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Classroom Discourse and Teacher-Student Interactions during the Enactment of Evolution and Human Genetics Units in a Rural High School: A Case Study of a Biology Teacher

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Abstract

Teachers often struggle to facilitate open discussions about evolution when they perceive it to be at odds with cultural and religious norms. Little is understood about classroom discourse and teacher-student interactions during the teaching of evolution. This study analyzed classroom discourse and teacher-student exchanges in a 10th-grade biology classroom at a rural high school during the evolution and human genetics units. It also considered contextual factors such as the teacher's acceptance and understanding of evolution and his perspective on the nature of science [NOS]. A microanalysis of classroom discourse showed that lecturing and recitation were the most commonly used discourse patterns. While the intent of the teacher's questions and their impact on students' subsequent responses varied across dialogue patterns, the most frequent objective of the teacher's questions in both units was to assess correctness. The teacher's feedback mostly acknowledges responses, confirms correct answers, and reiterates responses. The teacher displayed a comprehensive understanding of all aspects of NOS. He also demonstrated a strong acceptance of evolution. The questionnaire results and his teaching throughout the unit indicated a high understanding of evolution. This study suggested that teachers with solid acceptance and a well-informed understanding of evolution may still utilize teacher-dominated discourse patterns and ask questions primarily to obtain factual knowledge.

Introduction

Teachers are crucial in engaging students in meaningful discussions, particularly when addressing sensitive topics that might challenge cultural and religious norms. One such topic is evolution, which, despite nearly 200 years since Darwin's observations on the HMS Beagle, still stirs controversy and resistance in particular educational settings (Glaze et al., 2015). Individuals often encounter social and cultural sources that present viewpoints that differ from the scientific consensus. They may need to engage more deeply with the information to facilitate a conceptual shift, even when taught scientific perspectives. While aspects such as the nature of science [NOS] views and knowledge of evolutionary content can be enhanced through classroom instruction, other factors like personal beliefs and worldviews are considerably more challenging to influence or change via traditional instruction (Glaze et al., 2015). Jean and Lu (2018) underscore the intricate and ongoing debate surrounding evolution in public discourse and how language and ideology shape discussions on this topic. They examined the public discourse about evolution, including media coverage and public opinion polls, and found that it mirrored dominant narratives. Supporters of evolution typically employ scientific discourse, while those opposing evolution use religious discourse.

Evolution, considered the cornerstone of science and backed by abundant evidence from various fields of study, impacts many facets of our lives. Its effects can be seen in everything from the diversity of living organisms to the development of medical treatments, hence the necessity for individuals to deeply understand evolutionary concepts and apply them to real-world problems. However, the current approach to teaching evolution in classrooms often fails to meet the scientific rigor necessary for promoting scientific literacy (Glaze & Goldston, 2015) because many teachers frequently need help engaging students in an open discussion about evolution. Teachers may hesitate to devise an activity or initiate a discussion that could stir controversy due to societal disapproval of the topic and conflicts with regional/cultural norms (Lennon, 2017). Facilitating effective student discourse on controversial subjects is challenging, given that students may fear expressing their thoughts and may defer complex inquiries to others in groups. This outcome is common when teachers fail to use appropriate prompts and questions (Lennon, 2017). Thoughtful teacher questions often stimulate quality thinking and productive student responses (Shodell, 1995), and appropriate prompts can help students engage in various cognitive processes and enhance their reasoning skills (Lee & Irving, 2018; Ong et al., 2016).

While the scientific consensus on evolution is overwhelmingly supported by empirical evidence, significant resistance to the concept persists in public discourse. This resistance is often fueled by religious and ideological beliefs that portray evolution as threatening traditional values and beliefs (Jean & Lu, 2018). Acceptance or rejection of evolution is a multifaceted process influenced by various factors, including personal experiences, beliefs, and cultural values. It is not a simple dichotomy of acceptance or rejection but a continuum with many nuances (Glaze & Goldston, 2015). Glaze et al. (2015) explored the factors affecting the acceptance or rejection of evolution. They identified a relationship between acceptance, understanding of evolution content knowledge, and views on the nature of science (NOS). The latter was found to be a stronger predictor of acceptance of evolution.

When discussing topics that may challenge students’ beliefs, creating a safe and respectful environment that encourages open dialogue and discussion is crucial. Addressing student concerns and misconceptions about evolution can promote a deeper understanding of evolution (Bertka et al., 2019). Previous research found a culturally competent pedagogical approach useful for teaching evolution education. In this approach, researchers integrated scientific and religious perspectives respectfully, acknowledging the diversity of beliefs among learners (e.g., Barnes & Brownell, 2017; Pobiner et al., 2018).

Most existing studies on evolution education have been conducted in traditional university settings, which often need to include adequate representation from certain groups of people (Dunk et al., 2019). Little is known about how evolution instruction is implemented in high school classrooms. Also, previous studies show the complexity of managing effective classroom discourse and teacher-student interactions when enacting controversial topics in science classrooms (Owens et al., 2021). The results showed that the teachers’ interference constrained discussions and the teacher mostly failed to prompt students’ viewpoints. Therefore, more research is needed to understand how teachers manage classroom discourse and student interactions on controversial issues. To date, few studies have investigated classroom discourse and real-time teacher and student interactions about evolution in high school classrooms.

This study examined science classroom discourse practices by investigating the interactions between a biology teacher and his students in a rural high school classroom in the USA across two units: evolution and human genetics. The goal was to identify how the teacher posed questions and responded to students' answers, depending on the unit type. We selected these two units for specific reasons. Human genetics, a socioscientific issue, might spark controversies due to its practices. On the other hand, while not typically considered a socioscientific issue, evolution remains controversial as it may inadvertently contradict and be explained using cultural and teleological concepts (Gresch, 2020; Gresch & Martens, 2019). This study aimed to develop an in-depth understanding of (a) the verbal classroom discourse and teacher-student interactions in the 10th-grade biology classroom during the evolution and human genetics units and (b) the content and contextual factors that appeared to influence teacher-student dialogue and student engagement in this classroom. Three main research questions guided this study:

1. What types of spoken discourse patterns does a high school biology teacher employ to engage students in the units on evolution and human genetics?
2. What are the purposes and cognitive functions of the teacher's questions in teacher-initiated dialogues? What kinds of feedback does the teacher provide following the students' responses?
3. What factors might influence the teaching and learning of concepts related to evolution and human genetics, as well as teacher-student exchanges in this classroom?

