needed to run a training session, and increases the number of student teachers who can benefit from a single viewing of the classroom simulation. Additionally, the addition of a discussion element is a form of embedded feedback. Students talk to bounce ideas off one another and not to come to a definitive conclusion. There is no correct answer. The value in these simulations is the discussion and meshes well with the action practice of teaching as teaching is often improvisational that requires to predict many possible student responses.

As desktop computers became more accessible, teacher educators began to design simulations, though often referred to as programs by literature of the time, not only for classroom management, but for content specific teaching skills (Lloyd & Idol-Maestas, 1983; Cruickshank,

1988; Gorrell & Downing, 1989). Lloyd and Idol-Maestas (1983) describe a computer simulation designed to present special educators with common problems they may encounter when working with content teachers and their students. In this simulation, student teachers are presented with a scenario about one of their students and select an outcome. They are then shown what happens next and asked to make another decision. Research on this simulation showed that participants felt that they learned skills for consulting with content teachers about students in special education and that the simulation was authentic. This example shows how simulations, even when moving from the in-person, to video, to computerized models, continue to follow a branching narrative. Choose from A, B, or C, and D, E, or F will follow. In the same work, Lloyd and Idol-Maestas (1983) also describe a simulation for helping teachers understand how to address students' reading problems. Presented with a situation about a student's reading troubles, teachers selected the appropriate supports the student would need to improve their reading skills. A majority of participants found the simulation helpful, and several noted that the simulation let them explore potentially risky teaching choices.

Gorrell and Downing (1989) extended the simpler branching path simulations in a study that examined how computer simulations and direct instruction for teacher education differ in their outcomes for student teachers. In this study, different groups of participants either completed a simulation on classroom behavior management or participated in a lecture series on the same scenarios found in the simulation. Those who completed the simulation scored higher on their ability to solve classroom problems than others in the other lecture conditions. Again, the value of simulations as it relates to time is evident. Those in the lecture conditions had to spend extra class time seeing a teacher model best practices for classroom management to achieve the same skills that those in the computer simulation achieved.

This trend of branching path simulations continued through the nineties and into today's education simulations. Reich et al. (2018) describes several different teacher education simulation designs, including card games and online digital simulations designed at the Teaching Systems Lab at MIT. One of these digital simulation platforms, Teacher Moments, extends the work of simulations for teacher education by providing an open source platform to build simulations on (Reich et al., 2018; Sullivan et al., 2020). Teacher Moments is a digital web application that allows for the creation of slides with text, pictures, audio, or video representations of classrooms. Designers of the scenarios can collect data from their student teachers in the form of text, audio, and multiple choice responses. Additionally, this platform allows for the integration of natural language processing methods to provide customized, immediate feedback to participants (Hillaire et al., 2021; Marvez et al., 2022). Teacher Moments is free and open source which allows any user to remix the content on the site so that they can adjust it to their own educational contexts.

Furthermore, work done at the Teaching Systems Lab builds on previous simulations by highlighting the need for improvisational teacher practice. Initial simulation designs in the 1900s often focused on getting teachers to a predetermined correct answer (Kersh, 1962) that was aligned with the views on teaching that the teacher educators held. Through the design of more open-ended simulations, participants are free to react to novel situations naturally and then reflect on their intuition towards some difficult moment of teaching, such as reflecting on how unconscious bias related to race and gender result in different expectations teachers hold towards different kinds of students (Robinson & Reich, 2018). It is important to provide opportunities of purposeful reflection to teachers (Grossman et al., 2009), and simulations that do not funnel participants towards a previously established answer, but instead offer reflection on practice,

either through automated methods or facilitated debriefs, may be more insightful for teachers (Christensen et al., 2022).

Teacher Moments alone is not a specific simulation, but a way to host and design them. One such simulation group is called Danson-Autism and Turner-Rigor, two simulations that help student teachers practice what to say in two difficult parent-teacher conferences (Thomspon et al. 2018) based on prior simulation design work from Dotger (2013) with human actors. These simulations provide a way for student teachers to not worry about messing up what they might do with an irate parent in a conference. Student teachers watch a video where an actor plays an upset parent, either one who feels that the teacher is not equipped to deal with their child's autism or one where the parent feels like the teacher's standards are too high for their child. Student teachers then have the option of writing or recording their response to the parent, and the simulation continues with another video of the parent replying to the student teacher. One difference in these simulations from those in the past is that this simulation is linear. No matter what the student teacher says, the parent replies stay the same. This has some benefits and drawbacks. The standardization of content makes it easier for teacher educators to lead a discussion afterwards with their students about the simulation, but also means that students may find the simulation less responsive or authentic. At the time of the design of this simulation, Teacher Moments was not able to support branching paths, but is now able to, in addition to its artificial intelligence architecture (Hillaire et al., 2021). Researchers have utilized the branching path functionality in Teacher Moments and in Twine, a game engine, to develop simulations about leading controversial or difficult classroom discussions (Kaka et al., 2021). In these simulations, student teachers take on the role of a high school teacher leading a class discussion on immigration, gun violence, or freedom of speech. Student teachers have to manage not only

their content knowledge of the topic, but clashing student opinions and behavior issues. Participants in these scenarios have stated that the simulations acted as a tool of reflection in thinking about how they would manage a controversial discussion with their own students. Using branching paths in these simulations allows for each student teacher to have a unique experience and makes the simulations repeatable, so that student teachers are welcome to try a new discussion method over and over again.

Mixed reality has also been utilized for teacher education, especially for small group settings on a platform called Mursion (Ferguson & Sutphin, 2021). In Mursion, a student teacher is presented with a small group of four to five students that are all controlled by one, unseen actor. The student teacher teaches a lesson in the virtual environment and tries to uncover the misconceptions the students hold. There are also opportunities to practice teaching in a diverse classroom and parent-teacher conferences with Mursion. However, this platform is not without criticisms. Since the students within a Mursion simulation are not automated and are played by a remote actor, there is increased cost and time commitment to complete these simulations. Additionally, diverse students in a Mursion simulation are played by an adult actor who is sometimes not of the same minority category of the students being portrayed (Baker-White, 2021). In a recent article, Baker-White describes this as a form of digital Blackface in which white actors play Black characters and how this is harmful stereotyping, especially considering there are Black actors available. Mursion has stated that this was to prevent its Black employees from having to reenact the same microaggressions over and over in simulations that they already experience in their daily lives, but this is still an unsolved problem.

This also presents an additional facet of simulations that designers must consider. Most simulation designers have some education experience and are comfortable developing

simulations about content specific skills or general behavioral management. However, when designing specifically about issues of inequity for any minority group, it is important to consider who is the primary author of the scenario. The positionality of the designer can be a critical element in properly representing sensitive classroom scenarios, particularly in those about equity.

Simulations have evolved from video recordings and projections, to choose-your-own-adventure scenarios, to digital platforms equipped with VR and AI capabilities. Underlying all of these designs remains the question of improving teacher education efficiently and with equity in mind. In the next section, I discuss how the history of simulation design can help designers create the next generation of responsive teacher education technologies.

Discussion and Future Design Implications

Recent advancements in digital simulations for teacher education have focused not on improving broad teaching performance, but on specific difficult moments, including equity conversations and controversial discussions (Borneman et al., 2020; Kaka et al., 2021; Thompson et al., 2018). These simulations have moved from in-person evaluations of teaching, to online experiences where a participant may practice a certain difficult skill in a low-risk setting many times. The benefit of these digital simulations is that they often require less human facilitation than in-person experiences. These are key points for simulations for challenging moments of teaching since many teachers report that they have fewer opportunities to practice definitive elements of the profession (Grossman et al., 2009). The digital simulations have been made into web applications, phone apps, video games, and VR experiences (Olson & Harrell, 2019, 2020; Reich et al., 2018). Each of these has their own advantages and drawbacks, such as

the web applications are easy to deploy, but may lack some authenticity as they are often text based, and VR simulations are more expensive, but can better represent a whole classroom.

Through an examination of past simulations for teacher education, there is an obvious use case for branching narratives, even if the choices lead to only one or two possible outcomes. This allows for student teachers to make choices that directly affect the simulation and offers replayability of the simulation, a critical element of rehearsal of complex skills. However, most simulations do not provide personalized feedback or in-the-moment help. This is a significant drawback as feedback is crucial for learning. This is why several newer education simulations are designing conversational agents and natural language processing methods to analyze student teacher performance in simulations (Datta et al., 2021; Hillaire et al., 2021). For conversational agents, student teachers interact with a student "played" by an algorithm that has been trained on past student responses. Additionally, natural language processing methods have been designed to assess student teacher performance and provide feedback based on the text or audio response. For instance, in a simulation that focuses on misinformation, the natural language processing classifier can determine if the respondent correctly identifies a piece of media as satire and provides evidence as to why it is unreliable (Marvez et al., 2022). This model of feedback immediately lets participants know when they have made a mistake, and allows them to go back and try again. Previously, in simulations, student teachers would have to wait to reach the end of the simulation and wait for their class to finish to have a discussion about their work. Their teacher educator may have not had enough time to review all of the data, leading to a more difficult debrief period. By embedding the feedback systems, student teachers can rehearse skills quicker and receive personalized feedback trained on previous teachers' work.

Additionally, AI methods can be used to generate branches in scenarios instead of having them be prescriptive. Currently, most branching scenarios on Teacher Moments are hard coded, meaning that choosing X always leads to Y, and typing X response leads to Z embedded feedback. However, with OpenAI's API now available to use GPT-3 (Brown et al., 2020), it has become possible to imagine a simulation in which all student teachers start with the same classroom trigger event, respond in their own way through text or speech, and then are presented with completely novel student dialogue and actions. This design would create completely new classroom events every time someone started the simulation, leading to an incredibly rich dataset and experience. Though the problems with AI text generation are known, training on smaller refined datasets may help the GPT-3 be more accurate and improve the resulting output (Brown et al., 2020).

Teacher education has always focused on preparing teachers to deal with the challenging elements of teaching whether that be in the form of simulations or lectures. Past simulations designs have shown the need to have embedded feedback systems that can provide personalized help to student teachers and to create classroom environments that are seen as authentic. Authentic simulated classrooms cannot be done without including the voices of students, especially marginalized ones, and teachers in the design. Additionally, the inclusion of automatic feedback systems is critical in providing the most relevant help to student teachers, and makes the simulations replayable to try out new teaching methods and rehearse skills. Simulations remain a valuable tool in teacher education, but will benefit from the inclusion of new feedback methods and voices in their designs.

Chapter Two

Discussing Controversies in the STEM Classroom: A Critical Skill of Democracy and Innovation Under Attack

Borrowing from a chapter title from Diana Hess' book *Controversy in the Classroom: The Democratic Power of Discussion*, in this section I describe how preparing teachers to lead controversial discussions is paramount to the continuation of a functioning democracy. Classroom debates, when well done, provide students the opportunity to defend their ideas in a semi-public sphere and hear opinions that they might not normally encounter in their homes or social media bubble. Additionally, multiple studies have shown that students who participate in curriculum with frequent controversial discussions or other ways of everyday engagement with their communities are more likely to be active in politics (Ballard et al., 2016; Gould, 2011; Wray-Lake, 2019). Even though the idea of a class debate or Socratic seminar evokes images of a circle of desks in a Language Arts, History, or Social Sciences classroom, I believe that critical analysis can be an activity for any classroom, which inspired the design choice for the simulation to cover the topic of genetic editing and gene therapy. Debate should not be limited by course type, but encouraged across the curriculum. Not only do future politicians, policy makers, and historians need practice in debate, but so do future designers, engineers, researchers, and scientists. As technology continues to advance, it is urgent that those in the position to design the future are capable of deliberation with their peers.

Despite this need for debate in education, teachers often face significant challenges in implementing these kinds of lessons, and this is especially true in recent years. Not only do teachers feel pressure from administration and parents to avoid discussing controversial issues to maintain their employment (Misco & Patterson, 2007), but they also face issues around student

safety and misinformation. For instance, especially in light of the 2016 election cycle, 41% of teachers report that students have brought in more unfounded claims from unreliable sources (Rogers et al., 2017). Furthermore, the stressors from national political debates overwhelmingly affect students from minority populations (Rogers et al., 2017), another safety consideration for teachers who may want to teach controversial issues. Additionally, the recent political changes to classroom curriculums, due to unfounded fears surrounding the alleged indoctrination of students with materials on critical race theory, have made it harder for teachers to adequately address controversial issues in their classrooms, and access the materials that they need from school libraries (Powell, 2021).

In the face of such political backlash, it is key that schools push back and controversial discussions happen for students across grade levels and disciplines. Even elementary students can be engaged in discussions on controversial topics through highly structured work that aligns with the national standards for social studies education (Linowes et al., 2019). Implementing controversial issues is important to preparing students to be engaged and informed members of a democracy (Hess, 2009). However, this kind of instruction is best done when teachers feel prepared and are intentional about the ways in which they set up a class discussion with students (Hess, 2008). Additionally, these kinds of lessons should not be one off events, but carried through the curriculum over many years (Hess, 2008).

Through this chapter, I will describe the problems STEM educators may face when preparing for a controversial discussion, and how these are similar to common issues social studies teachers face, but emphasize that these are surmountable challenges that are worth overcoming to include instruction on controversies over multiple course types.

Why Include Controversial Topics in Education?

In general, classrooms are one of the few places where students engage with opinions outside of their informational bubble and can experience supportive environments to discuss differing opinions with others (Hess, 2009). Classrooms are already filled with controversial issues, but teachers may feel that they have to tiptoe around the crux of a controversial issue (Hess, 2008). Despite uncertainty, the inclusion of the discussion of controversial issues in classrooms has been shown to increase students' political engagement and communication skills (Gould et al., 2011). In these debates, there is also the opportunity to teach digital literacy skills. We know that students increasingly bring misinformation into the classroom (Rogers et al., 2017), and lack the skills needed to sift through the massive amounts of misinformation online (McGrew et al., 2018). By confronting misinformation in the moment during controversial discussions, teachers can model with students how to go about finding out the reliability of a source by investigating its funding, bias, and credibility (Breakstone et al., 2021).

A significant amount of prior work has focused on how teachers manage controversial discussions in social studies classrooms, and I believe many of these findings can be applicable to controversies in STEM classrooms. If we want students to develop an understanding of science and the skills needed to analyze the biotechnology innovations, then they must be given opportunities to recognize how science can change over time, to foster a desire to understand new information, and to learn argumentation skills surrounding controversial topics in science (Oulton et al., 2004; Sampson et al. 2011).

Problems of Practice

To understand why teachers may feel unprepared to lead controversial discussions, we need to understand the nature of teacher-education and evaluation, and how this can make it difficult to partake in meaningful practice of facilitating a controversial discussion.

In my own experience in teacher-education at the university level, we often considered different education theories and practiced implementing those techniques by practicing with the nearest available population of students, other teacher-candidates. This method of practice is useful in gaining familiarity with speaking in front of a class, rehearsing the timing of a lesson, and working on classroom management, but it does not allow for opportunities for repeated, intentional practice. Furthermore, practicing a teaching skill like facilitating a controversial discussion with undergraduate or graduate peers is very different from working with young students. University students have a more sophisticated understanding of possible controversies and would not react the same way as a middle or high school student. This is where simulated classroom environments can be useful.

By designing digital clinical simulations that focus on different controversial topics, teachers can access repeated opportunities of practice with simulated students. By approaching simulations as an approximation of practice (Grossman et al., 2009), participants can take time to reflect on their teacher dialogue choices and focus specifically on the conversational moves they enact in these kinds of discussions without concerning themselves with complexity of other elements of teaching. This kind of practice can be useful in increasing teachers' comfort with leading controversial discussions, as later detailed in Chapter Five and in other previous work (Kaka, 2021).

Outside of learning important facilitation skills, teachers also can encounter enormous resistance when they attempt to teach controversies. Hess (2004) describes how many Americans experience a "general aversion to controversy" and believe that teaching controversial topics in classrooms only makes schools more contentious instead of imparting the skills students need to critically engage with controversies. Stemming from this unwillingness to engage in controversy, teachers face other issues such as uncertainty about what counts as a controversial issue and fear of being labeled as someone who is "indoctrinating" students (Hess, 2004; Misco & Patterson, 2007). These issues may also be location specific. A debate on climate change may not even be considered a controversial topic in certain areas, but would be a hot topic in another school (Plutzer et al., 2016). These geographic distances also mean that professional learning experiences may need to take into account the school's political environment and how teachers can navigate this space. Additionally, people disagree as to the purpose of democratically focused education (Hess, 2004; 2008; 2009). Teachers face pressures to not include controversies due to this disconnect, and often feel pushed to remain neutral in facilitating classroom debates, even if they feel very strongly about a topic (Nation & Feldman, 2022). These challenges highlight the importance of including education for pre-service teachers on how to bring controversial issues in the classroom, especially for STEM teachers who doubly face anti-science and political arguments when leading a controversial debate with students (Plutzer et al., 2016).

Preparing STEM Teachers to Teach Controversy

Pedagogical Shifts

Teachers may feel the need to "teach both sides" and remain neutral when they facilitate a classroom debate (Misco & Patterson, 2007; Plutzer et al., 2016). For science educators, this stance often misrepresents what scientists know to be true (Plutzer et al., 2016; Borgerding &

Dagistan, 2018). For instance, it is inaccurate to teach climate change or evolution as issues that have multiple sides when the scientific community overwhelmingly agrees that humans' actions influence climate change and that humans evolved from a common ancestor; these are not open issues. However, pre-service teachers often feel that they must remain neutral and present all sides of an issue to students (Borgerding & Dagistan, 2018). Pre-service science teachers and in-service teachers easily identify areas of controversy in their curriculum, and also express how they do not feel adequately prepared to teach these topics, such as climate change or biotechnology topics (Steele & Aubusson, 2004; Borgerding & Dagistan, 2018). Nevertheless, teachers report that teaching the ethics of biotechnology is important, even if it is a difficult topic for students that may not be given enough space in the science curriculum (Steele & Aubusson, 2004). Though little research has been done on how pre-service teachers are prepared to teach controversies, prior work suggests that teacher-educators teach strategies to pre-service teachers so that they may mitigate risks of teaching a controversial issue, such as creating a safe classroom environment, examining controversies through multiple perspectives, and steering the discussion to be productive (Pace, 2019).

It is clear that teachers face a number of obstacles in including controversies in their science curriculum. However, I would agree with Oulton et al. (2004) that there needs to be a mindset shift in how teachers should approach teaching controversy. Specifically, in how teachers feel the need to present neutrality during these debates. I believe that teachers, and other educational stakeholders, have been misled about the importance of a neutral arbitrator in these classroom debates. In refraining from sharing their opinion, teachers are missing out on an opportunity to model for students how to respectfully communicate ideas about science and walk students through how they came to that understanding and opinion. However, science and

science education is not neutral, and to claim such is a disservice to students striving to be future innovators who need spaces to develop their argumentation skills.

Additionally, research has shown that teachers who teach controversies are concerned about the risks and implement strategies to avoid that by taking measures to guide student conversation (Pace, 2019). Relying on "teacher directed" conversational moves may keep the teacher in control or prevent the conversation from getting out of hand, but this does not allow students opportunities to develop the ability to self-regulate their own debates. I recognize that this notion may be challenging for many teachers who understandably feel pressure to maintain control over a neutral classroom.

Argumentation Skills to Practice and Challenges to Prepare For

To prepare to meet these challenges surrounding teaching controversies, I provided scaffolding in the simulation design in which each student conversion in the discussion increases in difficulty, from asking probing questions, to deciding whether to provide the teacher's opinion, to handling misinformation. This framework comes from research on how to best support the development of students' argumentation skills. In the analysis of several different discussions in social studies classrooms, Hess and Posselt (2002), found that students have positive ideas about participating in discussions, especially if they can see connections outside of school, and certain classroom norms and teacher decisions helped them to participate more, such as taking time to organize their ideas before speaking or a teacher that asks specific questions about their opinions. Practicing asking open ended or probing questions is also important for teachers as this has been shown to increase students' engagement with each other's' ideas (Pimentel & McNeill, 2010). Other challenges outside of rehearsing argumentation skills represented in this simulation include deciding whether to share the teacher's opinion and

helping students fact check digital misinformation. While there are challenges (Misco & Patterson, 2007) and benefits (Kelly, 1986) that come with choosing whether or not participants share the teacher's opinion, practicing this skill can give participants time to reflect on how they would actually react to a student's request to hear their opinion on a controversial issue. Furthermore, prior work has shown that misinformation in the classroom has recently become a larger concern for teachers (Rogers et al., 2017). To prepare for this challenge, participants in the simulation can practice modeling how to investigate a piece of information with students by using the skill of lateral reading (McGrew et al., 2018). Lateral reading is a skill used by professional fact checkers to analyze digital information that others can pick up easily (McGrew et al., 2018), making it a useful skill for participants to rehearse as they will undoubtedly encounter misinformation during a classroom debate.

Criticisms of Teaching Controversies

While I strongly support the inclusion of controversial topics in education, it is not without its criticisms. For instance, one can imagine a history class learning about the immigration process through Ellis Island and how this topic could spark student discussion about the immigration system in modern America. Should a teacher host a discussion on immigration reform if there is the possibility that there are students in the classroom for which deportation is an everyday fear? For similar reasons, should students debate the rights of transgender people or abortion rights in their classes? It can be argued that this kind of lesson has the possibility of students learning that others in the classroom do not respect their fundamental rights (Beck, 2013). This problem highlights the need to establish with students a set of classroom norms that ensure that students continue to feel safe in their classrooms after the discussion ends, but even this may not be enough to protect students in non-dominant social categories (Beck, 2013).

Students continuously encounter controversy outside the classroom, but at least instruction on how to engage in civil discussions and analyze evidence can prepare them to face these topics with those who may choose to debate in disrespectful ways.

Conclusion

I have argued that the lessons learned from social studies education are applicable to controversial discussions in STEM classes. Social studies teachers and experts in the field report that the purpose of discussing controversial issues in the classroom is to prepare students to be active, informed members of a democracy (Hess, 2009). For science teachers, the goal is to educate the next generation of engineers and scientists on the ethics of their fields by helping students learn to synthesize data and analyze the validity of evidence (Berland & Hammer, 2012). The discussion of the ethics of science and other controversial science topics is still critical to a functioning democracy as it asks young scientists to consider how their future work will have larger implications for society at large, such as students who will potentially make choices like the design and implementation of new genetic therapies that change the course of human nature.

Despite this importance, teachers in social studies and STEM classrooms confront similar barriers to teaching controversies in classrooms, like feeling unprepared to teach the issues or that they have to present neutrality or all sides (Borgerding & Dagistan, 2018; Nation & Feldman, 2022), and this may be why students rarely have the opportunity to engage in meaningful discussions (Nystrand et al., 2003). In the next chapter, I discuss the design of a digital simulation of facilitating a classroom discussion as a possible solution to helping teachers practice teacher dialogue strategies for controversial STEM classroom discussions.

Chapter Three

Simulation Design Methodology in *Discussion Leader*

In this chapter, I describe previous research in simulating controversial discussions on different digital platforms, and discuss the methods used in the design of *Discussion Leader - Genetic Modification* (Marvez, 2021), including playtesting, student profiles, and argument analysis. This simulation is playable at: https://teachermoments.mit.edu/run/fc5a028657/slide/1

Simulation Design Principles

Digital clinical simulations, sometimes referred to as practice spaces, follow a similar structure: an "anticipate" stage where participants prepare for the context of the scenario, an "enact" phase where participants practice the simulated skill, and a "reflection" phase where participants debrief their experiences (Self, 2016; Reich et al., 2018; Self & Stengel, 2020). Below, I discuss how the argument design, student profile creation, branching paths, and open response questions fulfill these phases of digital clinical simulation creation.

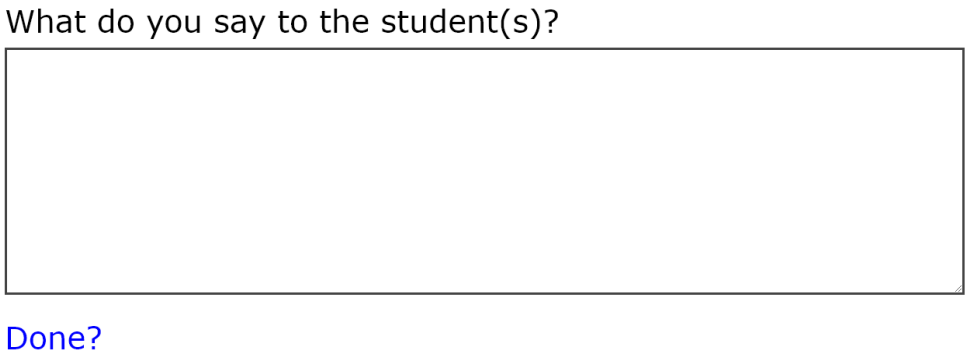
Previous Simulation Design Considerations

Several versions of *Discussion Leader* on various topics in social studies education have been made previously in different platforms for distinct audiences. In this section, I describe the evolution of this intervention and how feedback from participants at these stages helps inform the new design.

The *Discussion Leader* project began as a prototype in a slide deck designed as a linear simulation. In this design, a participant spoke with three students who had polarized views on the discussion topic of immigration law. The student profiles consisted of: Sofia, a Latina student

whose parents were professors at a university nearby who spoke about the positive aspects of immigration; Tom, a white student who argued strongly against immigration; and Minjun, a Korean student whose parents immigrated to America and argued that prospective immigrants needed to wait through the proper channels to immigrate. The participant took on the role of a high school social studies teacher and typed responses to student dialogue onto the slide and would click to progress (Figure 3.1). In this preliminary version, participants' typed responses did not affect student dialogue. No matter how the participant responded, the class discussion always resolved the same way. Additionally, feedback from playtesters, which included teacher educators, students, and other stakeholders in education, at lab playtests in 2019 suggested finding ways to make the scenario more adaptive to participant input and to make the scenario more authentic.

Figure 3.1
A Screenshot of an Early Prototype of Discussion Leader



These design issues and feedback from participants led us to consider using Twine as our next development platform. Twine is an open-source game engine that allows developers to make extensive choose-your-own-adventure or branching path games. Within Twine, it is possible to add in features using JavaScript and other macros made by the Twine community. Specifically, I used the SugarCube version of Twine, as it allows for the use of additional macros

and has the easiest way to implement an API call to collect user data, something that was not possible with our original implementation, and was needed critically for research.

In the first Twine implementation of *Discussion Leader* (Marvez & Littenberg-Tobias, 2019), we examined how to make the student dialogue outputs more responsive to user input in the same context of talking about immigration with the students. We implemented a branching path narrative with over 100 possible paths and 12 endings based on users' choices. This jump in complexity increased the replayability of the scenario, allowing participants to try different conversation moves with the students to see how the discussion evolves. In this version, there was also an ending where the discussion turns hostile, and the students refuse to participate any further. From this version, we also designed a second simulation similar in structure on the topic of legislation around gun control with a high school intern who helped us develop more authentic student dialogue practices (Smith & Marvez, 2019). Research on these scenarios showed that participants found *Discussion Leader* to be a useful tool of reflection on their discussion practices with students, and that participants often did not use the discussion strategies they predicted they would use, even when given the option (Kaka et al., 2021; Marvez & Littenberg-Tobias, 2020a). Specifically, student teachers in this study (Kaka et al., 2021) reported that the simulations helped them feel more comfortable in their facilitation skills, but also reported that they felt they needed to remain in control of the discussion and did not encourage debate between students. When students completed the two *Discussion Leaders* on immigration and gun policy as a part of their teacher preparatory program, students commented that the two simulations helped them realize that they needed more practice with leading controversial discussions and that they wished for more opportunities for this kind of practice (Kessner et al., 2020).

These two designs were well received (Kaka et al., 2021), but we wished to increase the complexity of the paths and conversational strategies that participants could practice. Since many paths in a simulation means that participants see different content, it can be difficult to facilitate a debrief on the content, so we also considered how to generate common experiences within the simulation. To meet this need, we looked towards a *Teacher Moments* implementation.

As described in Chapter One, *Teacher Moments* is a digital clinical simulation platform that allows for the creation of simulations in linear or branching ways. *Teacher Moments* also has more robust data collection than the Google API call we implemented in our Twine versions of *Discussion Leader* in that participants can create an account to link their simulation runs and the data is more easily accessible to researchers. With these functionalities in *Teacher Moments*, we designed a third branching scenario around managing a controversial discussion about the ability for schools to monitor and punish students for what they post on their private social media called *Breakout Groups* (Marvez & Littenberg-Tobias, 2020b). In this scenario, the participant takes on the role of a high school social studies teacher in a remote class who has split their class of 20 students into five breakout rooms of four. Participants could visit the rooms in any order, and in each breakout room, a different kind of discussion norm was being violated. Participants were expected to notice the violation, such as certain students being talked over or being personally attacked, and were given several options on how to respond. From this design, we learned that participants found the inclusion of 20 students to be more representative of an actual classroom environment, and benefitted from the opportunity to practice five different discussion skills. This differed from our previous simulations in which there were only three to four students and one basic discussion skill to manage (enforcing classroom norms). Using smaller groups to represent the larger classroom environment segmented the scenario better and allowed for practice of one

discrete skill at a time. Participants lamented that it was somewhat hard to keep track of what groups they had already spoken to in this design as the breakout groups could be visited in any order and revisited as needed.

Context Specific Controversy Surrounding Gene Therapy for Science Classrooms

Though I focus on the topic of gene therapy, a topic more specific to high school biology or biotechnology teachers, there are other controversial science topics students could discuss. These topics all share similar, underlying challenges. Teachers may feel pressure to not teach certain controversial science topics like climate change, evolution, or gene-editing techniques or may not be confident in their understanding of the issue or do not understand it to the depth needed to lead a controversial discussion (Plutzer et al., 2016; Nation & Feldman, 2022).

In the simulation I designed for this thesis, the participant takes on the role of a high school science teacher preparing to lead a discussion with their students on the ethics of gene therapy, a controversial topic within biotechnology education. I selected this topic because it remains an "open issue," a topic that remains controversial and that experts do not broadly agree on, and presents elements of scientific and ethical debate (Hess, 2009). For instance, students could respond equally to *What conditions should be tackled first by gene therapy research?* and *Should gene therapy treatments be offered to correct mutations in embryos or germline cells?* Research has shown that students (Vajen et al., 2021) and teachers (Steele & Aubusson, 2004), in addition to experts in the field (Armsby et al., 2019; v. Hammerstein et al., 2019), perceive this issue to be controversial. Common debates in the field of gene therapy include unequal access to these new health treatments and whether edits to the germline genome should be avoided to avoid unknowable downstream effects. This type of controversial discussion fits well into several areas of the preexisting science and engineering curriculum, such as biology (2016

Massachusetts Science and Technology/Engineering (STE) Curriculum Framework, 2016) and biotechnology classes in Career and Technical Education programs that have specific learning standards surrounding how students can learn to analyze ethical issues in biotechnology (Florida Department of Education Curriculum Framework: Industrial Biotechnology, 2018). Additionally, in the sixth unit for the Advanced Placement Biology exam, students learn about biotechnology, specifically on techniques for the manipulation of DNA (AP Biology Course and Exam Description, 2020).

Student Profiles

A critical element of simulation design is realistic student profiles, or a set way students in a scenario will act in response to participant actions. For *Discussion Leader - Genetic Modifications,* I designed 20 student profiles to populate the classroom. These students have profiles about their opinions and motivations on the topic hidden from the participants. I then split the 20 students across five groups and these groups stay consistent across different playthroughs of the scenario. In each group, a different discussion challenge is happening for the participant to face, and is also highlighted in Table 3.1.

The opinions on the ethics of somatic and germline edits from researchers and university students were synthesized to define the opinions of the simulated students in the scenario *Genetic Modification* (Table 3.1). A majority of the students in the scenario express support of somatic editing and are concerned about how the technology may advance and further widen opportunity gaps, but have differing opinions on how limited the technology should be. Outside of this mainstream opinion, several students state that either advancements in gene editing treatments should not be blocked for any reason because it hinders scientific progress or that no editing techniques should be allowed because they see it as interfering with nature. These differences in

student opinion provide a discussion space in which a participant is exposed to many ideas while the students debate the question: If genetic modification treatments in humans should be allowed, to what extent and why?

Table 3.1
Descriptions of the Five Groups and Student Profiles

Group Number and Discussion Description	Student Name	Student Profile
Group 1 - The students have some slight differences in opinion. Goal - Practice asking students probing questions.	Diego	He believes that research should continue to fight diseases.
	Victor	He does not have any strong opinions on the topic.
	Kaia	She wants research to continue, but with ethical regulations, such as no cosmetic changes.
	Taylor	They think that regulations on this research would set back treatments and progress.
Group 2 - All of the students support somatic edits but not germline edits. Goal - Practice implementing "exploration" and "telling" teacher-speech strategies	Abril	She has a stronger understanding of the technology than other students.
	Ro	She has more questions about how ethics committees have actual effects on research.
	Martin	He has some general questions about how CRISPR works.
	Joseph	He doesn't understand how cystic fibrosis is treated with CRISPR.
Group 3 - Students are interested in the teacher's opinion on the topic,	Mark	He agrees with the teacher's opinion that treatments that target somatic edits are beneficial, but not germline edits.

and all have conflicting opinions. Goal - Practice whether or not to disclose a personal opinion to students	Nadia	She strongly believes that genetic editing should not be allowed in any form.
	Zoe	She does not believe that research or technology advancements should be limited in any way.
	Ari	She believes genetic treatments should be allowed no matter the case, but is playing the "devil's advocate" in the group.
Group 4 - These students are not participating in the discussion and have few opinions. Goal - Practice bringing all student voices into a discussion and work with students who seem to have no opinions.	Peter	He did not complete the homework and is in the bathroom for most of the discussion. He does not have a clear opinion.
	Min-seo	She seems uninterested in the discussion and does not have a clear opinion because she believes genetic editing treatments would never affect her.
	Sahar	She wants to participate in a discussion, but is having difficulty getting her classmates to engage. She believes that somatic treatments are beneficial.
	Mateo	He is naturally quiet and will not offer his opinion unless called on. He believes that all genetic editing treatments should be allowed.
Group 5 - These students are having a very lively discussion about an article stating that GMO food caused someone's death from a satirical website.	Jude	He is presenting the satirical article to the group as fact and believes that genetic editing should not be allowed.
	Harper	They believe that the article Jude is showing is real and believes that genetic editing should not be allowed.

Goal - Practice managing how to react to students bringing misinformation into classroom discussions.	Tamir	He is skeptical of the claims shown in Jude's article and believes that any type of genetic editing should be allowed.
	Maryam	She does not believe at all in the article Jude is showing and believes that any type of genetic editing should be allowed.

Selection of Discussion Materials

In the scenario, it is stated that the students in a high school biology class read two articles for homework on genetic modification treatments highlighting possible positive and negative outcomes. The first is a Nature article on how gene therapy is being used against cystic fibrosis (Khamsi, 2020). The second is also a Nature article that discusses how two twin girls were born from genetically modified embryos and the possible policy related consequences (Cyranoski, 2019). Students in the simulation reference these articles in their arguments and incorporate other knowledge that a typical high school science student may know. Both articles are four pages long and were chosen so that a teacher could run this discussion in their own classroom after completing the practice space.

The Use of a Branching Dialogue System

Discussion Leader relies on a system of branching dialogue choices. At each node, there are three possible branching dialogues that influence the narrative, or essentially how the students respond to the teacher and where the conversation goes next. This structure is inspired by the original Choose-Your-Own Adventure book series from Bantam Books and newer interactive narrative games such as Detroit: Become Human (Quantic Dream, 2018) and Life is

Strange (Square Enix, 2015). In these kinds of games, players make dialogic choices that influence their avatar's actions and dialogue, and see the effects of their choices by how other characters in the game react.

With this game model in mind, we can further consider what Taylor-Giles (2014) describes as the Four Essential Properties of Branching Dialogues, which is an adaptation from Murrary's understanding of digital environments (1997). These properties include agency (allowing players to take actions that impact the story), ambiguity (maintaining the appearance of choice under limited written content), context (providing players with enough information that allows them to make informed choices), and lack of judgment (my own personal beliefs as a designer should not punish players for making choices I would disagree with). These properties are player-centered and are utilized in the design of *Discussion Leader*. Based on previous knowledge about the students' discussion (context), participants are presented with a limited number of teacher dialogue choices (ambiguity), but these choices affect the course of the students' conversations (agency). Additionally, I did not design the teacher dialogue choices to have right or wrong answers, but to include different kinds of discussion strategies that participants could explore (lack of judgment). By designing all choices to be acceptable ones, that is, they advance the conversation forward (Taylor-Giles, 2020), the choices participants make can be compared across different kinds of participants to analyze how preferred discussion moves differ and to examine which paths are the most commonly utilized.

As with most interactive narratives, be that books or video games, a single run is not sufficient to see the entirety of the story. This adds replayability to the games and means that players may spend more time hunting down certain moments in the story or rare endings. For *Discussion Leader*, this means that participants can play the simulations many times to try out

new discussion moves and see how students react. At each student table, there are 21 different paths, so across the five groups, this represents 21^5 possible paths. Though this design provides the opportunity for participants to engage in unique simulation runs, it does pose a debrief facilitation challenge should this be implemented in a teacher preparatory course as it may be more difficult for an instructor to talk about a certain key moment in the simulation when all of their students have seen different parts of the classroom's discussion.