Science Classroom Discourse

Efforts to prepare science teachers to teach in line with the most recent reforms, such as the Next Generation Science Standards (NGSS), focus on fostering rich classroom dialogue as one of the 'core' teaching practices (Kloser, 2014; the NGSS Lead States, 2013). Additionally, students find dialogic teacher talk more engaging than non-dialogic teacher talk situations (Juuti et al., 2020). Although science education reform and research findings envision an ideal for science classroom discourse, research indicates that this goal is only sporadically achieved in classrooms (Kranzfelder et al., 2020). As a result, much empirical research has been directed toward understanding science classroom discourse, teacher questioning, and teacher-student interaction (Bansal, 2018; Bossér & Lindahl, 2019; Hiltunen et al., 2021; Kranzfelder et al., 2020; Ong et al., 2016; Owens et al., 2021; Pimentel & McNeill, 2013; Sandoval et al., 2021).

Exploring such research findings, for instance, Kranzfelder et al. (2020) studied the discourse strategies of instructors teaching undergraduate biology courses in a US higher education institution. The results indicated that most biology instructors utilized authoritative and non-interactive discourse patterns. In a similar vein, Levinson (2004) scrutinized teacher-student exchanges on bioethical issues at a further education college in London. The findings revealed that the teacher predominantly controlled the classroom discourse, with the IRE discourse pattern (Initiate-Response-Evaluate) being the most prevalent. Hiltunen and colleagues (2021) collaborated with elementary and secondary science teachers, investigating the questions they posed during inquiry-based biology lessons. The study disclosed that during inquiry-based biology lectures, teachers primarily asked questions pertaining to facts and concept definitions, resulting in a lack of scaffolding for students' understanding by employing higher-order questions during investigations.

As identified in previous studies, teachers often dominate the discourse in many classrooms (Carlsen, 2007). In such classrooms, the discourse typically begins with a teacher's question, which expects a predetermined answer, and ends with the teacher's evaluation of the student's response. Mehan (1979) labels this interactional pattern as Initiation-Reply-Evaluation (IRE), wherein the teacher, already knowing the answer, elicits a response by asking questions with known information. This three-part discourse structure is called 'triadic dialogue' by Lemke (1990) and 'recitation' by van Zee and colleagues (2001). The recitation is an activity structure that gives teachers control over classroom discussions. Students must usually provide brief answers in this dialogue rather than initiate the conversation. This discourse structure is the most pervasive in classrooms and is mistakenly thought to increase student engagement (Chin, 2006; Chin, 2007; Lemke, 1990). The IRE pattern transitions to the IRF (Initiation-Response-Feedback) pattern when teachers provide feedback on students' responses in the final step (Sinclair & Coulthard, 1975).

Beyond recitation, there exist other discourse structures observed in science classrooms. As per a framework devised by van Zee and colleagues (2001), these science discourse practices encompass lectures, guided discussions, student-generated inquiry discussions, and small group interactions. Lectures transpire when teachers impart knowledge by directly providing information. Teachers typically pose rhetorical questions in this type of discourse, and students might only be able to ask questions after the lesson.

Different discourse patterns emerge when a teacher provides feedback and permits students to expand upon their ideas rather than just evaluating their responses and closing the conversation. In guided discussions, teachers collaborate with students to construct knowledge, allowing them to explain and refine their thoughts. In this mode of science instruction, teachers usually pose conceptual questions that uncover students' thought processes and understanding. In student-generated inquiry discussions, students build knowledge by asking questions and voicing their ideas. During these sessions, teachers facilitate and encourage creative student contributions. Small group interactions are akin to guided discussions when the teacher is involved. However, when the teacher is absent, students construct their knowledge by interacting with each other, asking questions, or sharing their understanding. In this instructional method, termed 'peer collaboration,' the teacher's presence is minimized, resulting in infrequent teacher questioning compared to the prevalence of student questions (van Zee et al., 2001).

Teacher Questions in Science Classrooms

Numerous studies on science classroom discourse have primarily focused on teacher questioning. Different types of teacher questions have varying impacts on students. Teachers in the USA have been criticized for predominantly asking questions to which they already know the answers (Mehan, 1979). Conversely, in student-centered classrooms, teachers pose questions that prompt students' reflection (Roth, 1996). Harlen (2001) labels these as "productive" questions because they encourage students to seek answers through observations and exploration.

van Zee and Minstrell (1997) centered their research on a type of teacher questioning called "reflective toss." This method aims to further stimulate students' thinking on a topic under discussion by shifting the responsibility back to them to reflect on their previous statements. A reflective toss comprises a three-part structure: a student responds to a point or question, the teacher poses a follow-up question, and the student reflects on their initial response. The reflective toss may also occur as an extension of a sequence of exchanges between the teacher and different students.

Instructor prompts can be used to achieve various goals and help students engage in numerous cognitive processes. Therefore, teachers must carefully consider using prompts when responding to students' answers. Appropriate teacher responses to student answers in the Initiation-Response-Feedback (IRF) pattern can expand students' conceptual knowledge and enhance reflective thinking on scientific concepts. Such approaches will likely shift discourse patterns away from recitation, fostering a more constructivist learning environment (Ong et al., 2016).

Some researchers have examined how teachers' questions influence students' modes of thinking. For instance, Chin (2006) studied how science teachers utilized questioning and followed up on students' responses to promote productive thinking and conceptual understanding. The researcher analyzed the students' utterances following teacher questions to trace the influence of teachers' questions on students' responses and thought processes.

Factors affecting Classroom Discourse and Teachers' Interactions with Students when Teaching Evolution

Though evolution is a scientifically well-established theory, many consider it controversial. Notably, scientific theories themselves do not generally incite controversy. For instance, discussions around other contentious issues, such as genetically modified organisms, revolve around ethics, not science (Reiss, 2019). However, when it comes to evolution, debates about its scientific content arise among its proponents and detractors. Therefore, Reiss argues that teachers should approach evolution as a sensitive topic rather than a socioscientific issue during instruction. Whether we term it controversial or sensitive, it is evident that opinions on accepting evolution are polarized, and such conflicts can even manifest in science classrooms.

Examples of such conflicts are widely discussed in the literature. For instance, Trani (2004) investigated the understanding, acceptance of evolution, views on the NOS, and religious beliefs of U.S. high school biology teachers. The results revealed that teachers' acceptance of evolution and religious convictions were negatively correlated, the most significant among all variables. Consequently, teachers with strong religious views were less likely to accept evolution. The second most substantial correlation was between teachers' acceptance of evolution and their willingness to present it in the classroom; teachers who did not accept evolution were less inclined to teach it. Aguillard (1999) discovered that teachers who considered creationism scientifically valid tended to spend more time teaching this perspective and less time teaching evolution. Additionally, many teachers in Nehm and Schonfeld's 2007 study believed that some creationism claims should be taught in science courses.

Even in countries where evolution is widely accepted and taught in schools, students and teachers may need to be aware of the teleological concepts embedded in evolutionary explanations. The language utilized in discussions about evolution often carries an emotional charge and a rhetorical bias. Supporters of evolution tend to emphasize the importance of scientific evidence, while opponents frequently rely on appeals to faith and cultural beliefs (Jean & Lu, 2018). Gresch and Martens (2019) discovered that secondary classroom teachers unconsciously employed teleological explanations when teaching evolution. Similarly, Gresch (2020) reported that teachers and students used teleological explanations when discussing adaptation within the evolution unit. The results revealed that students expanded on their teleological explanations in response to the teacher's feedback, which the teacher ultimately endorsed.