Branching Paths through the Groups

There are five groups of four students that the participant advances through in order. Each group is progressively harder, requiring participants to consider more complex dialogic choices, than the last and focuses on more challenging discussion facilitation skills. The practiced skill in each group is as followed:

1. Practice asking students open-ended, probing questions.
2. Practice implementing "exploration" and "telling" teacher-speech strategies.
3. Practice whether or not to disclose a personal opinion to students (in this scenario, it is stated to the participant that the teacher they are playing as believes in somatic edits, but not germline edits).
4. Practice bringing all student voices into a discussion and work with students who seem to have no opinions.
5. Practice managing how to react to students bringing misinformation into classroom discussions.

Prior work has named a number of skills that are important for teachers to have, such as centering students as the sense-makers, placing emphasis on open-ended and probing questions, and considering their position as a figure of authority in the classroom (Hess & Posselt, 2002;

Hess, 2008, 2009; McNeill & Pimentel, 2009; Berland & Hammer, 2012; González-Howard & McNeill, 2019). Utilizing these practices can mean that students engage in more productive forms of argumentation during their classroom discussions.

For the skills practiced in the five groups, they can be thought of as five levels of a video game in which the main skill and context addressed becomes more complex or pressing. Within Group One, the participant is presented with a group of students who are having a robust discussion. Here, the participant can select from teacher dialogue choices with varying levels of open ended question types. Practicing asking open ended questions is an important skill as in classes where teachers support students' argumentation by asking more open ended questions, students tend to engage with each other's' ideas more (McNeill & Pimentel, 2009).

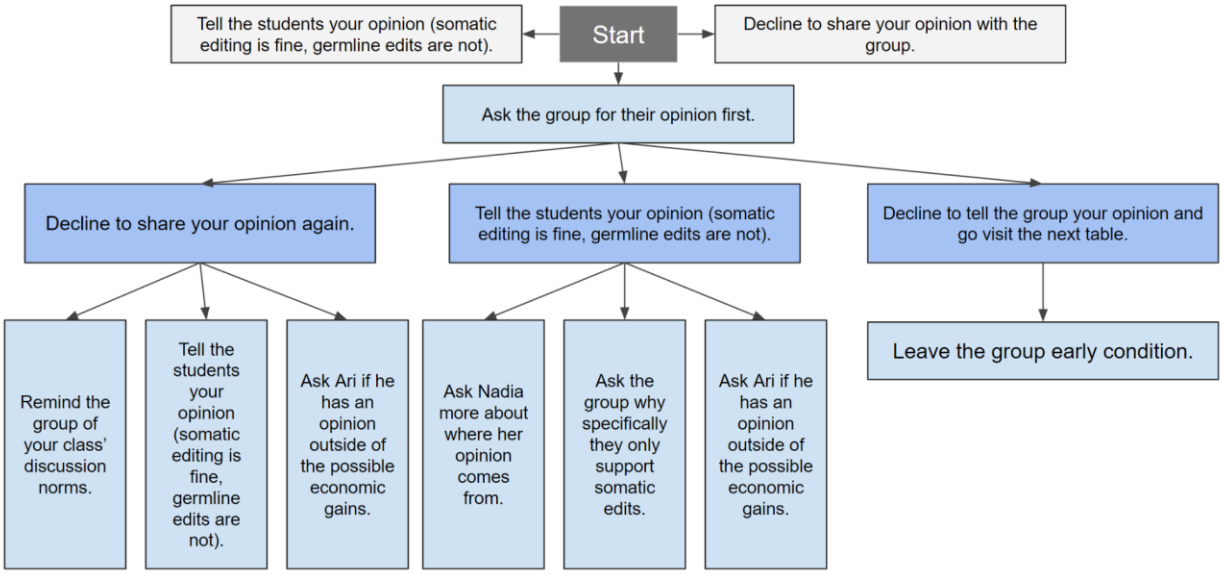
For Group Two, the students are looking to the teacher to provide a direct answer to a conceptual question they have. At this juncture, the participants can provide students the answer (a definition of a mechanism present in CRISPR) or "toss it back" to the group and have the students help each other look for the answer. There are several other "toss back" moments within this group where the participant can turn questions back to the table before asking students about their opinion of the discussion question. This skill of encouraging student exploration by asking them to discover answers together breaks out of the initiate-response-evaluate conversational turns often seen in whole class discussions, and may promote higher student engagement (Mehan, 1979; Pimentel & McNeill, 2010). The goal here is to engage in less informational turn-taking conversations with the teacher as the authority figure and shift towards a student controlled discussion where they can rely on each other's knowledge and decide for themselves in what productive ways they want to take the conversations. The teacher dialogue choices that flip the conversation back to the students ask the participant to give up a little more sense of

control in the discussion, and for that reason, might be slightly more difficult than the conversation that occurred in Group One.

In Group Three, the students immediately stop their conversation and ask the teacher for their opinion. In the teacher dialogue choices for this group, participants see the option to provide their opinion to the students up to three times. This is a somewhat of a contested choice to make. By even teaching controversies, a teacher may fear pushback or accusations of indoctrination of students (Hess, 2004; Misco & Patterson, 2007), and may, therefore, shy away from sharing their personal opinion, even when they believe strongly in an issue (Nation & Feldman, 2022). On the other hand, Kelly (1986) argues that teacher disclosure, defined as committed impartiality, is a critical discussion move a teacher can make. By disclosing their opinion and encouraging students to develop their own, they offer a moment for students to challenge the authority in the classroom. Additionally, other work has suggested that providing a teacher's opinion when asked can provide a modeling opportunity to show students how someone may utilize evidence available to them to land on a personal opinion (Oulton et al., 2004). To maintain the principle of the lack of judgment design choice, the conversation continues without punishment to the participant even if they chose to not share their opinion. While I maintain that disclosure of a teacher's opinion can be a valuable modeling opportunity, I did not want to design in-game penalties for non-disclosure. Participants are free to disclose their opinion or not to the students and do not face significant challenges should they choose to not do so. An example of the teacher dialogue choices after the participant asks the group for their opinions first is shown in Figure 3.2

Figure 3.2

Teacher Dialogue Choices in One Branch for Group Three



In Group Four, participants face a new problem. The prior three tables are full of chatty, excited students, and this new table is quiet and unengaged. In a discussion where the entire class is talking as a larger group, these quieter students may go unnoticed, and some students have reported that they are hesitant to speak in a discussion (Hess & Posselt, 2002). By placing quieter students in one group, it gives them all the opportunity to speak without having other students who may be more talkative cut them off, but also presents an opportunity for participants to interact directly with these quieter students. At this table, there are two quiet students who do not speak unless directly called on, one student who is participating, and another student who is in the restroom for most of the discussion and only comes back at a certain point in the narrative. In this group, there is a path of "least resistance" in which the participant can choose to mostly speak with the one student who is talkative, rather than include the quieter students, which requires more effort from the participant.

In the final Group Five, participants meet a table of students loudly arguing over the credibility of a source that a student has brought into the discussion that they have up on their

laptop. This source is a piece of misinformation and this is revealed to the participant by the simulation. Also, the article is about genetically modified foods, so it is somewhat off-topic as well. From there, participants can choose to tell students immediately that the source is fake and refocus the conversation, or investigate the misinformation with students. Confronting misinformation in the moment is important, but participants may also be concerned that the students are off-topic. Should participants choose to model how to investigate misinformation online with students, they enact the digital media literacy skill of lateral reading, or investigating who is behind a piece of information by opening a new tab and utilizing sites like Wikipedia and fact checking websites (McGrew et al., 2018; Breakstone et al., 2021). Media literacy is an important skill for students to be able to determine if a piece of information is truthful as having knowledge of controversial topics is not necessarily enough (Kahne & Bowyer, 2017). This group is difficult to work with because participants have to decide if it is worth investigating the misinformation with students or to refocus the conversation. Even within modeling how to investigate the source, there are teacher dialogue options in which the participant tells the students exactly what to search online to find out if it is true as compared to less directive options in which the students look up the source of the article themselves.

Iterative Design Changes

The prior implementations of *Discussion Leader* informed a majority of the simulation structure in *Discussion Leader - Genetic Modification*. Some distinct changes we made between *Breakout Groups* and *Genetic Modification* were that participants had to visit the groups in a particular order. This meant that the increase in difficulty could be controlled as the participants progressed through the simulation and participants could keep better track of what groups they had already visited. Additionally, when participants reached the end of their conversation with

each table, we asked them to summarize the main discussion point of the table and if they would have said anything different to the table in a real life scenario. These two questions allow us to consider two future design implications. First, the comprehension check question allows us to examine if a participant understood the ideas students discussed and can be used as a natural language processing feedback question. In a future version, we could provide participants personalized feedback on their conversations if they miss a main idea that a student brought to the table. The second question allows us to iterate on the teacher dialogue options in the simulations. If we were to find that a majority of participants stated that they would have made a conversation move not present in the scenario, we could adjust the teacher dialogue options to include that option. These new anticipation and reflection questions are shown in Table 3.2.

Table 3.2
Anticipate, Enact, and Reflection Questions

Section	Question
Anticipate	What is a discussion strategy you may use to encourage students to develop their own ideas about this topic?
	Genetic modification is a relatively new topic in science and public policy. Suppose a student brings up something in the discussion that you know is false or misleading. How would you respond to the student?
	How comfortable are you with leading a controversial discussion with students (1 - Totally Uncomfortable to 5 - Totally Comfortable)?
Enact - Group Reflect (x5)	Summarize the main discussion this group of students had on the question: If genetic modification treatments in humans should be allowed, to what extent and why?

	Was there anything you wished that you could've done differently with this group?
Final Reflections	Above is the discussion strategy you thought you might be able to use in this discussion (the participant's answer to question one from the anticipate section is displayed). Were you able to implement this? Please explain your answer.
	What were some of the challenges you encountered in this discussion?
	How comfortable are you with leading a controversial discussion with students (1 - Totally Uncomfortable to 5 - Totally Comfortable)?

An Overview of the Simulation's Path Structure

A teacher must be knowledgeable on the topic, prepared to manage conflict, and understand how to encourage the growth of student ideas. By breaking these tasks down into five discrete groups, it is easier to practice these skills than it would be facing 20 simulated students at once. Within each group, the participant is first presented with a screen of student dialogue that introduces the conflict at the table to the teacher. From there, the participant has three options for how they would like to respond. Based on the skill for that group, the participant is presented with three options that embody that skill, do not embody that skill, or offer a deflecting or off-track option. The student dialogue then changes to reflect the participant's choice. The participant then sees another three options to the new student dialogue, and at this stage, has the opportunity to leave the table and check on another group. Should they choose to continue their discussion with the group, they are then presented with the final three options, see the final screen of student dialogue and progress to reflection questions, and then onto the next group (an

example of these screens is shown in Figure 3.3). There are 21 distinct paths of discussion through each student group, meaning there are 21^5 (4,084,101) possible ways to complete the scenario. Tree graphs can be used to represent how one participant may progress through the five groups (Figure 3.4). This design allows for significant replayability from linear scenarios and empowers participants to try new discussion moves on subsequent runs.

Figure 3.3

A Screenshot of the Teacher Moments Interface, Showing a Possible Branch Through Group One's Discussion.

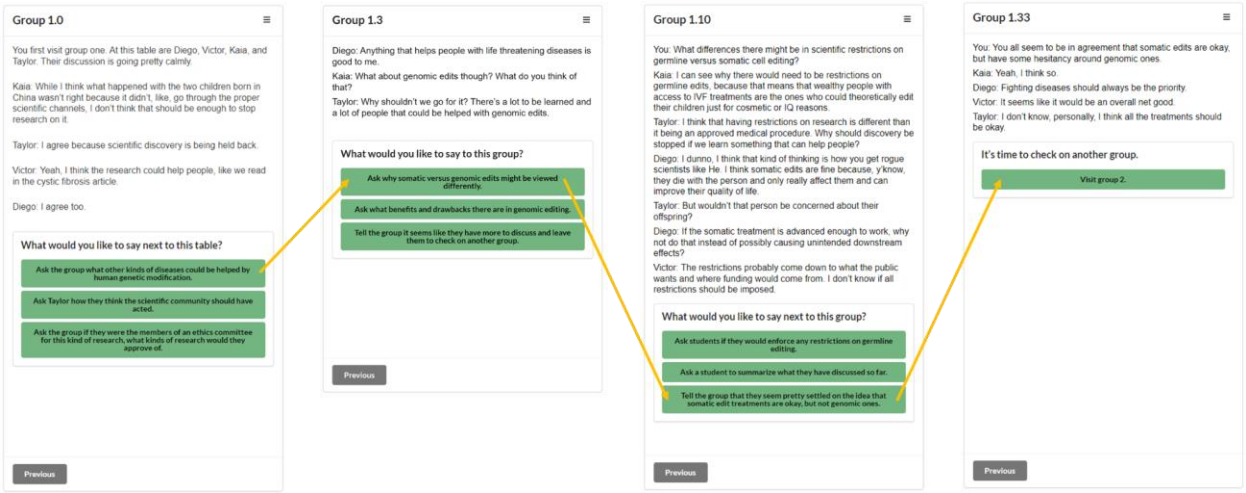
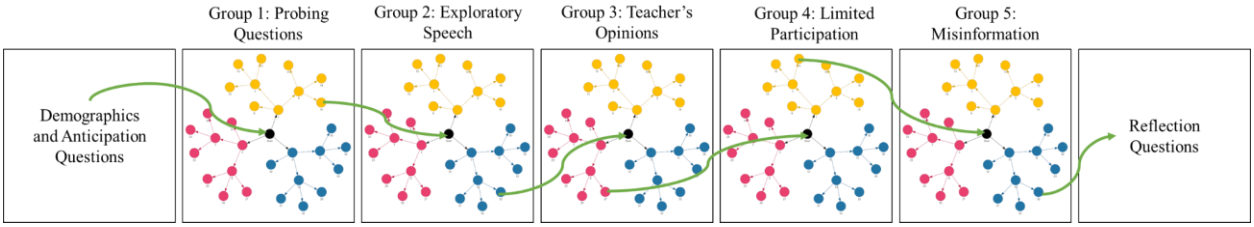


Figure 3.4

Five Tree Diagrams Representing the Possible Dialogic Branches Participants Could Explore



Path Analysis Based on Teacher Experience

This path data can be analyzed to compare path choices between groups, such as novice and experienced teachers, and for shifts in choices over time from Group One to Group Five.

Prior research has shown that novice and experienced teachers notice different classroom elements and approach teaching differently. For instance, expert teachers are more likely to design lessons that integrate students' prior knowledge, to redirect misbehavior the first time it occurs, and to create interactive classroom environments that allow teachers to deviate from their lesson plans if need be (Westerman, 1991). Additionally, expert teachers have been shown to be more flexible and adaptable in their lessons and have higher levels of open discussion with students (O'Connor & Fish, 1998).

To potentially tease out these differences in classroom moves between experts and novices within the teacher dialogue options, there are moments where these expert and novice features are present, such as drawing on what students already know, allowing students to remain in control of the discussion, or ignoring violations of classroom norms. Should participants' choices vary, it would show that those with different levels of teaching experience utilize different teacher dialogue strategies within the simulation and provide insight into the differences between the challenges in the five groups.

Conclusion

In this chapter, I have described how previous research in simulations for practicing leading controversial discussions inform the current design of *Genetic Modifications*. We have enhanced the authenticity of the simulation by designing a classroom environment with 20 students and by choosing a topic that can be discussed at several levels of science education. This design means that teachers can practice discrete skills within the broader skill of leading a discussion while still interacting with a larger number of simulated students that represent the classroom. Additionally, this scenario has significant replayability over previous work, such that participants could play it several times and not see the same pieces of student dialogue. By

increasing the replayability, participants can practice different approaches to the discussion and reflect on how changing their teacher dialogue choices influences students' discussions. We have also built in opportunities for future work by collecting from participants the different discussion moves they may employ in a real discussion about genetic treatments and through the inclusion of prompts that would lend themselves to natural language processing feedback methods. In the next chapter, I describe the methods of data collection for this simulation with student teachers, novice teachers, and expert teachers.

Chapter Four

Data Analysis Methods and Participants

In this chapter, I describe the data collection sites, the overall demographics of participants who consented to the research, the kinds of data collected, and the planned data analysis for the simulation.

Data Collection Sites

I utilized several data collection sites from undergraduate and graduate students in education related classes. I also collected data from participants in a Boston teacher training program. Several high school science teachers and university professors also completed the simulation through an emailed link to the simulation. Only participants who consented to be in the research and completed the entire simulation are described below.

Graduate Level Education Research Methods Class

In this graduate level education research methods class, I presented on how simulations can be used for learning and different kinds of data analyses that can be conducted with branching simulation data and natural language process. Students then had class time to complete the scenario and participated in a short debrief afterwards. Students in this class were Master's students in a program on statistical analysis and measurement for educational contexts.

Undergraduate Level Education Assessments Class

This class on education assessments consists of undergraduate students who are completing student teaching placements in schools in the Boston and Cambridge areas. I

presented an overview of the simulation and how it can be used for assessing teachers' methods for facilitating a controversial discussion. Students completed the simulation for homework.

Undergraduate Level Teacher Certification Class

In this class for teacher certification, undergraduate students are finishing their student teaching placements in Boston and Cambridge area schools and are preparing to take their Massachusetts Tests for Educator Licensures (MTELs). Some of the students in this class are preparing to become classroom teachers in the next year. Students in this class completed the simulation for homework.

Bilingual Educators & Accelerated Community to Teacher Program

In this program, Boston Public Schools is focused on training new teachers from the Boston area on anti-racist teaching practices, and provides tutoring help for the MTELs and support for their candidates' job search. This program consists of several sessions on different teaching practices and participants in this program completed the scenario in one of these sessions and debriefed afterwards.

Emailed Link

The link to the scenario was also sent to selected MIT instructors and a Massachusetts high school. Several high school science teachers completed the scenario. Additionally, two professors/instructors at MIT who were not involved in the project's development completed the scenario.

Demographics

Participants were asked demographics and survey related questions about their role in education and how many years of teaching experience they had. Participants were also asked if they had ever led a controversial discussion with students and their level of comfort with leading a controversial discussion (5-point Likert scale: Totally Uncomfortable - Totally Comfortable). Their comfort with leading a controversial discussion was used as a pre-simulation and post-simulation question. 42 people consented to be in the research and the overview of their demographics are shown below.

Role in Education

A majority of participants were either students from undergraduate or graduate level education classes or current K12 teachers (n = 36, 85.7%) (Table 4.1).

Table 4.1
Demographic Information on Participants' Role in Education

Role	Number of Participants (N = 42)
Student	26
K12 Teacher	10
University Professor	2
Not in Education	1
Educational Support Staff	1
EdTech/Curriculum Designer	1

Years of Teaching Experience

Participants were asked: How many years of teaching experience do you have (any K12 or college setting)? 35.7% of participants reported no teaching experience (n =15), 42.9% of participants reported less than five years of teaching experience (n= 18), and the remaining 21.4% reported more than five years of teaching experience (n = 9). In the data analysis, these groups are referred to as "non-teachers," "novice teachers," and "expert teachers."

Prior Experience with Leading a Controversial Discussion

Half of participants (n = 21) reported that they had previously led a controversial discussion with their students.

Simulation Data Collected

This simulation design includes an anticipation section, five enact sections each followed by an intermediate reflection section, and a final reflection section. The data collected from these sections is described below.

Anticipation Questions

Participants were asked two anticipation questions: *What is a discussion strategy you may use to encourage students to develop their own ideas about this topic?* and *Genetic modification is a relatively new topic in science and public policy. Suppose a student brings up something in the discussion that you know is false or misleading. How would you respond to the student?* The first question probes the participant's knowledge of common classroom discussion skills and how willing they are to let student voices control a debate. The second question examines what strategies a participant already knows about navigating misinformation with students. Both

questions can be used for comparison against the actions participants choose in the simulation. Previous research has suggested that in simulations of controversial discussions, participants do not make the discussion moves they state they will in pre-simulation anticipate questions and default to teaching strategies that keep the teacher in control of the conversation (Kaka et al., 2021). The text responses to these questions will be analyzed for common themes.

Network Data from Groups

In each of the five discussion groups, there is a network with three choice levels. At each level in the network, there are three teacher dialogue choices that progress the conversation with students. In these choices, there are options that embody the skill that group is designed to practice and options that do not, though all options advance the discussion and elicit appropriate conversational turns from students to ensure that the dialogic paths can be comparable (Taylor-Giles, 2020). The teacher dialogue options were assigned a label that describes the type of questioning or conversational strategy that participants are enacting when they select that choice so that the dialogue choices can be compared across the five groups (Table 4.2).

Table 4.2
Descriptive Labels for Teacher Dialogue Choices by Group

Groups	Descriptive Label	Teacher Dialogue Example
3	Decline to Share	Decline to share your opinion with the group.
3	Decline to Share / End Discussion	Decline to tell the group your opinion and go visit the next table.
5	Deflect	Tell the table you can't believe everything you see online.
4	Disciplinary	Ask the group why they are not

		participating.
1, 2, 5	Encourage Student Directed Discussion	Tell students they are on the right track. Ask them to find the information themselves.
1, 2, 3, 4, 5	End Discussion	Tell the group it seems like they have more to discuss and leave them to check on another group.
2, 3	Enforce Norms	Remind the group that Ro was speaking and ask them to continue.
1	Informational Closed Question	Ask students if single-point mutations would be easier or harder to work with than conditions that involve multiple gene sites.
1	Informational Closed Question - Prior Knowledge	Ask students to consider if sickle cell anemia (a topic they have already learned about) could be helped using a technology like CRISPR.
1, 2, 3, 4	Open Ended - Group Opinion	Ask the group if they were the members of an ethics committee for this kind of research, what kinds of research would they approve of.
1, 3, 4	Open Ended - Specific Student Opinion	Ask Taylor how they think the scientific community should have acted.
5	Open Ended - Specific Students' Opinion	Ask Tamir and Maryam if there are any limits on genetic editing treatments they would institute.
2	Open Ended - Specific Students' Understanding	Ask Martin and Joseph more about their misunderstanding with genetic editing.

1, 2, 5	Provide Information	Tell students that scientists and others in the field have different opinions on what should be done for germline versus somatic cell editing.
1, 2, 3, 4, 5	Refocus Conversation	Ask the group what they think about the cystic fibrosis article.
3	Share Opinion	Tell the students your opinion (somatic editing is fine, germline edits are not).
5	Student Directed - Investigate Misinformation	Ask Jude to explain about this source she is showing her group.
1, 2, 3, 4, 5	Student Directed Summary	Ask a student to summarize what they have discussed so far.
5	Teacher Directed - Investigate Misinformation	Ask Jude to search up World News Daily Report in another tab.
1, 4	Teacher Directed Summary	Tell the group that they seem pretty settled on the idea that somatic edit treatments are okay, but not genomic ones.

Intermediate Reflection Questions

In between each of the discussion groups, there are two reflection questions. The first question is “Summarize the main discussion this group of students had on the question: If genetic modification treatments in humans should be allowed, to what extent and why?” This question will be used to determine if participants understood students’ main arguments. The second question is “Was there anything you wished that you could've done differently with this group?” From a design standpoint, it provides information on how the teacher dialogue choices could be

tweaked in the next iteration of the simulation to more accurately reflect possible discussion moves a teacher could make.

Final Reflection Questions

After completing the enact phase of the scenario, participants answer three reflection questions. The first question displays their response to the anticipation question: *What is a discussion strategy you may use to encourage students to develop their own ideas about this topic?* The participants are then asked to answer the question: *Above is the discussion strategy you thought you might be able to use in this discussion. Were you able to implement this? Please explain your answer*. This question serves two purposes. Participants can reflect on their initial strategy ideas for encouraging student participation and it also provides insight into whether any critical strategies were not offered as options within the scenario. This question will be analyzed for themes across these two conditions.

The second reflection question is: *What were some of the challenges you encountered in this discussion?* This question probes some of the challenges that may have been surprising to participants and helps them reflect on how they could counteract that in a real discussion. This question will be analyzed for whether a participant correctly identified a discussion challenge posed in the scenario and any common themes across responses on how they may face this challenge in the future.

Participants then see *How comfortable are you with leading a controversial discussion with students?* This question is the same as the one they saw in the anticipation section and answers will be compared to see any changes in level of comfort from the beginning to end of the simulation.

Data Analytic Approach

The collection of these data sets addresses the main research questions discussed in the introductory section of this thesis.

01. Can a simulation on leading a controversial discussion make participants more confident in their facilitation skills and act as a tool for reflection on practice?
02. Can a simulation on leading a controversial discussion act as a tool for reflection on practice?
03. Are the teacher dialogue choices different among participants with different levels of teaching experience?

To address the first research question, I will compare the pre- and post-measure of comfort between all participants and between those of different experience levels to investigate if this tool could be useful for certain types of teachers as it may be possible that this tool is more useful for teachers with less experience. In examining whether this simulation acts as a tool of reflection, I will analyze the responses to the anticipate and reflection questions for common themes to determine what participants may value when leading a discussion and determine how they managed the challenging moments of discussion.

I am also interested in the teacher dialogue choices novices and expert teachers make. These choices will be analyzed in the network to understand common paths and how the choices of non-teachers, novice teachers, and expert teachers may differ based on previous work about differences between how novices and experts perceive teaching (Westerman, 1991; O'Connor & Fish, 1998). By analyzing the different paths that participants utilize, I will be able to compare the most common paths between the groups to determine how the discussion strategies employed by these groups differ. It may be that certain groups of teachers cluster around a set of teacher

dialogue choices, suggesting that teachers unintentionally agree on a single course of action to take with students. On the other hand, participants that are more dispersed in the branches of the discussion would suggest that participants spent time exploring possible options or that there is not an agreed upon way to approach part of the discussion with students.

Conclusion

Through the analysis of the simulation data, I will examine the results and the three research questions about comfort, teachers' reflections on practice, and teacher dialogue choices for all participants and in the three groups stratified by experience. In the next two chapters, I will describe the analysis of the simulation data, implications for the results of this pilot study, and how this can inform future work into simulation designs and teacher education.

Chapter Five

Simulation Analysis and Results

In this chapter, I describe the analysis of the different kinds of data collected from participants in the simulation through survey, path choices, and text responses. From the survey data, I examined the changes in the reported confidence participants had about facilitating controversial discussions with students. The teacher dialogue path choices can show which paths are more common overall and which were favored by those with different levels of teaching experience. The text responses to the anticipate and reflection questions provide insight into common themes that participants thought were important and show potential areas for design improvement in the next iteration of this simulation.

Overall, participants with at least five years of teaching experience (n = 9) tended to choose more open ended lines of questioning as compared to those with less than five years of teaching experience (n = 18) or no teaching experience (n = 15). I will show examples in participants' teacher dialogue choices that show how this trend persists along many paths in the simulation. By going through the five groups, I will also highlight key moments in each of the groups, such as which participants chose to reinforce classroom norms or inform students of the teachers' opinion.

Anticipate Questions: Pre-Discussion Strategies and How to Combat Misinformation

Pre-Discussion Strategies

Before speaking with students, participants answered two short response questions about different discussion strategies they may use with students. The first question focuses on how to bring out student ideas in a discussion. Participants answered: *What is a discussion strategy you may use to encourage students to develop their own ideas about this topic?* Rather than talk

about strategies they would enact during the actual discussion, many participants mentioned activities they would do with students *before* the discussion, such as giving students time to write their ideas down in pro and con lists, having students complete a think-pair-share, and establishing discussion norms with students.

How to Combat Misinformation

The second question participants answered is concerned with misinformation and how they would address it in their classroom. Participants saw the following question: *Genetic modification is a relatively new topic in science and public policy. Suppose a student brings up something in the discussion that you know is false or misleading. How would you respond to the student?* Though no participants directly used the words "fact checking," many participants mentioned such strategies, such as asking about the source or guiding students through investigating the misinformation to see if it is misleading or objectively wrong. About a third of participants also mentioned the importance of correcting misinformation in the moment, and a smaller percentage were concerned with embarrassing or judging the student. This question sets up participants for interacting with Group Five, a group discussing an article that states that someone died from eating a genetically modified tomato. Not only are these students somewhat off-topic, discussing a slightly gene therapy related issue, participants have to contend with how they address the misinformation as well.

Group One: Asking Open Ended Questions

In Group One, participants come to a table with Diego, Victor, Kaia, and Taylor. Here, the students have slight differences in opinion and the discussion is described as calm.

> You first visit group one. At this table are Diego, Victor, Kaia, and Taylor. Their discussion is going pretty calmly.

Kaia: While I think what happened with the two children born in China wasn't right because it didn't, like, go through the proper scientific channels, I don't think that should be enough to stop research on it.
Taylor: I agree because scientific discovery is being held back.
Victor: Yeah, I think the research could help people, like we read in the cystic fibrosis article.
Diego: I agree too.

The learning goal for this group is to practice asking probing questions. There are opportunities to make teacher dialogue choices that include asking different kinds of open-ended questions, simpler yes or no questions, providing students with information, or avoiding the discussion.

First Level Choices

After reading the first screen of student dialogue, participants saw the following three choices: Ask the group if they were the members of an ethics committee for this kind of research, what kinds of research would they approve of. [Open Ended - Group Opinion]; Ask Taylor how they think the scientific community should have acted. [Open Ended - Specific Student Opinion]; Ask the group what other kinds of diseases could be helped by human genetic modification. [Informational Closed Question]. Across all participants, 71% chose the most open ended teacher dialogue choice, 21% chose the open ended question directed at one student, and 7% selected the closed, informational line of questioning. Breaking this down by years of experience, it becomes apparent that the participants with five or less years or no teaching experience, are those who select the closed, informational question teacher dialogue option more frequently (11% and 7%), while none of the more experienced participants selected this option (Table 5.1).

Table 5.1
First Level Choices Stratified by Level of Teaching Experience in Group One

	[Informational Question] G1.1	[Open Ended - Specific Student Opinion] G1.2	[Open Ended - Group Opinion] G1.3

All Participants (N = 42)	7%	21%	71%
No Experience (n = 15)	7%	20%	73%
< 5 Years (n = 18)	11%	28%	61%
>= 5 Years (n = 9)	0%	28%	88%

Note. In this table, these paths are referred to by their numerical designation or choice descriptor (Informational Question, Open Ended - Student Opinion, Open Ended - Group Opinion).

Second Level Choices

Open Ended - Specific Student Opinion - G1.2 Path Options. Those in the limited open ended branch (n = 9) see the following three new choices: Ask the group what they think about the cystic fibrosis article. [Refocus Conversation]; Ask the group if patients should be concerned about effects later in their life when they undergo somatic genome edits. [Open Ended - Group Opinion]; Tell the group it seems like they have more to discuss and leave them to check on another group. [End Discussion]. Those who selected to check on the next table leave Group One early. Participants selected the focused open ended path regardless of experience, though only those with no or less than five years of experience selected to leave the table early (Table 5.2).

Table 5.2

Second Level Choices Stratified by Level of Teaching Experience from the Open Ended - Specific Student Opinion - G1.2 Branch

	[Refocus Conversation] G1.7	[Open Ended - Group Opinion] G1.8	[End Discussion] G1.9
All Participants (n = 9)	11%	56%	33%
No Experience (n = 3)	0%	67%	33%
< 5 Years (n = 5)	20%	40%	40%
>= 5 Years (n = 1)	0%	100%	0%

Open Ended - Group Opinion - G1.3 Path Options. Those in the open ended branch (n = 30) see three new choices: Ask why somatic versus genomic edits might be viewed differently. [Informational Closed Question]; Ask what benefits and drawbacks there are in genomic editing. [Informational Closed Question]; Tell the group it seems like they have more to discuss and leave them to check on another group. [End Discussion]. For those in the avoidant group, they leave Group One early and move on to Group Two, and do not see the third, final level of choices. The most popular option in this grouping was the second closed dialogue choice among all experience level groups, though a slightly smaller percent of experienced participants selected to end the discussion early. A more detailed breakdown is shown in Table 5.3 of the choices the 30 participants made on the second level of the open ended branch.

Table 5.3
Second Level Choices Stratified by Level of Teaching Experience from the Open Ended - Group Opinion - G1.3 Branch

	[Informational Closed Question] G1.10	[Informational Closed Question] G1.11	[End Discussion] G.12
All Participants (n = 30)	10%	73%	17%
No Experience (n = 11)	9%	73%	18%
< 5 Years (n = 11)	9%	73%	18%
>= 5 Years (n = 8)	11%	67%	11%

Third Level Choices

Informational Closed Question - G1.11 Path Options. Those from the closed dialogue choice (n = 22) saw: Ask why somatic versus genomic edits might be viewed differently. [Informational Closed Question]; Tell the group it seems like they have more to discuss and leave them to check on another group. [End Discussion]; Ask the group if they think that there

are any conditions that they would not allow genetic treatments for. [Open Ended - Group Opinion]. Participants with less teaching experience more often chose the closed option or chose to end the discussion, while those with more experience chose the open ended question (Table 5.4).

Table 5.4
Third Level Choices Stratified by Level of Teaching Experience from the Informational Closed Question - G1.11 Branch

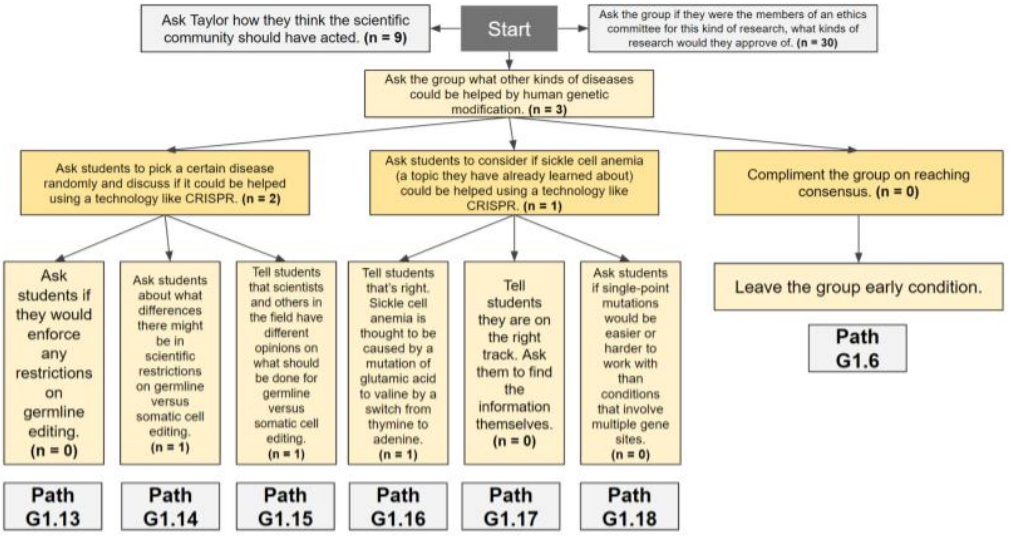
	[Informational Closed Question] G1.34	[End Discussion] G1.35	[Open Ended - Group Opinion] G1.36
All Participants (n = 30)	10%	73%	17%
No Experience (n = 11)	9%	73%	18%
< 5 Years (n = 11)	9%	73%	18%
>= 5 Years (n = 8)	11%	67%	11%

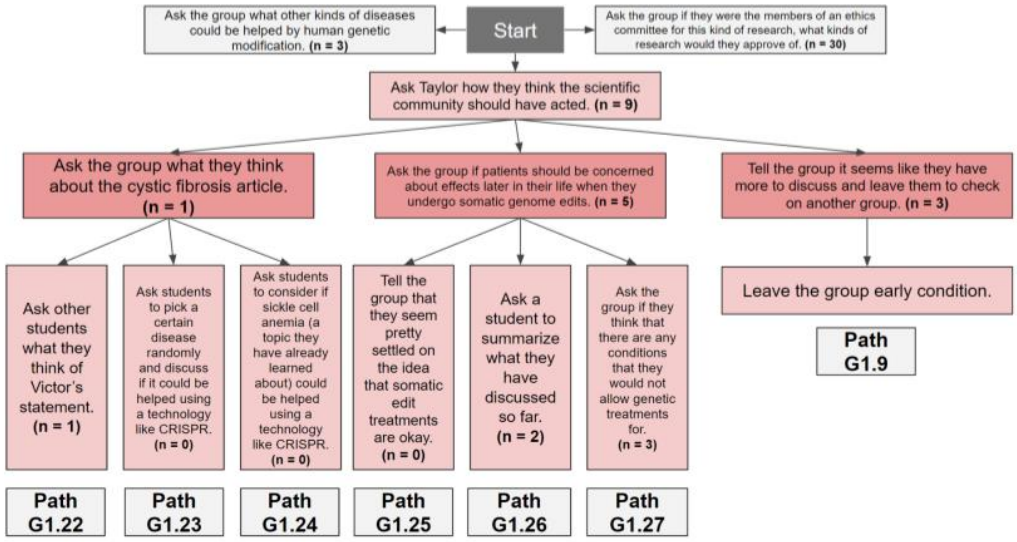
Common Paths and Key Moments

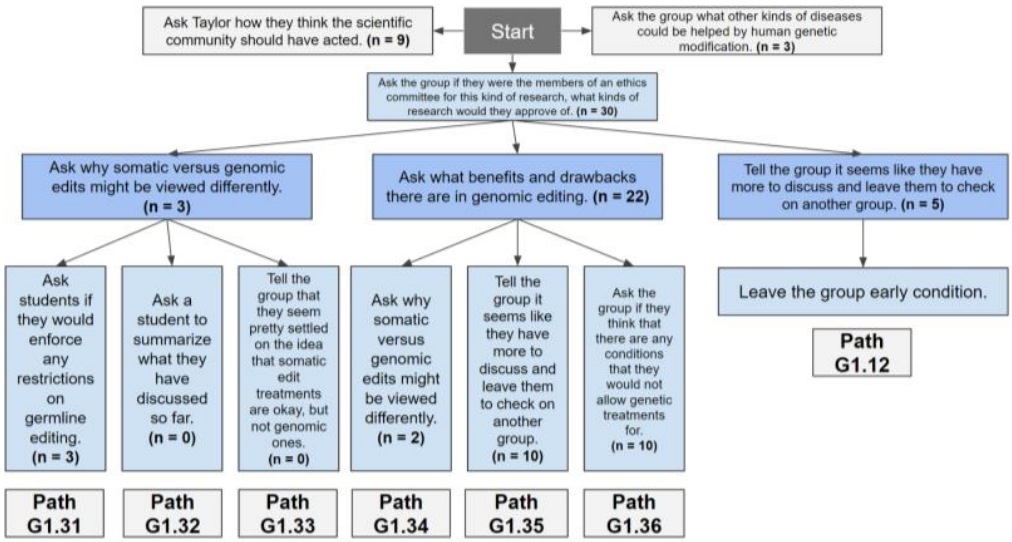
Within Group One, there were two most common paths, each chosen by 24% of all participants: G1.35 and G1.36. Both of these paths start with the same two teacher dialogue options: (1st level choice) Ask the group if they were the members of an ethics committee for this kind of research, what kinds of research would they approve of, and (2nd level choice) Ask what benefits and drawbacks there are in genomic editing. Their third level option is where these paths differ. At this level, in path G1.35, participants select “Tell the group it seems like they have more to discuss and leave them to check on another group.” Alternatively, selecting “Ask the group if they think that there are any conditions that they would not allow genetic treatments for,” places participants on path G1.36. The difference between these two choices is that one is a statement that ends the discussion (G1.35) and the other continues the discussion with the

students with an open ended question (G1.36). Ten participants ultimately ended in each of these paths. G1.35 was favored by non-teachers and novice teachers, while G1.36 was favored by expert teachers. 27% of non-teachers and 22% of novice teachers utilized G1.35, and 44% of expert teachers utilized path G1.36. All paths for this group and the number of participants who selected each choice are shown in Figure 5.1.