Beyond mere acceptance, an understanding of evolution challenges its teaching. Rutledge and Warden (2000) found a significant correlation between biology teachers' understanding and acceptance of evolution. In a subsequent study, Rutledge and Mitchell (2002) analyzed U.S. high school biology teachers' knowledge construction and perceptions of evolution, revealing that those in the acceptance groups developed the most comprehensive concept maps. While many studies have observed a positive correlation between understanding and acceptance of evolution, comprehension does not necessarily equate to endorsement. An individual with limited knowledge might accept evolution, while another may reject it despite having a good understanding due to religious or non-scientific beliefs (Dunk et al., 2019). Although the disparity between comprehension and acceptance of evolution is not exclusive to the United States, most studies have been conducted in the U.S. for valid reasons (Dunk et al., 2019). Among 32 European countries and Japan, only Turkey records a lower public acceptance rate of evolution than the United States (Miller et al., 2006).

Misconceptions about evolution often stem from the misunderstanding that 'evolution is just a theory' (BouJaoude et al., 2011). This finding has led several researchers to question whether understanding the nature of science is related to understanding and teaching evolution. A correlation has been identified between teachers' epistemological views, their understanding of the nature of science, and their acceptance of evolution (Akyol et al., 2012; Deniz et al., 2008; Rutledge & Warden, 2000; Trani, 2004). For instance, Deniz & Donnelly (2011) investigated the relationships among preservice secondary teachers' acceptance and understanding of evolution, thinking dispositions, and epistemological views. The results indicated a positive correlation between the participants' epistemological stage and their level of acceptance of evolution. Prior studies have suggested that science teachers with more expertise may still need clarification about the evolutionary process, such as employing Lamarckian reasoning to explain biological evolution (Tidon & Lewontin, 2004).

Science teachers may need an understanding of evolution and the NOS, so they inadequately cover or even avoid the topic. Evaluating how teachers approach the subject is crucial for assessing the state of evolution education in high school classrooms. In particular, given that education is facilitated through communication, an analysis of teachers' use of classroom discourse could provide valuable insights into evolution education. When broaching topics that may challenge students' beliefs, it is essential to cultivate a safe and respectful environment that encourages open dialogue and discussion (Pobiner et al., 2018).

Theoretical Framework

Lemke's (1990) social semiotics and Carlsen's (1991) sociolinguistic approach were used as the theoretical framework for this study. This study focused on teachers' use of classroom discourse, specifically questioning sensitive and controversial issues. The social semiotics approach studies the contexts in which people build meanings and the relationship between intentions and contexts. Similarly, as Carlsen points out, teachers' questions depend on students' content, context, and reactions. This study investigated how a high school biology teacher used discourse and questioning questions across evolution and human genetics units.

We explored whether and how context influenced the teacher's questions. The context included but was not limited to the teacher's understanding of evolution, his acceptance of evolution, and his views about NOS, the school district, and the students. We also explored how the teacher's initial questions affected students' subsequent responses and how students' reactions and responses shaped the teacher's follow-ups and later questions.

Methodology

We employed a case study approach to address the research questions in this study. A case study enables researchers to concentrate on a 'case' while maintaining a holistic perspective on real-life educational scenarios (Yin, 2009). Case study researchers typically collect rich and in-depth data over extended periods, often using diverse methods such as observations, interviews, audio and video recording, and the researcher's field notes (Bloor & Wood, 2006; Creswell & Poth, 2016). This study centered on a case involving a teacher and his 10th-grade biology students. Working with one teacher allowed us to gather substantial data from that individual. As Patten (2010) has suggested, there are other concerns than the sample size in qualitative research. Instead, it is more valuable to dedicate sufficient time to a small number of participants than to work quickly with large sample sizes (Patten, 2010).

Context and Participants

We conducted this study during the second semester of the school year at a rural high school in the Midwest region of the United States. The school catered to approximately 660 students and was ethnically homogenous, with a 94% Caucasian population. It also had a relatively high poverty rate, with 44% of students eligible for free or reduced lunch. The study participants included one biology teacher and 14 students from one of his classes. The teacher, 'Evan' (pseudonym), was specifically chosen for the study due to his inclusion of evolution in his biology curriculum (Patton, 2002). Evan, a 34-year-old white Caucasian male, originally majored in environmental science before transitioning to education. He graduated with a major in education and minors in biology and chemistry. He was in his second year of teaching science at this high school at the time of the data collection. The study initially included 13 students (eight females and five males) for the first three weeks.

Between the third and ninth weeks of data collection, the number of students increased to 14 (nine females and five males) due to the addition of a female student who transferred from another school and consented to participate with parental permission. These tenth-grade students were from one of the three biology sections Evan was teaching. Students' responses to Evan's questions and interactions with him were used as data on teacher-student interactions and classroom discourse.

Data Collection

To address the research questions, we utilized multiple data sources. Firstly, we employed a teacher background questionnaire comprising open-ended questions about demographic information: education, age, gender, ethnicity, teaching experiences, science course background, time allocation for teaching evolution and NOS, and concerns about teaching evolution. We used the 'Views of the Nature of Science' (VNOS-B) questionnaire to evaluate Evan's views on NOS (Lederman et al., 2002). Thirdly, we applied the 'Generalized Acceptance of Evolution Evaluation (GAENE 2.0)', a 14-item Likert-scale survey developed by Smith et al. (2016), to measure acceptance of evolution. Lastly, we utilized an 'Understanding of Evolution Questionnaire,' initially developed by Johnson (1985) and later modified by Rutledge and Warden (2000), to gauge Evan's understanding of evolution. This test comprises 21 multiple-choice items covering various evolution subtopics.

Subsequently, we employed semi-structured interviews to delve deeper into various ideas. At the study's outset, we conducted the first interview to ascertain Evan's perspective on the overall school district and student population, his biology lessons and instructional strategies, and his views on classroom discourse and questioning. This interview aimed to gather information about Evan's approach to biology teaching, his difficulties or challenges in teaching biology, and his interactions with students. The second interview focused on Evan's understanding of scientific theories and laws to gain insight into his comprehension of these crucial scientific constructs and his views on evolution. The third interview occurred at the end of the study, after Evan had finished teaching the human genetics and evolution units. This interview explored Evan's perceptions of using classroom discourse and questions in these two units. His reflections and responses provided insight into Evan's perspective on his interactions with the students and the factors he believed influenced his classroom discourse in these units. During this interview, we presented Evan with selected clips from the video recordings of his teaching and asked him to reflect on his classroom discourse and interactions with the students.