Figure 5.1
Three Branching Diagrams Depicting the Teacher Dialogue Choices Participants Selected in Group One


Start
Ask Taylor how they think the scientific community should have acted. (n = 9)
Ask the group if they were the members of an ethics committee for this kind of research, what kinds of research would they approve of. (n = 30)
Ask the group what other kinds of diseases could be helped by human genetic modification. (n = 3)
Ask students to pick a certain disease randomly and discuss if it could be helped using a technology like CRISPR. (n = 2)
Ask students to consider if sickle cell anemia (a topic they have already learned about) could be helped using a technology like CRISPR. (n = 1)
Compliment the group on reaching consensus. (n = 0)
Ask students if they would enforce any restrictions on germline editing. (n = 0)
Ask students about what differences there might be in scientific restrictions on germline versus somatic cell editing. (n = 1)
Tell students that scientists and others in the field have different opinions on what should be done for germline versus somatic cell editing. (n = 1)
Tell students that's right. Sickle cell anemia is thought to be caused by a mutation of glutamic acid to valine by a switch from thymine to adenine. (n = 1)
Tell students they are on the right track. Ask them to find the information themselves. (n = 0)
Ask students if single-point mutations would be easier or harder to work with than conditions that involve multiple gene sites. (n = 0)
Leave the group early condition.
Path G1.6
Path G1.13
Path G1.14
Path G1.15
Path G1.16
Path G1.17
Path G1.18


Start
Ask the group what other kinds of diseases could be helped by human genetic modification. (n = 3)
Ask the group if they were the members of an ethics committee for this kind of research, what kinds of research would they approve of. (n = 30)
Ask Taylor how they think the scientific community should have acted. (n = 9)
Ask the group what they think about the cystic fibrosis article. (n = 1)
Ask the group if patients should be concerned about effects later in their life when they undergo somatic genome edits. (n = 5)
Tell the group it seems like they have more to discuss and leave them to check on another group. (n = 3)
Ask other students what they think of Victor's statement. (n = 1)
Ask students to pick a certain disease randomly and discuss if it could be helped using a technology like CRISPR. (n = 0)
Ask students to consider if sickle cell anemia (a topic they have already learned about) could be helped using a technology like CRISPR. (n = 0)
Tell the group that they seem pretty settled on the idea that somatic edit treatments are okay. (n = 0)
Ask a student to summarize what they have discussed so far. (n = 2)
Ask the group if they think that there are any conditions that they would not allow genetic treatments for. (n = 3)
Leave the group early condition.
Path G1.9
Path G1.22
Path G1.23
Path G1.24
Path G1.25
Path G1.26
Path G1.27


Start
Ask Taylor how they think the scientific community should have acted. (n = 9)
Ask the group what other kinds of diseases could be helped by human genetic modification. (n = 3)
Ask the group if they were the members of an ethics committee for this kind of research, what kinds of research would they approve of. (n = 30)
Ask why somatic versus genomic edits might be viewed differently. (n = 3)
Ask what benefits and drawbacks there are in genomic editing. (n = 22)
Tell the group it seems like they have more to discuss and leave them to check on another group. (n = 5)
Ask students if they would enforce any restrictions on germline editing. (n = 3)
Ask a student to summarize what they have discussed so far. (n = 0)
Tell the group that they seem pretty settled on the idea that somatic edit treatments are okay, but not genomic ones. (n = 0)
Ask why somatic versus genomic edits might be viewed differently. (n = 2)
Tell the group it seems like they have more to discuss and leave them to check on another group. (n = 10)
Ask the group if they think that there are any conditions that they would not allow genetic treatments for. (n = 10)
Leave the group early condition.
Path G1.12
Path G1.31
Path G1.32
Path G1.33
Path G1.34
Path G1.35
Path G1.36

Group Two: Encouraging Student Directed Dialogue

For Group Two, the participant meets Abril, Ro, Martin, and Joseph who have similar opinions, but are discussing a technical aspect of CRISPR and related technologies.

> You visit group two's table. At this table are Abril, Ro, Martin, and Joseph. The debate at this table is a little more heated than group one.
> Ro: So, why was the ethics committee and larger scientific community able to stop the germline edits so fast and -
> Martin: So, wait, can we back up one second? How do the edits even know where to go?
> Joseph: It does like, the snipping and inserting new things, right?
> Abril: I guess in the most basic terms possible, yes.
> Joseph: Can you re-explain how CRISPR works, Ms. Powell?

The learning goal for this group is to practice asking more probing, exploration questions (student directed conversations), instead of telling students the answers (teacher directed conversations). Within this group, participants can work with students on their prior knowledge, tell students information, ask students to summarize their discussion, ask for their opinions, or avoid the discussion.

First Level Choices

At the first level of choices, participants have three possible options: Explain a quick overview of how CRISPR works. [Provide Information]; Ask Abril or Ro if they would like to explain it to their classmates. [Encourage Student Directed Discussion]; and Ask Martin and Joseph to explain their thinking. [Open Ended - Specific Students' Understanding]. For all participants, 40% selected the teacher directed option to provide students the answer, 43% chose the student directed option, and 17% chose to ask Martin and Joseph specifically. Looking at the groups of years of teaching experience, expert teachers did not select the teacher directed option as frequently as those with less teaching experience (Table 5.5).

Table 5.5
First Level Choices Stratified by Level of Teaching Experience in Group Two

	[Provide Information] G2.1	[Encourage Student Directed Discussion] G2.2	[Open Ended - Specific Students' Understanding] G2.3
All Participants (N = 42)	7%	21%	71%
No Experience (n = 15)	7%	20%	73%
< 5 Years (n = 18)	11%	28%	61%
>= 5 Years (n = 9)	0%	28%	88%

Second Level Choices

Provide Information - G2.1 Path Options. In this branch, participants can select from the following three teacher options: Ask Martin and Joseph more about their misunderstanding with genetic editing. [Open Ended - Specific Students' Understanding]; Remind the group that Ro was speaking and ask them to continue. [Enforce Norms]; and Now that you've clarified that, go check on another group. [End Discussion]. 17 participants, seven non-teachers, eight novice teachers, and two expert teachers, reached this part of the branch (Table 5.6). At this decision point, those with any level of teaching experience chose more often to address a violation in classroom norms than those without experience. A higher percentage of participants also chose to ask Martin and Joseph about their understanding as compared to leaving the discussion early.

Table 5.6
Second Level Choices Stratified by Level of Teaching Experience in Group Two from the Provide Information - G2.1 Path Options

	[Open Ended - Specific Students' Understanding] G2.4	[Enforce Norms] G2.5	[End Discussion] G2.6
All Participants (n = 17)	35%	47%	18%
No Experience (n = 7)	57%	14%	29%
< 5 Years (n = 8)	25%	75%	0%

>= 5 Years (n = 2)	0%	50%	50%

Encourage Student Directed Discussion - G2.2 Path Options. Coming from the student directed branch, participants in this path (n = 18) selected from: Explain to the table how frameshifts might be avoided. [Provide Information]; Ask the group what they think. How could frameshift mutations be avoided? [Encourage Student Directed Discussion]; Tell the group they need to review their CRISPR basics. [End Discussion]. At this point, a higher percentage of participants chose the student directed dialogue option, though those with less teaching experience chose teacher directed speech more often (Table 5.7).

Table 5.7

Second Level Choices Stratified by Level of Teaching Experience in Group Two from the Encourage Student Directed Discussion - G2.2 Path Options

	[Provide Information] G2.7	[Encourage Student Directed Discussion] G2.8	[End Discussion] G2.9
All Participants (n = 18)	22%	67%	17%
No Experience (n = 5)	40%	40%	20%
< 5 Years (n = 8)	25%	75%	0%
>= 5 Years (n = 5)	0%	80%	20%

Open Ended - Specific Students' Understanding - G2.3 Path Options. The third branch comes from the Student Directed - Prior Knowledge choice. In this path, participants (n = 7), selected from the following options: Remind the group that Ro was speaking and ask them to continue. [Enforcing Norms]; Ask the group what points they agree or disagree on in the discussion. [Student Directed Summary]; Now that you've clarified that, go check on another group. [End Discussion]. At this node, enforcing norms was a slightly less popular choice than

at the second level of G2.1 (Table 5.6). Only a participant in the non-teacher group chose to leave the discussion early (Table 5.8).

Table 5.8
Second Level Choices Stratified by Level of Teaching Experience in Group Two from the Open Ended - Specific Students' Understanding - G2.3 Path Options

	[Enforcing Norms] G2.10	[Student Directed Summary] G2.11	[End Discussion] G2.12
All Participants (n = 7)	43%	43%	14%
No Experience (n = 3)	33%	33%	33%
< 5 Years (n = 3)	33%	66%	0%
>= 5 Years (n = 1)	100%	0%	0%

Third Level Choices

Student Directed - G2.8 Path Options. In this path, there were 12 participants, two non-teachers, six novices, and four experts. Participants selected from: Ask the group what they think are public opinion differences in somatic versus germline editing. [Open Ended - Group Opinion]; Ask the group what limitations they may impose on genetic editing treatments. [Open Ended - Group Opinion]; Ask the group what points they agree or disagree on in the discussion. [Student Directed Summary]. Overall, participants tended to shy away from asking students a more direct question about the students' personal opinions, and those with more teaching experience at this node chose with a higher frequency the summary option (Table 5.9)

Table 5.9
Third Level Choices Stratified by Level of Teaching Experience in Group Two from the Encourage Student Directed Discussion - G2.8 Path Options

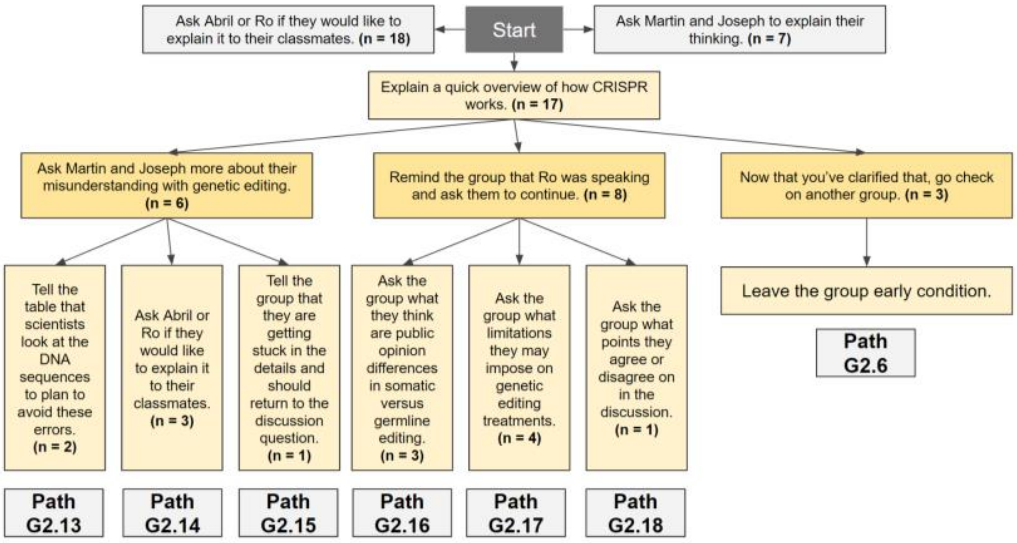
	[Open Ended - Group Opinion] G2.25	[Open Ended - Group Opinion] G2.26	[Student Directed Summary] G2.27
All Participants (n = 12)	42%	17%	43%

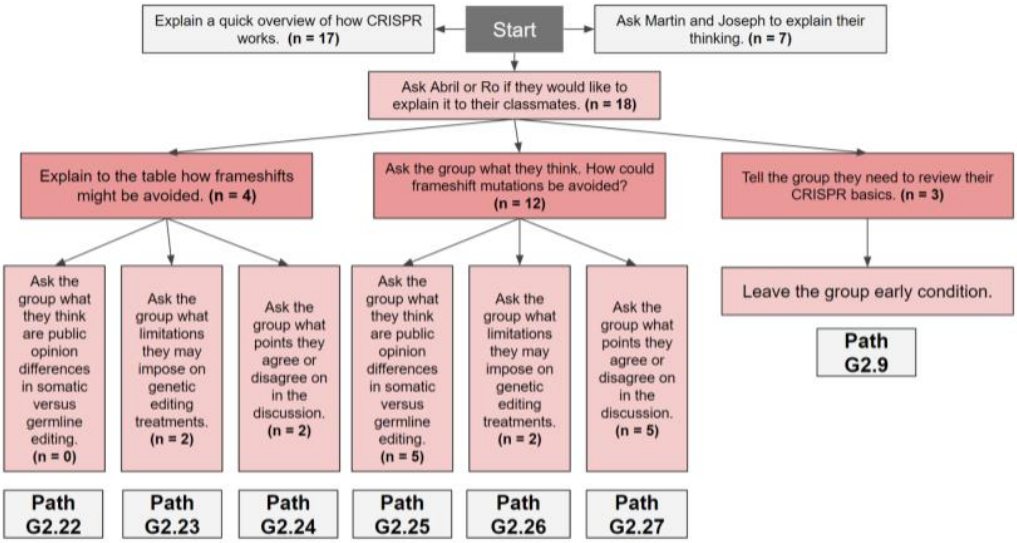
No Experience (n = 2)	100%	0%	0%
< 5 Years (n = 6)	33%	17%	50%
>= 5 Years (n = 4)	25%	25%	50%

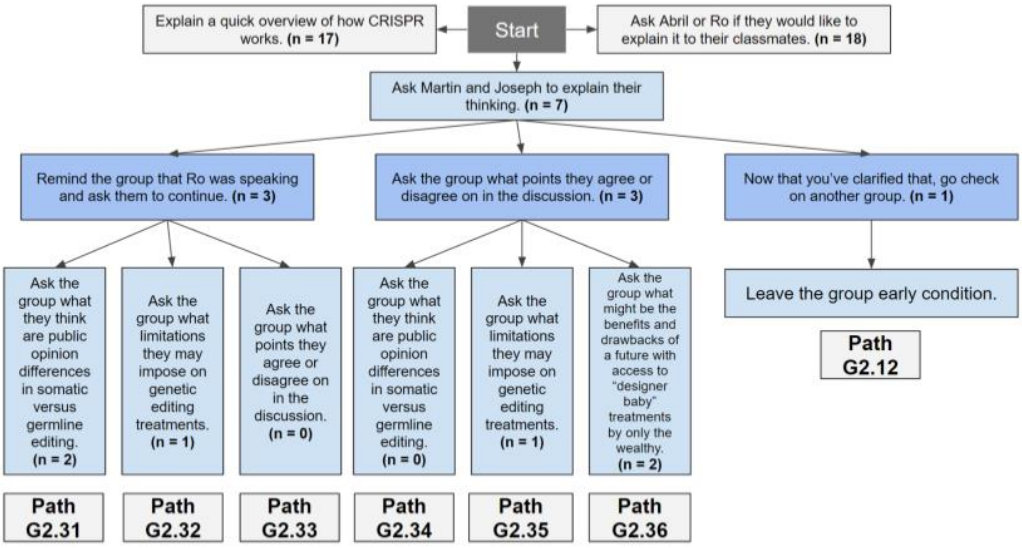
Common Paths and Key Moments

When examining all participants, the most popular paths are G2.25 and G2.27, with 27% of participants utilizing each path. However, in a breakdown by experience, non-teacher participants take much more dispersed paths. Equal numbers of non-teacher participants chose paths G2.6, G2.9, G2.13, and G2.25, accounting for 52% of all non-teachers. Additionally, this was the only subgroup in which the leave early condition choices were popular. No novices chose to leave the conversation early and only one expert did. For novices, 17% chose G2.16 and G2.27, and 22% experts chose G2.27 and G2.33. Even though G2.27 was a popular choice for novices and experts, no non-teacher participant ended up on this path. 24 participants also reached a part of the narrative in which there was an opportunity to enforce classroom norms, and 11 chose to do so, with this option being somewhat more popular with novices (eight of 11 novices called out the discussion violation). All paths for this group and the number of participants who selected each choice are shown in Figure 5.2.

Figure 5.2
Three Branching Diagrams Depicting the Teacher Dialogue Choices Participants Selected in Group Two


Ask Abril or Ro if they would like to explain it to their classmates. (n = 18)
Start
Ask Martin and Joseph to explain their thinking. (n = 7)
Explain a quick overview of how CRISPR works. (n = 17)
Ask Martin and Joseph more about their misunderstanding with genetic editing. (n = 6)
Remind the group that Ro was speaking and ask them to continue. (n = 8)
Now that you've clarified that, go check on another group. (n = 3)
Tell the table that scientists look at the DNA sequences to plan to avoid these errors. (n = 2)
Ask Abril or Ro if they would like to explain it to their classmates. (n = 3)
Tell the group that they are getting stuck in the details and should return to the discussion question. (n = 1)
Ask the group what they think are public opinion differences in somatic versus germline editing. (n = 3)
Ask the group what limitations they may impose on genetic editing treatments. (n = 4)
Ask the group what points they agree or disagree on in the discussion. (n = 1)
Leave the group early condition.
Path G2.6
Path G2.13
Path G2.14
Path G2.15
Path G2.16
Path G2.17
Path G2.18


Explain a quick overview of how CRISPR works. (n = 17)
Start
Ask Martin and Joseph to explain their thinking. (n = 7)
Ask Abril or Ro if they would like to explain it to their classmates. (n = 18)
Explain to the table how frameshifts might be avoided. (n = 4)
Ask the group what they think. How could frameshift mutations be avoided? (n = 12)
Tell the group they need to review their CRISPR basics. (n = 3)
Ask the group what they think are public opinion differences in somatic versus germline editing. (n = 0)
Ask the group what limitations they may impose on genetic editing treatments. (n = 2)
Ask the group what points they agree or disagree on in the discussion. (n = 2)
Ask the group what they think are public opinion differences in somatic versus germline editing. (n = 5)
Ask the group what limitations they may impose on genetic editing treatments. (n = 2)
Ask the group what points they agree or disagree on in the discussion. (n = 5)
Leave the group early condition.
Path G2.9
Path G2.22
Path G2.23
Path G2.24
Path G2.25
Path G2.26
Path G2.27


Explain a quick overview of how CRISPR works. (n = 17)
Start
Ask Abril or Ro if they would like to explain it to their classmates. (n = 18)
Ask Martin and Joseph to explain their thinking. (n = 7)
Remind the group that Ro was speaking and ask them to continue. (n = 3)
Ask the group what points they agree or disagree on in the discussion. (n = 3)
Now that you've clarified that, go check on another group. (n = 1)
Ask the group what they think are public opinion differences in somatic versus germline editing. (n = 2)
Ask the group what limitations they may impose on genetic editing treatments. (n = 1)
Ask the group what points they agree or disagree on in the discussion. (n = 0)
Ask the group what they think are public opinion differences in somatic versus germline editing. (n = 0)
Ask the group what limitations they may impose on genetic editing treatments. (n = 1)
Ask the group what might be the benefits and drawbacks of a future with access to "designer baby" treatments by only the wealthy. (n = 2)
Leave the group early condition.
Path G2.12
Path G2.31
Path G2.32
Path G2.33
Path G2.34
Path G2.35
Path G2.36

Group Three: Deciding on Disclosure of Teacher Opinion

For Group Three, the participant meets Mark, Nadia, Zoe, and Ari. These students all have vastly different opinions and are having an extremely lively debate. Ari is also playing "devil's advocate" in the discussion. When the participant approaches this table, the students immediately want to know the teacher's opinion.

> Before you even leave Group 2, you can hear Group 3's voices carry over the classroom. The debate is lively. At this table are Mark, Nadia, Zoe, and Ari.
> Zoe: You're just straight up wrong, okay.
> Mohamed: I'm sorry that you are clearly projecting because it is you who are wrong.
> Nadia: Have I mentioned how much I love listening to your circular arguments?
> Ari: Okay, be quiet, no one influence the teacher. Mrs. Powell, what do you think? What would you say is acceptable: only editing techniques that are somatic in nature and fight diseases or anything goes?
> Zoe: Well when you present each side like that . . .
> Ari: Shush.

The learning goal for this group is for the participant to become familiar with their personal ideas about when they may find it appropriate to add their own opinion to a discussion. For this group of students, the participant can choose to share their opinion, not share their opinion, ask students more about their personal opinions, or avoid this group of students.

First Level Choices

At the first level, participants have the following teacher dialogue choices: Tell the students your opinion (somatic editing is fine, germline edits are not). [Share Opinion]; Decline to share your opinion with the group. [Decline to Share]; Ask the group for their opinion first. [Open Ended - Group Opinion]. The vast majority of participants selected to ask the students for their opinion first. Only one participant in the non-teacher group chose to decline to share outright, and a higher percentage of the expert participants shared their opinion than the others at this stage (Table 5.10).

Table 5.10
First Level Choices Stratified by Level of Teaching Experience in Group Three

	[Share Opinion] G3.1	[Decline to Share] G3.2	[Open Ended - Group Opinion] G3.3
All Participants (N = 42)	10%	2%	88%
No Experience (n = 15)	7%	7%	87%
< 5 Years (n = 18)	6%	0%	94%
>= 5 Years (n = 9)	22%	0%	77%

Second Level Choices

Open Ended - Group Opinion - G3.3 Path Options. By far the most popular choice, 37 participants accessed this part of the simulation. Participants could choose to say the following: Decline to share your opinion again. [Decline to Share]; Tell the students your opinion (somatic editing is fine, germline edits are not). [Share Opinion]; Decline to tell the group your opinion and go visit the next table. [Decline to Share / End Discussion]. A majority of participants again declined to share their opinion, and four chose to leave the discussion early (Table 5.11).

Table 5.11
Second Level Choices Stratified by Level of Teaching Experience in Group Three for Open Ended - Group Opinion- G3.3 Path

	[Decline to Share] G3.10	[Share Opinion] G3.11	[Decline to Share / End Discussion] G3.12
All Participants (n = 37)	68%	22%	11%
No Experience (n = 25)	62%	31%	8%
< 5 Years (n = 8)	50%	38%	13%
>= 5 Years (n = 4)	25%	50%	25%

Third Level Choices

Decline to Share - G3.10 Path Choices. 25 participants accessed this branch. Here, participants could choose from: Remind the group of your class' discussion norms. [Enforce Norms]; Tell the students your opinion (somatic editing is fine, germline edits are not). [Share Opinion]; Ask Ari if he has an opinion outside of the possible economic gains. [Open Ended - Specific Student Opinion]. No participants chose to share their opinion, and 23 of 25 participants enforced classroom norms (Table 5.12).

Table 5.12
Third Level Choices Stratified by Level of Teaching Experience in Group Three for Decline to Share - G3.10 Path

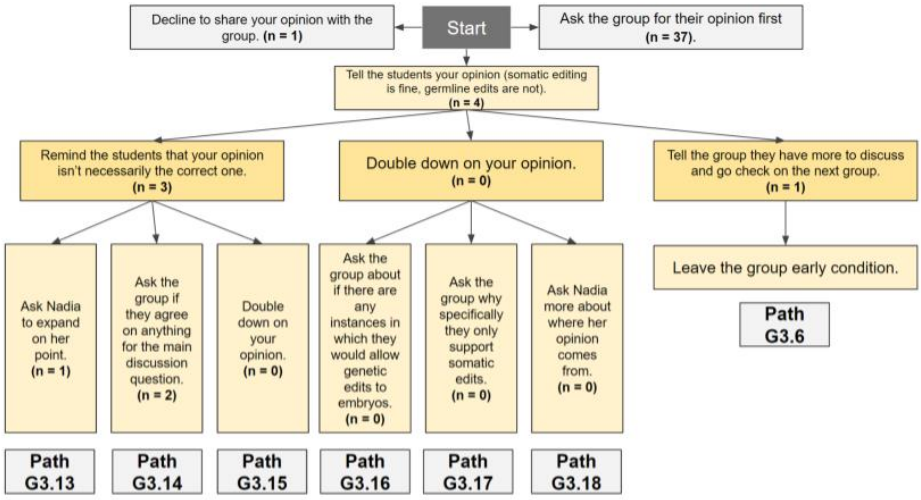
	[Enforce Norms] G3.31	[Share Opinion] G3.32	[Open Ended - Specific Student Opinion] G3.33
All Participants (n = 25)	92%	0%	8%
No Experience (n = 8)	88%	0%	13%
< 5 Years (n = 12)	100%	0%	0%
>= 5 Years (n = 5)	80%	0%	25%

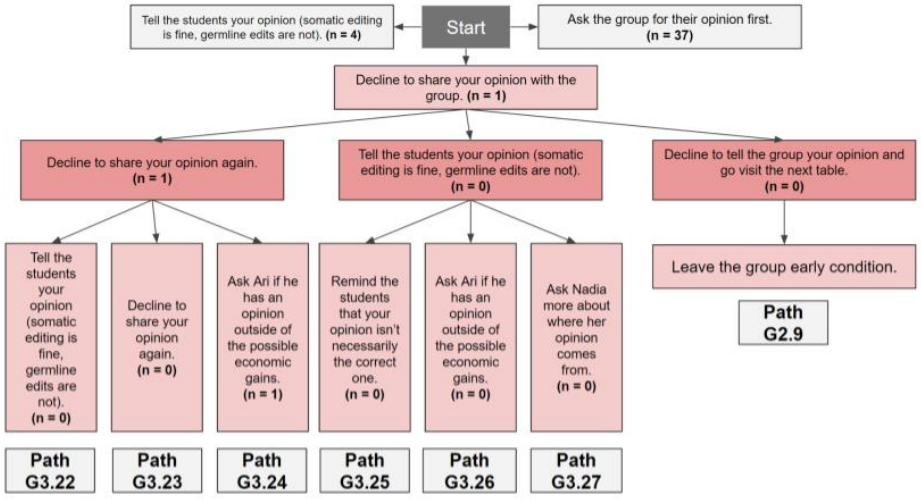
Common Paths and Key Moments

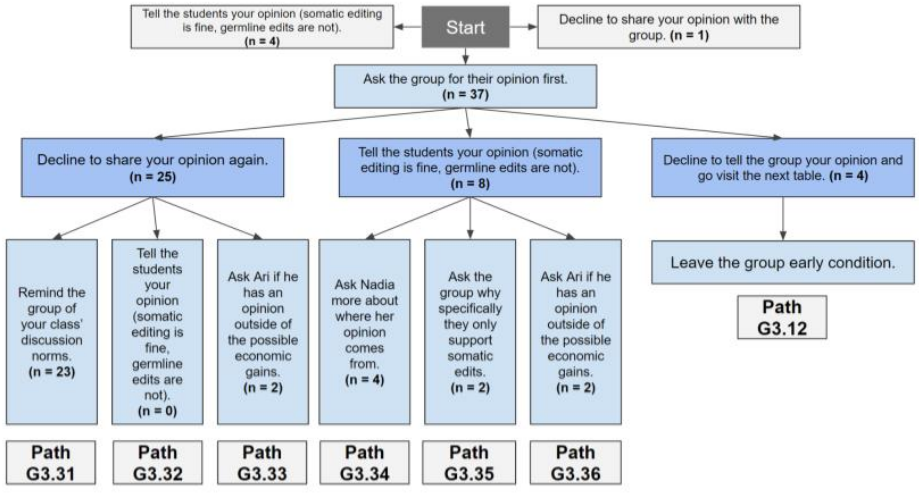
For Group Three, the most common path across all experience levels was path G3.31, with 60% of all participants selecting this path (non-teachers: 47%, novices: 78%, and experts: 44%). Though every participant had the opportunity to share their opinion - some participants had three chances to do so - only 29% (n = 12) chose to disclose their opinion. 33% of experts, 22% of novices, and 7% of non-teachers shared their opinion. 25 participants saw a piece of student dialogue in which a discussion norm was being violated, and 92% of them chose the

teacher dialogue option of reminding students of their class' discussion rules. All paths for this group and the number of participants who selected each choice are shown in Figure 5.3.

Figure 5.3
Three Branching Diagrams Depicting the Teacher Dialogue Choices Participants Selected in Group Three


Start
Decline to share your opinion with the group. (n = 1)
Ask the group for their opinion first (n = 37).
Tell the students your opinion (somatic editing is fine, germline edits are not). (n = 4)
Remind the students that your opinion isn't necessarily the correct one. (n = 3)
Double down on your opinion. (n = 0)
Tell the group they have more to discuss and go check on the next group. (n = 1)
Ask Nadia to expand on her point. (n = 1)
Ask the group if they agree on anything for the main discussion question. (n = 2)
Double down on your opinion. (n = 0)
Ask the group about if there are any instances in which they would allow genetic edits to embryos. (n = 0)
Ask the group why specifically they only support somatic edits. (n = 0)
Ask Nadia more about where her opinion comes from. (n = 0)
Leave the group early condition.
Path G3.6
Path G3.13
Path G3.14
Path G3.15
Path G3.16
Path G3.17
Path G3.18


Start
Tell the students your opinion (somatic editing is fine, germline edits are not). (n = 4)
Ask the group for their opinion first. (n = 37)
Decline to share your opinion with the group. (n = 1)
Decline to share your opinion again. (n = 1)
Tell the students your opinion (somatic editing is fine, germline edits are not). (n = 0)
Decline to tell the group your opinion and go visit the next table. (n = 0)
Tell the students your opinion (somatic editing is fine, germline edits are not). (n = 0)
Decline to share your opinion again. (n = 0)
Ask Ari if he has an opinion outside of the possible economic gains. (n = 1)
Remind the students that your opinion isn't necessarily the correct one. (n = 0)
Ask Ari if he has an opinion outside of the possible economic gains. (n = 0)
Ask Nadia more about where her opinion comes from. (n = 0)
Leave the group early condition.
Path G2.9
Path G3.22
Path G3.23
Path G3.24
Path G3.25
Path G3.26
Path G3.27


Start
Tell the students your opinion (somatic editing is fine, germline edits are not). (n = 4)
Decline to share your opinion with the group. (n = 1)
Ask the group for their opinion first. (n = 37)
Decline to share your opinion again. (n = 25)
Tell the students your opinion (somatic editing is fine, germline edits are not). (n = 8)
Decline to tell the group your opinion and go visit the next table. (n = 4)
Remind the group of your class' discussion norms. (n = 23)
Tell the students your opinion (somatic editing is fine, germline edits are not). (n = 0)
Ask Ari if he has an opinion outside of the possible economic gains. (n = 2)
Ask Nadia more about where her opinion comes from. (n = 4)
Ask the group why specifically they only support somatic edits. (n = 2)
Ask Ari if he has an opinion outside of the possible economic gains. (n = 2)
Leave the group early condition.
Path G3.12
Path G3.31
Path G3.32
Path G3.33
Path G3.34
Path G3.35
Path G3.36

Group Four: Including Voices of Quieter Students

For Group Four, the participant meets Min-seo, Sahar, Mateo, and Peter. These students have some similarities in opinion, but also do not see how the topic could ever affect them. This group has very low participation and Peter is actually absent for most of the discussion, having gone to the restroom.

> *You visit group 4. At this table are Peter, Min-seo, Sahar, and Mateo. There is not a lot of talking going on here. It looks like Peter took the hall pass to go to the restroom.*

At this table, participants practice how to engage students who seem uninterested or have no opinions about a topic. Here, participants have teacher dialogue options that include asking the group as a whole or certain students for their opinions, asking the table why they are not participating, summarizing what other students have talked about, or avoiding this group.

First Level Choices

After meeting the students at the table, the participants had the following options: Ask the group as a whole about what they have discussed so far. [Student Directed Summary]; Ask the group why they are not participating. [Disciplinary]; Tell the table a little about what other groups have discussed to get a conversation started. [Teacher Directed Summary].

The majority of participants chose to ask the students for a summary of their discussion so far. Only one participant in the non-teacher group chose the more direct, disciplinary toned statement (Table 5.13). This is the only group in which participants across all experience levels made similar choices to each other at the first level.

Table 5.13
First Level Choices Stratified by Level of Teaching Experience in Group Four

	[Student Directed Summary] G4.1	[Disciplinary] G4.2	[Teacher Directed Summary] G4.3
All Participants (N = 42)	69%	2%	29%
No Experience (n = 15)	67%	7%	27%
< 5 Years (n = 18)	72%	0%	28%
>= 5 Years (n = 9)	67%	0%	33%

Second Level Choices

Student Directed Summary - G4.1 Path Options. 29 participants accessed this branch. Their teacher dialogue options here were to: Ask Sahar what she thinks. [Open Ended - Specific Student Opinion]; Ask why they seem uninterested in the discussion. [Disciplinary]; Tell the group they need to refocus on participating in the discussion and visit the last group. [End Discussion]. The most popular choice was to ask Sahar, the one student at the table who is interested in the discussion, more about her opinions, and expert teachers did not choose to leave this table early (Table 5.14).

Table 5.14
Second Level Choices Stratified by Level of Teaching Experience in Group Four for Student Directed Summary - G4.1 Path

	[Open Ended - Specific Student Opinion] G4.4	[Disciplinary] G4.5	[End Discussion] G4.6
All Participants (n = 29)	69%	24%	7%
No Experience (n = 10)	70%	20%	10%
< 5 Years (n = 13)	69%	23%	8%
>= 5 Years (n = 6)	66%	33%	0%

Teacher Directed Summary - G4.3 Path Options. 12 participants accessed this branch. Participants had the option to say: Try to bring Min-seo into the conversation. [Open Ended - Specific Student Opinion]; Try to bring Mateo into the conversation. [Open Ended - Specific Student Opinion]; Tell the group they need to refocus on participating in the discussion and visit the last group. [End Discussion]. Neither Min-seo or Mateo have spoken up to this point in the discussion. Overall, more people chose to call on Min-seo over Mateo, 80% of novices called on Min-seo, and no one chose to leave the discussion early (Table 5.15).

Table 5.15
Second Level Choices Stratified by Level of Teaching Experience in Group Four for Teacher Directed Summary - G4.3 Path

	[Open Ended - Specific Student Opinion] G4.10	[Open Ended - Specific Student Opinion] G4.11	[End Discussion] G4.12
All Participants (n = 12)	75%	25%	0%
No Experience (n = 4)	50%	50%	0%
< 5 Years (n = 5)	80%	20%	0%
>= 5 Years (n = 3)	66%	33%	0%

Third Level Choices

Open Ended - Specific Student Opinion - G4.4. 20 participants accessed this branch. Their options at this node were: Try to bring Mateo into the conversation. [Open Ended - Specific Student Opinion)]; Try to bring Min-seo into the conversation. [Open Ended - Specific Student Opinion]; Ask if others agree or disagree with Sahar. [Open Ended - Group Opinion]. Overall, the most common option was to ask the table as a whole what they think of Sahar's ideas, though those with more experience chose to ask Mateo his opinion (Table 5.16).