Lastly, we utilized classroom observations and audio-video recordings from two biology units as our primary data sources. We observed and recorded all lessons taught by Evan in both units. We monitored and documented 31 lessons during which Evan taught evolution (nine weeks) and the human genetics unit (spanning three weeks). We also held one-on-one informal debriefing sessions with Evan, during which he reflected on various aspects of his lessons, including his teaching methods and student interactions.

Data Analysis

We utilized video and audio recordings to identify the types of verbal classroom discourse patterns used in the evolution and human genetics units. We adopted the science classroom discourse patterns delineated by van Zee and colleagues (2001) as a priori codes for our analysis of classroom discourse patterns. van Zee et al. (2001) differentiate five teacher-student discourse patterns: 'lecture, recitation, guided discussion, student-generated inquiry discussion, and peer collaboration.' We organized our data into these pre-established categories (Merriam, 2009). We did not include incidents that did not have reciprocal interaction between teacher and students or match any of the patterns. These incidents included teacher instructions or explanations about the weekly plan, assignments, activities, and student presentations with only student talk. Therefore, we only used the time when the teacher and students interacted and coded 709 minutes for the evolution unit and 169 minutes for the human genetics unit.

We utilized NVivo, a software program for organizing and storing non-numerical data. Using NVivo, we reviewed video clips from the 31 lessons (23 lessons from the evolution unit and eight from the human genetics unit) and listened to audio recordings of small group interactions. We employed verbatim transcription to capture everything audible in the discourse that began with Evan’s question (Paulus et al., 2013). We utilized the time feature of NVivo and added the duration of the selected discourse patterns to quantify the time Evan allocated to each type of classroom discourse.

To answer the second research question, we transcribed everything audible in the discourse patterns that started with teacher questions in the 14 lessons among 31 lessons across units to analyze the purposes and cognitive functions of the teacher’s questions, the student's responses, and the teacher’s follow-up. We coded each utterance separately, whether a teacher question, student response, or follow-up. The code categories we applied to each utterance included content, move, purpose of the utterance, speaker, students' cognitive processes, types of utterance, and types of teacher follow-up. We adopted predetermined subcategories that Chin (2006) developed for the speaker, moves, types, and purposes of utterances, teacher feedback, and students' cognitive processes. We created new sub-codes, especially for the categories of purpose of utterance, types of teacher feedback, and students' cognitive processes, when we encountered data that did not fit any of the predetermined categories.

We analyzed a range of sources for the third research question, which pertains to the content and contextual factors that may affect teacher-student interactions. These included teacher interviews, reflections shared by Evan in daily debriefing meetings, and his responses to various instruments such as the teacher background questionnaire, the Nature of Science questionnaire (VNOS-B), the Acceptance of Evolution Survey (GAENE 2.0), and the Understanding of Evolution questionnaire. We categorized Evan’s views of the nature of science (NOS) into two categories: a) naïve or b) more informed views, following the suggestion of Lederman and his colleagues (2002). We transcribed the second semi-structured interview verbatim, which focused on Evan’s understanding of theories and laws in science and his perspective on evolution as a scientific theory. We used the insights drawn from this interview to support the conclusions derived from the VNOS-B. Evan's acceptance of evolution was measured using GAENE 2.0 (Smith et al., 2016). We assigned numerical values to his answers: 1 = strongly disagree, 2 = disagree, 3 = I don't know / no opinion, 4 = agree, and 5 = strongly agree. The higher the value, the more strongly the respondent accepts evolution, with 5 indicating strong acceptance, three suggesting uncertainty or neutrality, and one indicating rejecting evolution. The questionnaire consisted of 14 statements, so the total score could range from 14 to 70, with higher scores indicating greater acceptance of evolution.

The questionnaire used to probe Evan's understanding of evolution was derived from one of the three subscales of a questionnaire developed by Rutledge and Warden (2000), which itself was modified from Johnson's (1985) scale. Rutledge and Warden found this assessment reliable and valid for measuring teachers' understanding of evolution. According to their scale, a score of 21 indicates a high level of knowledge, while a score of 0 signifies a complete lack of understanding of the concept. Following the recommendation of Rutledge and Warden, cumulative scores from correct responses were used to determine Evan's grasp of evolution.

Results

This section will present the study's results, addressing each research question. We provide relevant quotations to facilitate understanding and have organized the information into subsections. This structure will assist readers in conceptualizing the discourse and interpreting the findings.

The Types and Frequency of Spoken Discourse Patterns in Evolution and Human Genetics Units

The frequency analysis of discourse patterns used in evolution and human genetics lessons showed that recitation was the most commonly utilized discourse pattern. This pattern was identified 133 times in 23 evolution lessons and 35 times in 8 human genetics lessons, as illustrated in Figure 1. Lecture, the second most frequently employed pattern, was coded 110 times in evolution and 33 times in human genetics units. The other two discourse types, peer collaboration (coded 19 times) and guided discussion (coded 15 times), were exclusively found in the evolution unit. Evan did not employ peer collaboration or guided discussion in the human genetics unit; student-generated inquiry discussions were absent in both units.

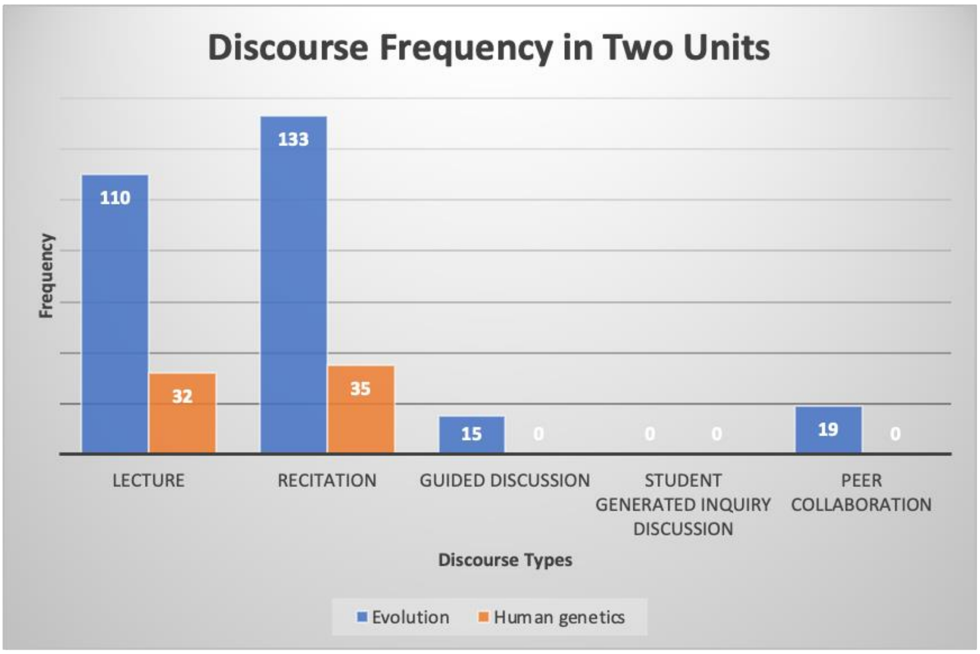

Figure 1. Discourse Frequency in Evolution and Human Genetics Unit

Recitation

Evan used recitation in almost every phase of his lessons, particularly before or after lectures. Although Evan initiated some dialogues with 'why' or 'what do you think?' questions, many of these dialogues eventually turned into recitation-style discussions. This shift is demonstrated in the excerpt below, where he tries to elicit students' ideas about the factors that could affect human population growth. However, when the initial response did not align with his expectations, Evan explained and partially answered the question without furthering the discussion. Subsequently, he posed a closed question seeking one specific response, as illustrated below.