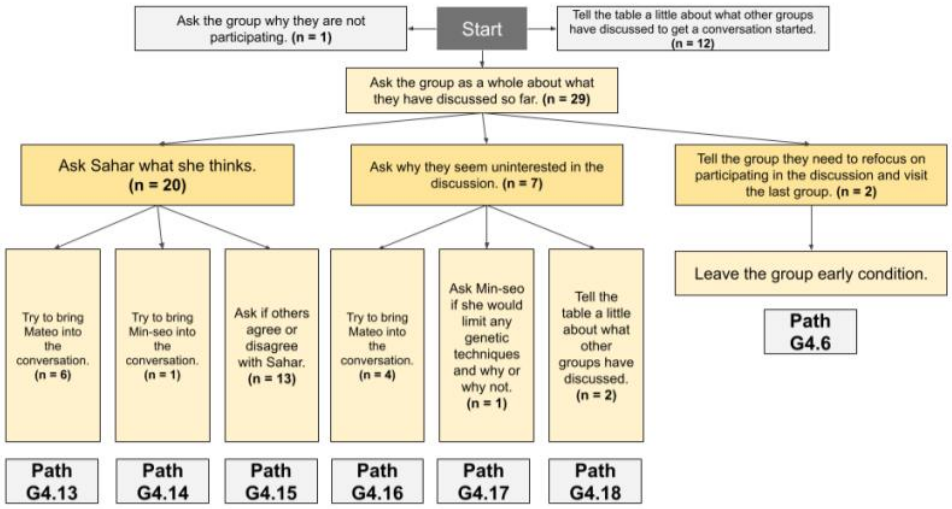
Table 5.16
Second Level Choices Stratified by Level of Teaching Experience in Group Four for Open Ended - Specific Student Opinion - G4.4 Path

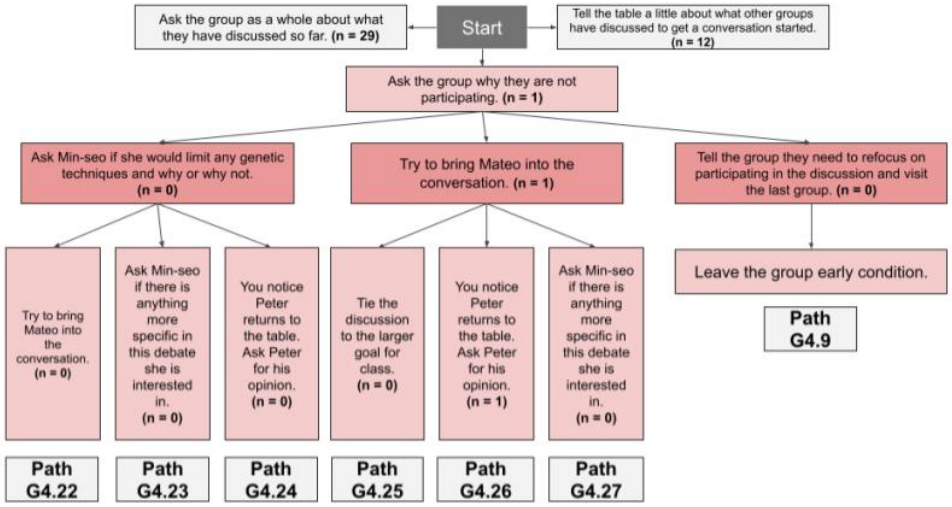
	[Open Ended - Specific Student Opinion] G4.13	[Open Ended - Specific Student Opinion] G4.14	[Open Ended - Group Opinion] G4.15
All Participants (n = 20)	30%	5%	65%
No Experience (n = 7)	0%	14%	86%
< 5 Years (n = 9)	44%	0%	56%
>= 5 Years (n = 4)	50%	0%	50%

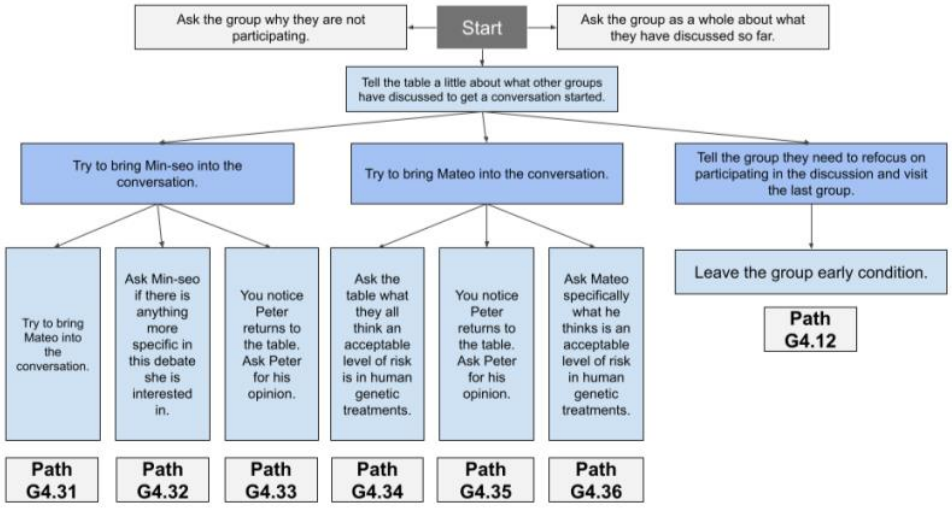
Common Paths and Key Moments

For Group Four, the most common path overall was path G4.15 with 33% of participants in this route. This path was also the most popular for non-teachers (40%) and novices (28%). For experts, equal numbers of participants favored paths G4.13 and G4.15 (22%). Though G4.15 was popular, as participants become more experienced, there is a decline in the number of participants from that experience group utilizing that path. Additionally, 13 participants reached the part of the simulation where Peter returns from the restroom and rejoins his group. However, only two participants ever addressed Peter and asked for his opinion. All paths for this group and the number of participants who selected each choice are shown in Figure 5.4.

Figure 5.4
Three Branching Diagrams Depicting the Teacher Dialogue Choices Participants Selected in Group Four


Ask the group why they are not participating. (n = 1)
Start
Tell the table a little about what other groups have discussed to get a conversation started. (n = 12)
Ask the group as a whole about what they have discussed so far. (n = 29)
Ask Sahar what she thinks. (n = 20)
Ask why they seem uninterested in the discussion. (n = 7)
Tell the group they need to refocus on participating in the discussion and visit the last group. (n = 2)
Try to bring Mateo into the conversation. (n = 6)
Try to bring Min-seo into the conversation. (n = 1)
Ask if others agree or disagree with Sahar. (n = 13)
Try to bring Mateo into the conversation. (n = 4)
Ask Min-seo if she would limit any genetic techniques and why or why not. (n = 1)
Tell the table a little about what other groups have discussed. (n = 2)
Leave the group early condition.
Path G4.6
Path G4.13
Path G4.14
Path G4.15
Path G4.16
Path G4.17
Path G4.18


Ask the group as a whole about what they have discussed so far. (n = 29)
Start
Tell the table a little about what other groups have discussed to get a conversation started. (n = 12)
Ask the group why they are not participating. (n = 1)
Ask Min-seo if she would limit any genetic techniques and why or why not. (n = 0)
Try to bring Mateo into the conversation. (n = 1)
Tell the group they need to refocus on participating in the discussion and visit the last group. (n = 0)
Try to bring Mateo into the conversation. (n = 0)
Ask Min-seo if there is anything more specific in this debate she is interested in. (n = 0)
You notice Peter returns to the table. Ask Peter for his opinion. (n = 0)
Tie the discussion to the larger goal for class. (n = 0)
You notice Peter returns to the table. Ask Peter for his opinion. (n = 1)
Ask Min-seo if there is anything more specific in this debate she is interested in. (n = 0)
Leave the group early condition.
Path G4.9
Path G4.22
Path G4.23
Path G4.24
Path G4.25
Path G4.26
Path G4.27


Ask the group why they are not participating.
Start
Ask the group as a whole about what they have discussed so far.
Tell the table a little about what other groups have discussed to get a conversation started.
Try to bring Min-seo into the conversation.
Try to bring Mateo into the conversation.
Tell the group they need to refocus on participating in the discussion and visit the last group.
Try to bring Mateo into the conversation.
Ask Min-seo if there is anything more specific in this debate she is interested in.
You notice Peter returns to the table. Ask Peter for his opinion.
Ask the table what they all think an acceptable level of risk is in human genetic treatments.
You notice Peter returns to the table. Ask Peter for his opinion.
Ask Mateo specifically what he thinks is an acceptable level of risk in human genetic treatments.
Leave the group early condition.
Path G4.12
Path G4.31
Path G4.32
Path G4.33
Path G4.34
Path G4.35
Path G4.36

Group Five: Confronting Misinformation

At the final table, participants meet Tamir, Jude, Harper, and Maryam. These students are having a lively discussion, but when the participants reach this table, they realize that the students are discussing a piece of misinformation.

> You visit the final group. In group 5 is Tamir, Jude, Harper, and Maryam. The group is intently studying something on Jude's laptop. They are looking at a retweet of an article that claims: *Doctors Confirm First Human Death Officially Caused by GMOs.*

The learning goal here is how to guide students through researching a piece of novel information to uncover if it is trustworthy. Participants have the opportunity to help students apply digital media literacy strategies, tell them outright that the information is false, refocus the conversation to the discussion question of the day, or end the discussion early.

First Level Choices

At the first level, participants can choose from the following teacher dialogue options: Ask Jude to explain about this source she is showing her group. [Student Directed - Investigate Misinformation]; Ask to hear about what the group has discussed so far. [Student Directed Summary]; Tell Jude to close their computer. You already know that the information is from a fake news site. [Provide Information]. A majority of participants chose to investigate the news article with students, though more non-teachers chose to deflect, by asking for a summary, or to tell students outright that the information was false, and no experts chose to tell the students from the start that the information was false. (Table 5.17).

Table 5.17
First Level Choices Stratified by Level of Teaching Experience in Group Five

	[Student Directed - Investigate Misinformation] G5.1	[Student Directed Summary] G5.2	[Provide Information] G5.3
All Participants (N = 42)	83%	10%	7%
No Experience (n = 15)	67%	20%	13%
< 5 Years (n = 18)	94%	0%	6%
>= 5 Years (n = 9)	89%	11%	0%

Second Level Choices

Student Directed - Investigate Misinformation - G5.1 Path Options. 35 participants accessed this branch. Here, participants could choose from: Ask the table what organization published this article. [Student Directed - Investigate Misinformation]; Tell the table you can't believe everything you see online. [Deflect]; Tell the table that you can't believe anything you see on social media and leave the group to the rest of their discussion. [End Discussion. No participants chose to leave the discussion early and working with the students on a digital literacy skill by investigating the misinformation was the most popular choice (Table 5.18).

Table 5.18
Second Level Choices Stratified by Level of Teaching Experience in Group Five for Student Directed - Investigate Misinformation - G5.1 Path

	[Student Directed - Investigate Misinformation] G5.4	[Deflect] G5.5	[End Discussion] G5.6
All Participants (n = 35)	83%	17%	0%
No Experience (n = 9)	70%	30%	0%
< 5 Years (n = 17)	88%	12%	0%
>= 5 Years (n = 8)	88%	13%	0%

Third Level Choices

Student Directed - Investigate Misinformation - G5.4 Path Options. 29 participants utilized this branch. Their teacher dialogue options were: Ask Jude to search up World News Daily Report in another tab. [Teacher Directed - Investigate Misinformation]; Ask the group if anyone has ever heard of World News Daily Report. [Student Directed - Investigate Misinformation]; Tell the group they need to refocus on the actual class discussion topic. [Refocus Conversation]. A majority of participants chose to guide the students through using lateral reading to research World News Daily Report (Table 5.19).

Table 5.19
Second Level Choices Stratified by Level of Teaching Experience in Group Five for Digital Literacy Skill - G5.4 Path

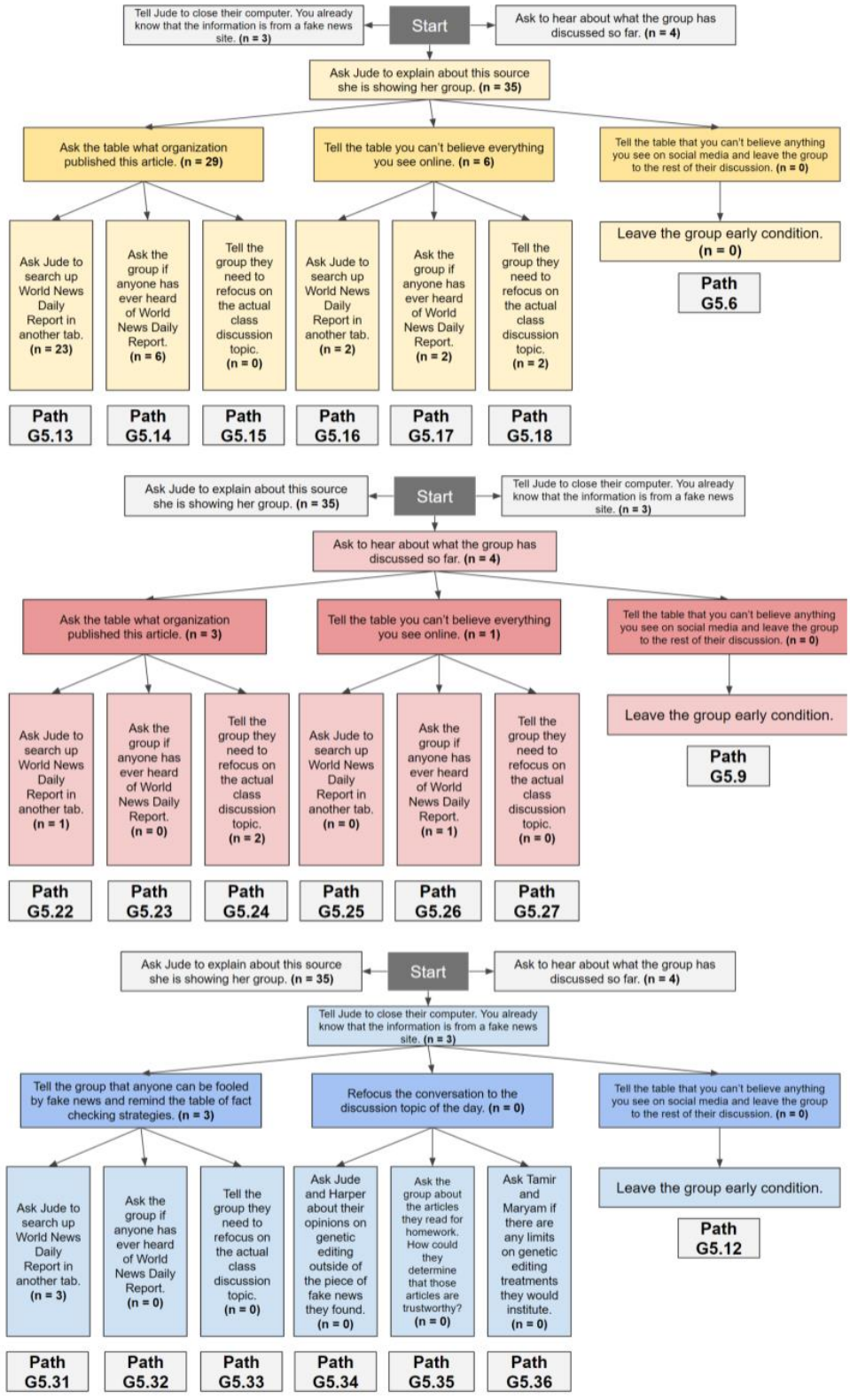
	[Teacher Directed - Investigate Misinformation] G5.13	[Student Directed - Investigate Misinformation] G5.14	[Refocus Conversation] G5.15
All Participants (n = 29)	79%	21%	0%
No Experience (n = 7)	71%	29%	0%
< 5 Years (n = 15)	80%	20%	0%
>= 5 Years (n = 7)	86%	14%	0%

Common Paths and Key Moments

Path G5.13 was the most common across all participants, in which the teacher guides the students through using lateral reading to discover that their source is actually from a satirical website. 55% of all participants, 33% of non-teachers, 67% of novices, and 55% of experts completed this path. Also, no participants chose to leave this table early. All paths for this group and the number of participants who selected each choice are shown in Figure 5.5.

Figure 5.5

Three Branching Diagrams Depicting the Teacher Dialogue Choices Participants Selected in Group Five



Reflection Questions: Challenges and Alternate Teacher Dialogue Choices

Group Reflection Questions

At the end of each group participants answered two questions: (1) Summarize the main discussion this group of students had on the question: If genetic modification treatments in humans should be allowed, to what extent and why? and (2) Was there anything you wished that you could've done differently with this group?

In summarizing the groups' discussion, this was mostly done as a sanity check to see if participants were focused on what the main ideas of the students were. Over 80% of responses showed that participants could identify the main discussion the students had. This percentage may be somewhat lower than expected as those who chose to leave their discussion groups early may have not spent enough time with students to fully understand their ideas.

The second question was created to inform future designs of *Discussion Leader*. In asking participants what they wished they could have done differently, designers can learn what teacher dialogue choices and other design considerations they could include in the next iteration. Though about a fifth of responses said they would not have said anything differently, responses included strategies that were mentioned in the first anticipate question that were concerned with activities done before the discussion, like allowing students to write their ideas out first. Even though this is not directly related to the teacher dialogue options, this informs how the introduction of the simulation could be enhanced by adding flavor text that states that students wrote their ideas down for a Do Now, and then offering a way for participants to view the student responses before the discussion begins. Participants also mentioned wanting more ways to drill down into student ideas, and by expanding the length and teacher dialogue choices, this design need could be met.

Overall Reflection Questions

At the end of the simulation participants were shown their answer to the first anticipate question: *Above is the discussion strategy you thought you might be able to use in this discussion. Were you able to implement this? Please explain your answer.* For this question, the responses were scored for three levels: "Yes, the participant stated that they did implement their strategy," "Partly, the participant stated that they were able to implement part of or one of their strategies," and "No, the participant stated that they did not implement their strategy." 20 responses were scored as "Yes," four as "Partly," and eight as "No." 10 responses were off topic. Of the eight responses that stated they could not implement their strategy, many of them stated that the strategy they wanted to use was having students write their ideas before the discussion, or other activities for students that would have been done before the discussion activity. This may indicate that participants are not only considering how their teacher dialogue choices affect student debates, but also how their framing of a controversial discussion can help better prepare students for the discussion.

Participants also answered: *What were some of the challenges you encountered in this discussion?* In these responses, common themes included how to engage students that seemed disinterested, deciding when or if the teacher's opinion belonged in the discussion, and establishing and enforcing good classroom norms. Essentially, participants stated that they were faced with the five challenges the simulation was designed to probe: asking open-ended, drill down questions, working with students through the answer instead of giving it away, deciding whether to share a teacher's opinion, engaging uninterested students, and combating misinformation.

Comfort Survey: An Increase in Participants' Confidence

As a part of RQ1, I am interested in how participants' level of comfort with leading a controversial discussion can be shifted through practice in a simulation. By examining the pre- and post-measure of comfort, I show that there is a positive shift in participants' level of comfort, with the largest boost in comfort for novice teachers.

In the pre-simulation survey, 15 participants (35.7%) reported feeling at least slightly comfortable leading a controversial discussion. In the post-simulation survey, 27 participants (64.3%) reported feeling at least slightly comfortable leading a controversial discussion (Table 5.20). This change represents a shift in the average comfort score from 2.95 to 3.69 (SD = 1.09, SD = .94) and is significant (p-value < 0.01, t = -3.286, df = 80.224; Cohen's d = .73).

Table 5.20
Pre/Post Comfort with Leading a Controversial Discussion (N = 42)

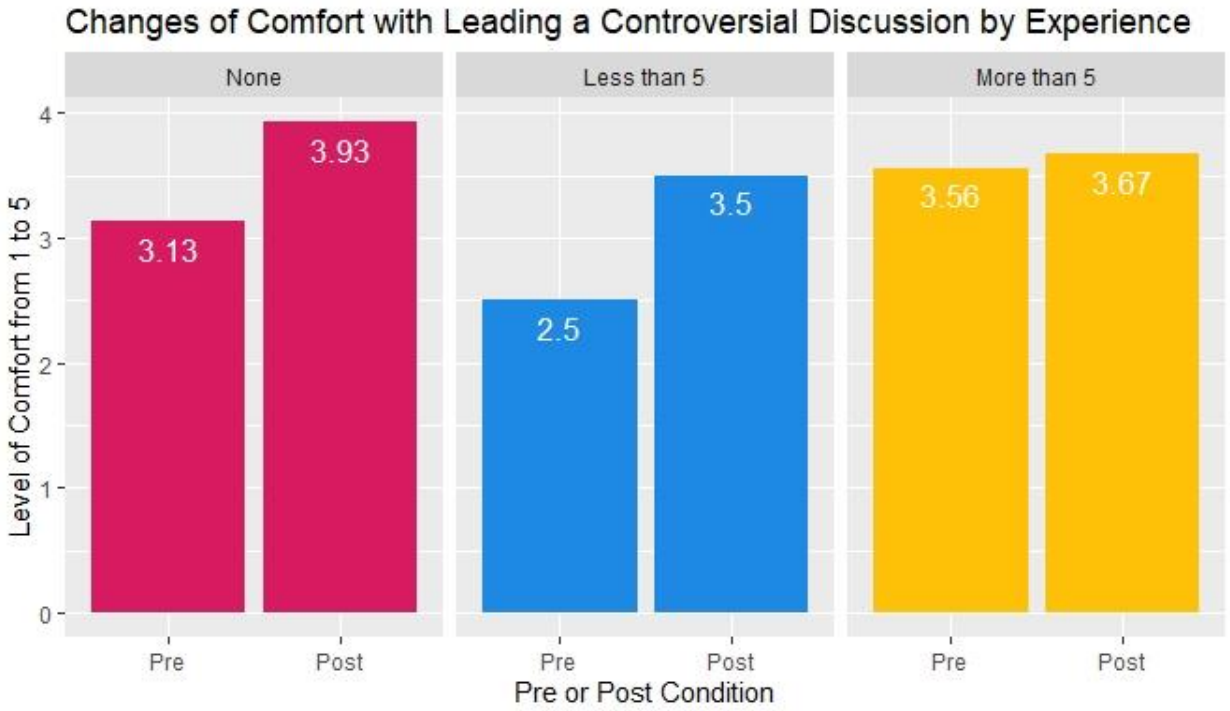
Level of Comfort (Score)	Pre-Comfort	Post-Comfort	Delta
Totally Comfortable (5)	3	8	+11.90%
Slightly Comfortable (4)	12	19	+16.7%
Neutral (3)	10	9	-2.38%
Slightly Uncomfortable (2)	14	6	-19.05%
Totally Uncomfortable (1)	3	0	-7.14%

A similar trend is seen when these totals are broken down by teaching experience levels (Figure 5.6). The differences between the pre- and the post-comfort average with participants with no experience, pre-average = 3.13 (SD = .96) and post-average = 3.93 (SD = .85), is also significant (p-value < .05, t = -2.3342, df = 27.644; Cohen's d = .88). Novice teachers, those with

less than five years of teaching experience, saw the largest boost of one point (pre-average = 2.5, SD = 1.07; post-average = 3.5, SD = .90), and this increase is significant (p-value < .01, t = -2.9568, df = 33.029; Cohen's d = 1.01). For expert teachers with more than five years of teaching experience, the average of comfort with leading a simulation increased from 3.56 (SD = .96) to 3.67 (SD = 1.05), but this small change was not significant (p-value > 0.8, t = -0.22086, df = 15.849; Cohen's d = .11).

Figure 5.6

Pre/Post Comfort with Leading a Controversial Discussion by Teaching Experience (N = 42)



Conclusion

Across the five groups, there are some similar trends in teacher dialogue choices in the different experience level groups. More experienced participants tended to choose teacher dialogue options that were more open ended and student directed, allowing students to have greater control over the discussion. Additionally, it is shown in the text responses that all participants are concerned with setting up a safe classroom environment before the discussion

begins and that they place value in pre-discussion tasks in which students can take the time to write down their ideas before speaking with their peers. Lastly, participants reported increased comfort with leading a controversial discussion, and this increase was largest for novice teachers. In the final chapter, I will discuss the implications of these results, and how they can inform future work.

Chapter Six

Discussion and Future Research

In this final chapter, I cover possible implications of the results of this pilot study through analyzing the text responses to anticipate and reflection questions, the teacher dialogue choices, and the measure of pre- and post-comfort with leading controversial discussions. The results have shown that participants with more experience are more likely to select teacher dialogue choices that allow students to remain in control of the discussion and may be more inclined to take on "riskier" discussion moves such as sharing their opinions with students. Additionally, through their text responses, participants were concerned with the setup of the discussion and providing students time to reflect before the debate. And in regards to comfort, this simulation has boosted the self-reported level of comfort for all participants, and this is especially prominent for those with less teaching experience. These preliminary findings suggest that not only can *Discussion Leader* be used as a tool of reflection on practice, but as a way to raise the confidence of novice teachers in the skills they already possess. Additionally, this simulation can be used to analyze the differences in the teacher dialogue choices made by those with differing levels of experience. It is also possible that other metrics, such as level of political activity, could be used to stratify the data set to examine other possible trends in future research.

Simulation Data Discussion

Anticipate and Reflection Discussion

In the anticipate and reflection questions about general discussion strategies and challenges, participants mention that they want students to do activities before the discussion to ensure that they have time to reflect on their own ideas. This may show how participants are

concerned with setting up the right classroom environment before the discussion even begins. Indeed, this is a critical part of a controversial classroom discussion, an activity that should be a safe place of democratic discourse. If students feel unsafe or that their ideas will not be respected in a classroom, they are less likely to engage in good faith conversations with their peers (Thompson & Wheeler, 2008). Additionally, research has shown that it is often students in minority positions who face the most discomfort in class debates (Beck, 2013; Rogers et al., 2017), so setting up the discussion in such a way that students feel that they and their ideas will be respected is key to maintaining classroom safety.

Teacher Dialogue and Common Paths Discussion

In Group One, participants focus on questioning strategies focused around asking probing versus closed questions. This group has intentionally low difficulty with students who are very engaged and civil with each other to ease the participant into speaking with students in the simulation. Those with less experience more often chose avoidant or closed lines of questioning, and this is especially apparent in the difference between the most popular paths G1.35 and G1.36 where expert participants favored the path with more open lines of questioning. Though the level of teacher intervention in a student-led discussion needed may vary by discussion, asking students questions to deepen their thinking is still a critical skill to wield to encourage student-to-student engagement (Hess, 2008, 2009; McNeill & Pimentel, 2009; Pimentel & McNeill, 2010).

This group also had the highest number of participants leaving the discussion early. Eight participants selected to leave this table to visit Group Two at the second choice level, and these participants included more non-teachers and novices than experts. This may show that those with less experience need more practice in noticing subtle parts of the discussion, instead of leaving

students to themselves, even when their discussion seems to be successful, to raise their communication skills to that of expert teachers (O'Connor & Fish, 1998).

In Group Two, participants practice discussion methods to lead students through their thought processes by working with their peers' ideas, instead of supplying students with the answer. This discussion strategy has been associated with higher student engagement in discussions (Pimentel & McNeill, 2010). More experienced participants more often chose teacher dialogue options that were student directed, such as asking other students to explain a concept or asking students about where their ideas come from. It is possible that participants considered an invisible time factor in their conversations with students in the simulation, and chose dialogue choices that they saw as "shorter," such as when they chose to tell students the answer as many novices did. To account for this in future iterations, it may be useful to inform simulation participants that there are no time limits built into the scenario and they are welcome to explore other options in additional runs of the simulation.

Additionally, this group had the most dispersed participants. Of the 21 possible paths, only three did not have any participants in it, suggesting that overall participants were less similar to each other in their ideas about how to address students who ask for a direct answer during a discussion. Even through this dispersion, path G2.27 was a popular choice for novices and expert teachers and no non-teachers selected this path. Since non-teachers also chose to leave this group early in greater numbers than participants with any level of teaching experience, this suggests that novices and experts are more similar in the way they "toss back" (Pimentel & McNeill, 2010) questions to the group while those without teaching experience are uncomfortable relinquishing control of the debate to students.

With the students at Group Three, the participants are tasked with thinking about how they may address students who want to know their teacher's personal opinion, and whether they decide to share their opinion with their students. A majority of participants initially chose to ask the students for their opinion first and then continued to decline to share their opinions, even despite the pushy demands from students. However, those with more experience chose to share their opinion with students more often than novices or non-teachers, suggesting that more experienced teachers may feel more comfortable sharing their opinions with students, that less experienced teachers may be concerned with possible repercussions that may occur if they share their opinions, or that those without any teaching experience do not believe that a teacher's opinion belongs in the classroom. These possibilities touch on the problems teachers often face about self-disclosure when leading a discussion. Self-disclosure, as more often utilized by experts in the simulation, is an opportunity for teachers to model how to share an opinion and back it up with reasonable evidence (Kelly, 1986; Oulton et al., 2004). However, this option does not come without risks, like being labeled as someone who "indoctrinates" students (Hess, 2004; Misco & Patterson, 2007). Participants may have also felt that they did not want to sway the students' discussion and refrained from self-disclosure for that reason (Kuş, 2015). Additionally, almost all participants who saw a moment of discussion norms being violated, addressed it in the moment, showing that certain discussion skills may be understood by all participants, even those with no experience.

Participants are more similar than different in the way they speak to Group Four. With this group, participants practice how to engage students who seem uninterested in the discussion through teasing out the ideas of the students slowly. At the first level of choices, similar proportions of participants across experience levels chose to either have students summarize the

discussion or to provide a summary, though student directed summary was more popular. Participants may have found this table to be particularly challenging as the prior three student groups already had discussions going. Many participants also took the path of least resistance. The most popular path, G4.15, involves asking the most engaged student at the table, who laments that the other students do not want to participate in the discussion, for her opinion, and then asking the other three students what they think. The paths where participants directly called on students who were not participating were less popular. Quiet students often report that their voices get lost in discussions involving the whole class (Hess & Posselt, 2002) and that is what is seen here. Even with only four students, participants tended to engage with the most talkative student, meaning about a third of participants do not directly hold any time to hear the opinions of others.

Additionally, though 13 participants saw a part of this group's conversation in which the missing student returns to the table, only two chose to ask him for his opinion. It was expected that a higher proportion of participants would be interested in the opinion of, from their perspective, a newcomer in a discussion where participation was low, but participants continued to focus on the students they had already begun speaking with.

Within Group Five, participants met the challenge of how to address misinformation with students. This is an important skill to practice as 41% of teachers report that students have brought in more unfounded claims from unreliable sources since the 2016 election (Rogers et al., 2017). At the first level of choices, participants with less experience chose to tell students outright that their article was misinformation more frequently than those with more experience. The most popular teacher dialogue choices show that participants valued walking students through how to investigate misinformation, even if they were unaware of the exact term for this

type of fact finding called lateral reading (McGrew et al., 2018; Breakstone et al., 2021). Since the most popular path included guiding students through identifying the trustworthiness of the article, participants may have felt a responsibility to correct the misinformation, but still wanted to focus on students discovering this information for themselves. This was also the only group of the five in which no participants elected to leave the group early, which may highlight the importance participants attributed to combating misinformation in classroom discussions.

Measure of Comfort Leading Discussions

The data from the pre- and post-comfort question has shown that all participants, but particularly those with less than five years of teaching experience, report an increase in comfort with leading discussions after completing the simulation. This suggests that simulations may provide an increase to participants' perceived ability to carry out potentially contentious lessons, like controversial debates. This may be the most helpful for pre-service teachers who are often not exposed to how to teach controversies in their teacher preparation programs or to those pre-service teachers looking for an opportunity to connect the theory from their classes to their practice (Darling-Hammond et al., 2005; Borgerding & Dagistan, 2018; Pace, 2019). However, this was a single self-report question, so it does not measure other possible dimensions of leading a controversial discussion. In future iterations of this work, it may be prudent to design or utilize a scale of teacher comfort with controversial topics to gain greater insight into which aspects of a discussion a simulation can help teachers prepare for exactly.

Future Design and Research Possibilities

There are several future possibilities for this line of work. First, with the information collected from participants through their answers to reflection questions, it will be possible to

modify the teacher dialogue choices to include different strategies that varying types of teachers may value. Additionally, participants noted that they were especially concerned with the environment of the classroom before the discussion began, such as providing students time to write down their ideas. This information can help inform a redesign of the introduction of the simulation that either states the activities that students did prior to the discussion to prepare for it, or a more interactive version in which participants select which pre-debate activities they would like students to engage in. This additional simulation component could boost the perceived authenticity of the simulation and help participants focus more on their dialogue choices, knowing that the activities before the discussion ensured students had time to organize their ideas.

An extension of this study could involve A/B testing in which a cohort of novice teachers is split into two groups, one group that would complete the simulation and then facilitate this lesson with their students, and the second group that only leads the discussion on gene therapy with students. These two groups could be interviewed before and after teaching the lesson to see how their feelings towards teaching controversies may differ. Additionally, the classroom discussions could be recorded and analyzed to see if the questioning strategies between these two groups differed. While this could be done with human raters, it would also be possible to use natural language processing methods (NLP) to track teacher questions and other evidence of dialogic instruction from the recordings of classroom discussion (Blanchard et al., 2015). Should there be a difference - in that those that completed the simulation asked more open ended questions, for instance - this would show some evidence that the skills participants practiced in the simulation carried over to their actual practice.

Furthermore, there are two other possible avenues on the use of NLP methods in a redesign of this simulation: in-the-moment feedback and generative dialogue. One challenge of simulations is that participants do not receive feedback until the very end of a simulation in which they may partake in a debrief led by a teacher educator or professional development facilitator. By building machine learning classifiers that take in participants' text responses, it would be possible to provide them with immediate feedback on their ideas. For example, one of the anticipate questions in this simulation asks participants how they handle misinformation. Should a participant state that they would ignore the misinformation, the classifier would be able to provide feedback on the importance of confronting misinformation as it appears and show the participant how to use fact checking skills. My colleagues and I have shown in prior work that personalized feedback at key moments improves participants' performance (Eppinger et al., 2022; Hillaire at al., 2022; Marvez et al., 2022), so this would be an important addition to the simulation. However, this technique is currently limited by a small number of text responses. After more participants complete the simulation, more robust classifiers could be made to meet the need of methods of providing personalized, immediate feedback.

Additionally, the branching dialogic system I propose in this design has hard coded elements. That is, selecting teacher dialogue choice A always leads to student dialogue screen B. This is useful in designing branching narratives that are traceable for research, but it would be possible to create responsive student dialogue using NLP methods such as GPT-3 or a BERT model trained on student discussions such that participants could type their responses and then the models would generate novel student dialogue in response to the participants' text. This design could provide insight into how participants react to a number of unique situations and would represent a more authentic task as participants would have to type a response instead of

selecting from a list of presets. However, generating new dialogue for each participant would present a facilitation challenge in that the participants would see vastly different pieces of student discussion, making it harder to have a class debrief afterwards. Some prior work has shown that this model of analyzing participants' text input can be used to place participants into the correct narrative path, but it has similar challenges with other NLP designs in that unexpected inputs are often handled poorly (Bellassai et al., 2017).

Limitations of this Work

In this thesis, I have described the challenges that teachers may face when teaching controversies, such as handling misinformation and whether or not they should take a neutral stance on the issues they present. However, this simulation does not prepare educators for the outside influences that may prevent them from including controversial discussions in their classes, like community influences, that lead them to self-censorship (Misco & Patterson, 2007). While this pilot work suggests that this simulation may be useful in raising teachers' comfort with leading a controversial discussion, it does not prepare teachers to confront these external challenges. Further professional development work may be needed to inform teachers on the ways in which they could include controversial topics in their curriculums for those who teach in places where this type of instruction may be frowned on or outright prohibited.

Additionally, I have chosen to only stratify this data set by level of teaching experience as prior work has shown that novice and more experienced teachers perceive the act of teaching differently (Livingston & Borko, 1989). However, it would be possible to examine this dataset or future similar studies, from other angles, such as initial comfort with leading discussions, political engagement or affiliation, as these also could have connections with the dialogue moves teachers make in a discussion.

Conclusion

In the analysis of the simulation data, three overarching themes emerged. First, this simulation raised the comfort of participants in leading a controversial discussion across all experience levels, and this change was the most striking for novice teachers. This is possibly the group that needs the most support in raising their self-confidence in their teaching skills. This may indicate that the simulation eased some of the worries that novice teachers typically have about teaching a controversial topic in their classroom, such as backlash from parents and a worsening classroom environment (Misco & Patterson, 2007). As new teachers may struggle with many aspects of teaching, it is important to provide them with opportunities to practice high-risk moments in low-risk environments as an approximation of practice (Grossman et al., 2009). The simulation is not designed to have right or wrong answers, simply choices that are more or less engaging for students across the more than four million paths, so novice teachers would have the opportunity to practice over and over again different questioning strategies to see which fits their facilitator style the best.

Second, those with higher levels of teaching experience more often chose more open-ended, student directed, and guiding questioning strategies. This ties in with the trend in dialogue choices across all groups, wherein those with less experience select more teacher directed actions, like telling the students the answer, than those with more experience. This shows a key difference in conversations led by more experienced teachers, that the frequency of open-ended, probing questions is higher than those with little teaching experience. The difference in frequency of student directed dialogue choices by participants may be due to that less experienced participants felt the need to keep control of the conversation as much as possible, and therefore, selected options in which there were predictable student answers instead of the

more probing questions. A limitation of this analysis is that, at the third level of choices, participants are fewer in number, so paths with a small number of participants on it are harder to compare to others. However, this analysis does hold even when only the first levels of teacher dialogue choices are compared. In a future study, it would be useful to conduct interviews with select participants to better understand their choices and uncover any other concerns they had and why exactly they made those choices.

Lastly, participants are not only concerned with what they say to students during the discussion, but what happens before. In both the anticipate and reflect short response sections, participants mention strategies that they could do to prepare students for the discussion. These include having students take time to write out their ideas before speaking with peers and establishing norms with students. These answers show that participants want to establish safe discussion environments for students and value the importance of self-reflection before jumping into a debate. These responses will inform designs going forward by improving the introductory text through providing ways for participants to see that their classroom has established norms and show options for activities they could have students do before they begin discussing.

References

Introduction

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Chapter Five

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