> "*Evan: Darwin asked why other species don't experience this overcrowding as humans did then.*
> *Student 1: Natural selection*
> *Evan: Well, many things limit the population growth of species —things like lack of food, space, predators, and disease. We can think of a few more. The environment selects those who can persist and successfully do what? What do they need to do?*
> *Student 2: Mate.*
> *Evan: They need to reproduce. not just to mate. They also need to raise their offspring successfully. They need to find a mate and be able to produce offspring to continue their species*" (In-class dialogue, evolution unit).

In another instance of a recitation-style dialogue, Evan explained that acquired characteristics could not be passed on to the next generation. He used the example of an experimental test that disproved Lamarck's hypothesis. Following this, he asked the students what they thought about the trial's outcome, even though he had already provided the answer.

> "*Teacher: He [the scientist] tested some rats." He took a whole series of rats, cut off all their tails, and had them reproduce. He tested to see if the next generation would miss tails because of those acquired characteristics. What do you think? Does the next generation have tails?*
> *Students: Yes.*
> *Teacher: So, cut off all their tails and have them breed. Does the next generation have tails?*
> *Students: Yeah.*
> *Teacher: He did this repeatedly, every time they had tails. So, that experiment did not support Lamarck's hypothesis*" (In-class dialogue, evolution unit).

Additive Recitation Series

Evan occasionally employed multiple recitation series, especially when evaluating students' understanding of previously taught content. In this dialogue pattern, Evan began conversations with a question to which he already knew the answer. Upon receiving the correct response, he would then transition to another known-answer question, aiming to elicit textbook-based knowledge from the students. He would continue this process until a topic review was complete. The following excerpt illustrates Evan's application of additive recitation dialogue in the human genetics unit:

> “*Evan: What happens during translation?*
> *Student 1 (female): DNA changes, right?*
> *Evan: What happens during translation?*
> *Student 2: DNA is translated into RNA.*
> *Evan: Translation?*
> *Student 2: Uh, no RNA is translated into protein.*
> *Evan: Yes, RNA is translated into protein. So, each code becomes one amino acid.*
> *Evan: Hey. What happens during transcription?*
> *Student 3: DNA is transcribed into RNA.*
> *Evan: DNA is transcribed into RNA, and where does that happen in the cell? Inside of the…?*
> *Student: Nucleus.*
> *Evan: Nucleus. Okay, good. How many alleles for each trait are found in an individual?*” (In-class dialogue, human genetics unit).

Guided Discussion

Evan did not utilize guided discussions in the human genetics unit, and he used this method only 15 times in 23 evolution lessons, allotting 20 minutes out of the 709 minutes dedicated to all types of discourse in the evolution unit. Occasionally, Evan would begin with a guided discussion but then switch to recitation. At other times, he would transition from a guided discussion to a recitation when students' responses were inappropriate or incorrect. The excerpt below illustrates how Evan initiated a conversation with an open question, seemingly attempting to elicit students' ideas. However, when the first two students gave responses that did not align with his expectations, he began guiding them towards a specific answer.

> “*Evan: What evidence would you guys say exists to support the idea that organisms come from a single common ancestor? Can you think of anything?*
> *Student 1: Wolves!*
> *Student 2: Eyes!*
> *Evan: "Eyes, maybe? What is one thing that is common to everything alive?*
> *Student 3: Single trait*
> *Evan: Think about the characteristics of life.*
> *Student 2: Cells, DNA*
> *Evan: DNA! Everything is operating using the same code. Every species on earth uses the same code; you can find genes in bacteria that are homologous or the same, as the genes we have. So, bacteria have genes that are identical to ours; it makes sense that there may be a relationship going way back”* (In-class dialogue, evolution unit).

Evan utilized guided discussion sparingly in the evolution unit, and it lasted only a short time before he started directing students towards specific responses, shifting his dialogue pattern from guided discussion to recitation, as illustrated in the example. Notably, while Evan incorporated guided discussion briefly in the evolution unit, he excluded it entirely from the human genetics unit. He viewed evolution as a broader topic more conducive to open-ended discussion than the human genetics unit. This perception is reflected in the following excerpt from the third interview, where Evan discussed his classroom discourse in both units after reviewing sections from the video-recorded lessons:

> *Researcher: What do you think about your classroom discourse in these two units?*
> *Evan: I think a lot of my talk is to deliver the information initially, and then the students give feedback, saying, "Yes, I get this". As I became more thoughtful towards the end of the evolution unit, the interactions involved more discussion and actual dialog rather than me saying, "Okay, the pairing with adenine is…" and then having everyone give me the correct response. I asked more questions that evoked dialog during the evolution unit. Evolution lends itself more to that. Human genetics is more or less: "Here's the science; let's understand these concepts like DNA chromosomes and how heredity works"*
> *Researcher: So, is this just related to the concept?*
> *Evan: It is related to concepts. Human genetics can be easily spelled out in a short outline, whereas the concepts of evolution are more complex. There are many mechanisms of evolution and different types of evidence for evolution, including how evolution relates to taxonomy now, how evolution relates to our understanding of living systems, and how evolution influences all of biology. So, it's just a broader subject overall"* (third interview).

Peer Collaboration

Peer collaboration took place in two distinct ways. It occurred when Evan distributed worksheets with problems to groups, providing instructions for collaborative problem-solving, thereby facilitating collective knowledge construction. The second instance of peer collaboration arose when Evan presented a problem and instructions, tasking students with evidence collection and explanation development. Notably, peer collaboration was exclusively used in the evolution unit. Although students were expected to complete tasks by brainstorming and sharing ideas within their small groups, they were only partially independent, as many steps of this discourse type remained teacher-directed. Evan maintained oversight of students' work by circulating among their tables, reviewing their written work, and asking or answering questions in a directive manner. Evan did not incorporate peer collaboration or hands-on activities involving tangible materials and tools throughout the human genetics unit. Although students participated in what Evan termed a "paper-pencil lab," they completed worksheets individually rather than in small collaborative groups. In these paper labs, students generated graphs and concluded independently. According to Evan, human genetics does not readily lend itself to hands-on activities except DNA manipulation, which requires costly equipment. Conversely, he asserted that the topics of evolution and ecology are much more conducive to hands-on experiences:

> *"Human genetics is challenging because we fundamentally don't have the means to play with actual DNA. We did a DNA extraction lab earlier in the school year, but the best I can do is extract DNA and*

> *have it precipitate into ethyl alcohol. Then the students can look at it and say, 'Look, ew, that goopy stuff, that stringy stuff.' However, with evolution, we can do natural selection labs. Those are pretty easy to conduct hands-on." (First Interview).*

Purposes and Cognitive Functions of Teacher Questions and Student Feedback Types

The teacher's most frequent objective when posing questions was to assess correctness; a goal reflected in 142 out of the 276 analyzed questions. The majority of these questions were asked during recitation dialogues. 'Checking' (76 instances) was the second most common purpose, primarily employed during small group work sessions when Evan moved around to inspect students' progress on the given task. The third most frequent objective was to remind students of a previously covered concept or activity, which occurred 44 times. 'Eliciting' was the fourth most frequent purpose, occurring 35 times, and was used to draw out students' understanding. Evan often restated the question if students gave incorrect answers or no response at all (31 instances). In some cases, he made minor adjustments to the questions when repeating them, in which case the question was also coded as 'fine-tuning' (26 instances). 'Specifying' was used 19 times, indicating instances when Evan highlighted a particular aspect of a question. Lastly, Evan seldom used 'probing' questions (11 cases) to prompt students to elaborate on their reasoning. Other purposes for questioning, which were used less frequently, included 'attention-driving' (7 instances), employed solely to focus and engage students; 'clarifying' (6 instances), used to ensure that the question was understood; 'linking' (6 instances), utilized to connect the question to another concept or real-life example; and 'challenging' (6 instances), used provocatively in response to a student's remark. The 'extending' purpose, which aims to guide students towards a deeper understanding, was not used by Evan. Figure 2 displays the frequency of Evan's questions' goals (see the Appendix A for examples of each type of purpose for questioning Evan exhibited across 14 lessons).

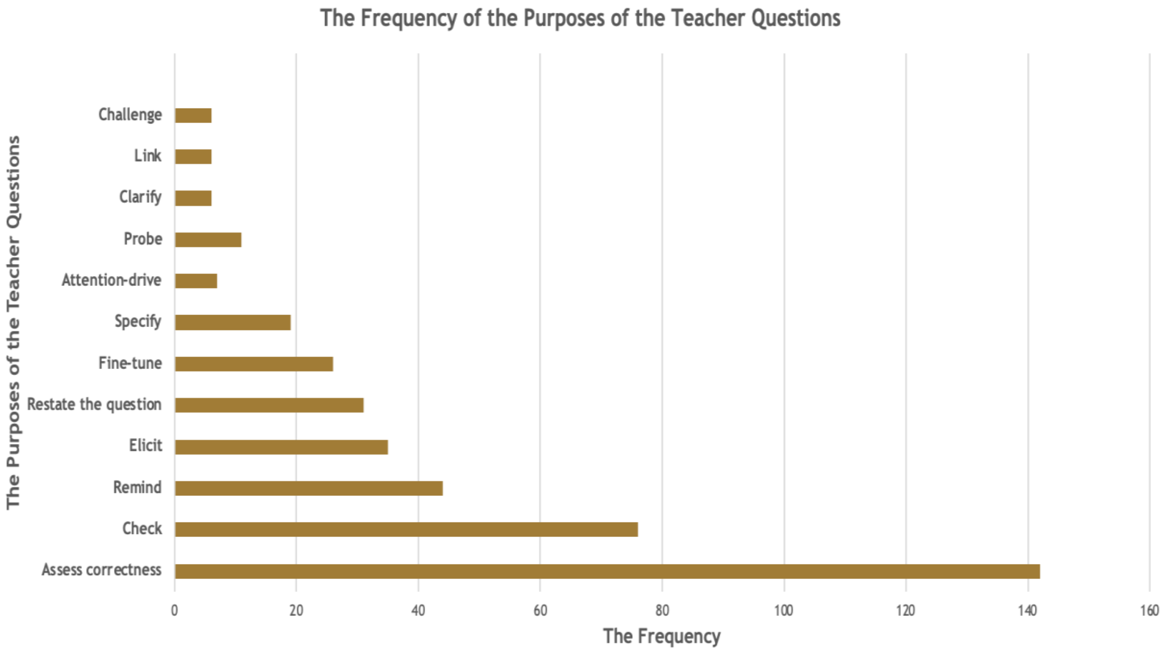

Figure 2. The Frequency of the Purposes of the Teacher Questions

Types and Frequencies of Cognitive Processes in Students' Responses

The cognitive process skills most frequently demonstrated in students' responses were recalling previously covered material, evaluating (usually with brief responses such as "yes" or "no"), and reading to answer a question. Evan less frequently employed higher-order process skills, including hypothesizing, explaining, comparing, identifying, and applying. This study did not identify other higher-order cognitive skills, including observing, sorting, classifying, and theorizing.

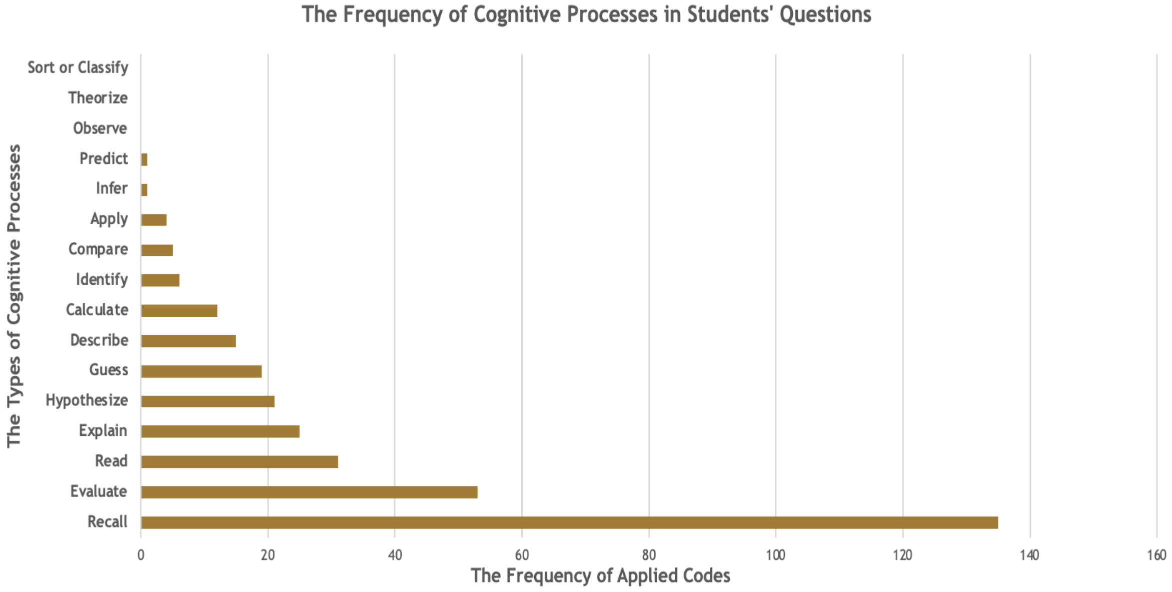

Figure 3. The Frequency of the Cognitive Processes in Students' Responses

The Purposes of Teacher Feedback to Student Responses

We used Chin's (2006) categories of teacher utterance purposes in our analysis of teacher feedback, and new codes emerged during the examination. The two most frequent purposes found in the teacher's feedback were 'acceptance' (125 instances), responses like "okay" or "yes," typically used to confirm correct answers, and 'restatement of responses' (82 instances), a reinforcing strategy that Evan often utilized following a valid response.

Consolidation' (35 instances), typically summarizing the main points in a teacher-student exchange, was another common purpose in Evan's feedback. 'Correction' (22 instances) was also frequently observed, with Evan either directly correcting students' responses by saying "no" or indirectly, often by repeating the same question. 'Informing' (19 instances) involved Evan adding information to students' responses. 'Guiding' (17 instances), where he attempted to steer students in a specific direction during small group or individual work, was the next most common purpose in Evan's feedback.

Less frequently observed purposes of Evan's feedback included 'clarifying' the feedback (9 instances); 'praising' (7 instances), using phrases such as "good example;" 'linking' (7 instances), relating to other relevant concepts or real-life examples; 'reminding' (6 instances), bringing attention to a previously covered idea or example; 'expounding' (5 instances), providing additional factual knowledge; and 'teasing' (2 instances), light-heartedly joking about students' responses.

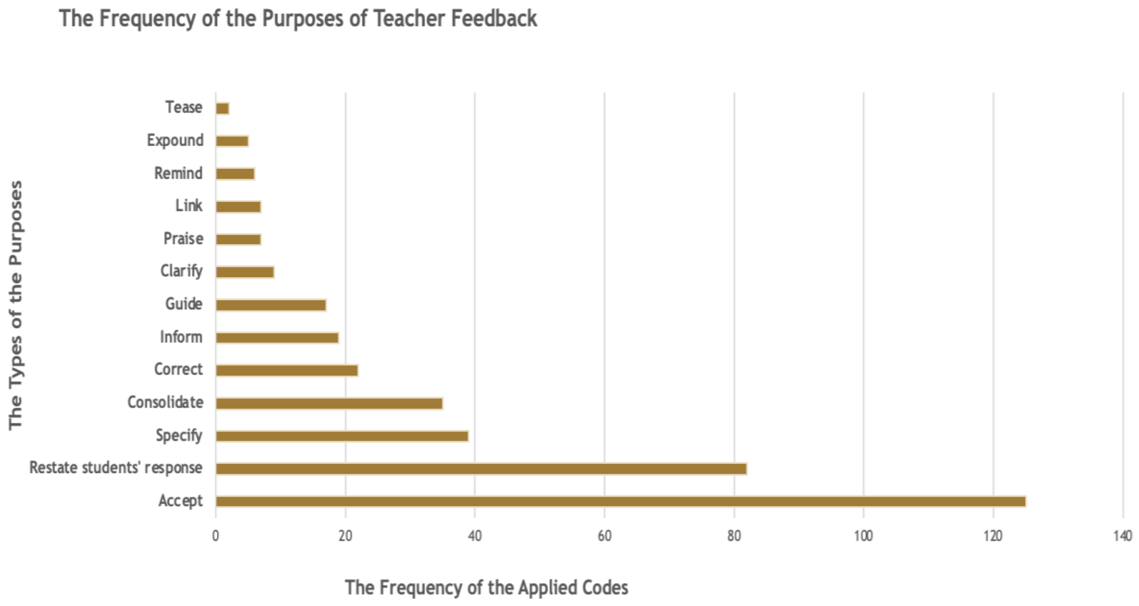

Figure 4. The Purposes of the Teacher's Feedback to Students' Responses

The purposes of the teacher's questions and their effects on students' subsequent responses varied across different dialogue patterns. In recitation, Evan predominantly asked questions to remind students about previously covered concepts and assess the scientific accuracy of their responses. An example of recitation dialogue from a review session on autosomal and sex chromosomes in the genetics unit is provided in the Appendix B. This dialogue represents a narrow range of purposes and cognitive functions. Evan fine-tuned and repeated questions until he received a correct response, leading to a new code, re-initiation (RI).

In contrast to the recitation dialogue, the guided discussion featured Evan primarily asking questions to elicit students' understanding or probe their thinking. These questions engaged higher-level thinking, as reflected in the students' responses. An example of a guided discussion dialogue is shown in the Appendix C. In this dialogue, Evan aimed to stimulate students' understanding of adaptation, which promoted higher cognitive skills such as hypothesis generation.

Significant Factors Influencing the Teacher's Instruction of Evolution and Human Genetics

Evan's Understanding of the Nature of Science

Our data analysis primarily focused on aspects highly relevant to evolution, including the tentative nature of science, the distinction between theory and law, and the importance of inferences in science. Evan's responses on the VNOS-B questionnaire, alongside his verbal explanations in interviews and teacher debriefings, demonstrated an informed understanding of these elements. Some may argue that “evolution is just a theory,” reflecting a common misconception about the value and significance of a theory in science. Evan displayed an informed understanding of theory and law in his responses to the questionnaire and the interview.

> "*A scientific theory explains a wide range of phenomena repeatedly tested and applied to a broad range of situations." An example is the theory of natural selection, which applies on a cellular level, such as in studies of antibiotic resistance and observing a population of elephants. A scientific law is different from a theory. Laws can typically be expressed mathematically and applied to quantifiable observations. Examples would include the laws of thermodynamics or Ohm’s law (VNOS*-B questionnaire).

His discussion in the second interview also supports his understanding of the concepts of theory and law. Additionally, he emphasized that the theory of evolution was very well-supported in science, as shown in the following excerpt from this interview.

> "*A scientific theory explains why a natural phenomenon that's been observed happens." If it's achieved theory status, such as the Theory of Evolution, it's been supported by many experiments over time. "Evolution is a perfect example of a scientific theory, and that's one where if people don't understand evolution or the nature of science, they'd say it's just a theory*" (second interview).

> "*If I'm going to talk about evolution, I discuss it from a scientific viewpoint; as far as I'm concerned, evolution is a fact." I have promised my students that if they experimentally disprove the theory of evolution, they will win a Nobel prize because it will be a massive event in the history of science*" (second interview).

Evan also stressed that people's rejection of evolution stems from a need for more understanding of the nature of science and its workings rather than their ability to support their views with evidence. The excerpt below illustrates his argument on this issue.

> “*People should understand the nature of science well enough to understand evolution. When people believe that evolution isn't real or that climate change doesn't exist, it's not because they have excellent knowledge and evidence to back up why they think those things aren't real. Typically, it's that they don't understand how science works. They don't understand or are unwilling to realize that this theory has been supported by thousands of experiments*” (second interview).

Evan’s Acceptance of Evolution

The GAENE 2.0 results revealed that Evan strongly agreed with 13 statements and agreed with the remaining statement, resulting in a score of 69. This score is just one point below the maximum, placing him at the top of the acceptance of evolution scale. In the final interview, Evan expressed his readiness to defend the validity of evolution in any public or personal situation. However, he was not inclined to engage with views he considered unscientific:

> *"Researcher: Would you so easily use the word evolution outside of the classroom?*
> *Evan: I do!*
> *Researcher: In a public forum?*
> *Evan: Yes,... We had a little gathering there, and people asked, "What do you do? I said that I teach biology in high school. I used the word "evolution," and it caught me completely off guard that this gentleman I was speaking with had some wacky ideas about it. "He did not think evolution occurred the way science said it did" (Third interview).*

Evan's Understanding of Evolution

Evan demonstrated a sound understanding of evolution. On the 21-item evolution understanding test, Evan provided 18 correct and three incorrect responses. Based on our observations of his teaching throughout the evolution unit, his wrong answers may result from careless reading as he covered the concepts in the test during his instruction. For instance, in response to a question asking what best represents Lamarck's ideas on the evolutionary process (question #19), Evan chose "survival of the fittest" instead of the correct answer, "inheritance of acquired characteristics." However, he explained Lamarck's notion of inheriting acquired characteristics in his lessons using examples. In one class, he used a PowerPoint slide featuring giraffes to illustrate Lamarck's belief that their long necks evolved because they stretched to reach leaves and then passed this trait on to their offspring.

Other Contextual Factors

During interviews and debriefing meetings, Evan mentioned that the community in which the students lived influenced their interest in learning science and their critical thinking skills. These factors also shaped his instructions. He estimated that about 15-20% of his students had parents who rejected science, a sentiment reflected in broader county views, and these parents' conservative beliefs could hinder their children's appreciation of science. According to Evan, these students tended to believe that science was filled with myths, and it was nearly impossible to convince them of the validity of any scientific issue. In the second interview, he cited the example of a former student who was greatly influenced by his grandfather's ideas: "I'll never forget a student I had last year in my aerospace class. He told me, 'My grandfather said never to trust doctors or scientists" (first interview).

> *"As a rural county in the United States, we are very homogeneous, particularly regarding race. These kids lack experience with people from cultures different from their own. For instance, I live in B…, and one of the things I love about residing here is that my children and I can interact with people from all over the world. We value that greatly. Despite being only thirty minutes from B…, it feels like an entirely different world"* (first interview).

> *"Their general outlook on science and education might be influenced by their parents. So, if their parents tell them, 'What you're studying isn't worth anything,' or something similar, then it doesn't matter whether*

> *it's evolution, genetics, or any other topic; they're likely to engage less if they receive such a message"* (third interview).

Discussion

The sociolinguistic approach considers language and context as related phenomena mutually influencing each other. As such, teacher interactions hinge on the classroom context, student responses, and subject matter (Carlsen, 1991). In this study, we analyzed the types and frequencies of classroom discourse patterns utilized by a biology teacher, Evan, during the evolution and human genetics units. In addition, we scrutinized the individual utterances of Evan and his students, including teacher questions, student responses, and teacher feedback, to gain deeper insights into the scientific discourse's dynamics in the classroom during these controversial topics. We also considered other contextual factors that might influence classroom discourse, including Evan's views on the nature of science, his acceptance and understanding of evolution, and his reflections on the students and school environment.

Previous studies have established a correlation between understanding and acceptance of evolution (Deniz & Donnelly, 2011; Glaze et al., 2015; Rutledge & Warden, 2000). In this context, Evan demonstrated a robust acceptance and a comprehensive understanding of evolution. Prior research indicates that teachers who do not accept evolution are less likely to teach it (Aguillard, 1999). Contrarily, Evan dedicated nearly two months to the evolution topic, illustrating that he considered this subject as crucial as any other science topic.

Evan demonstrated an informed understanding of all aspects of the Nature of Science (NOS), a factor previously found to indicate acceptance of evolution (e.g., Glaze et al., 2015). The limited understanding of evolution among many teachers is often due to their need for more knowledge regarding the nature of science (Rutledge & Mitchell, 2002), particularly the significance of theories within the scientific realm (BouJaoude et al., 2011). This deficiency can reduce their appreciation of this fundamental scientific concept. However, Evan exhibited a comprehensive understanding of the NOS, including the characteristics of theories and laws in science.

Previous research has indicated that teachers often require assistance to engage students in open discussions about controversial topics. This may be due to discomfort acknowledging student ideas during conversations or a reluctance to spark controversy around the subject matter (Lennon, 2017; Owens et al., 2021). However, our findings showed that Evan did not shy away from discussing the concepts of evolution and did not express concern over potential student disapproval. The primary challenge he identified in his instruction was related to his students' backgrounds. Many came from families that did not value science or higher education highly, often due to religious beliefs or a lack of exposure to diverse perspectives.

Evan dedicated more time to teaching evolution than the human genetics unit. Additionally, he involved students in hands-on activities more frequently during the evolution unit. According to Evan, some biological concepts, such as natural selection, lend themselves better to hands-on activities than others, like human genetics, which he stated require expensive equipment. Evan utilized student-centered discourse patterns more frequently in the evolution unit than in the human genetics unit. For instance, he occasionally incorporated small group work, peer collaboration, and guided discussions exclusively in the evolution unit. However, recitation (IRE) was the most frequently used discourse pattern in Evan's classroom. This finding aligns with numerous studies demonstrating that this three-part discourse structure, which is both interactive yet authoritative, is widespread in many science classrooms. (Chin, 2006; Chin, 2007; Lemke, 1990; Hiltunen et al., 2021; Kranzfelder et al., 2020).

An emergent discourse type that Evan frequently used was the additive recitation series, which he used to review students' knowledge of previously covered topics. Examining the length of these conversations might give the impression that Evan had rich interactions with students. However, he often concluded one recitation with an evaluation and swiftly transitioned to another. Based on this finding, it is reasonable to infer that extended dialogues, including multiple teacher questions and student responses, do not equate to meaningful discussion. Furthermore, there was no substantial difference between the units regarding Evan's questioning style, which suggests two points for discussion, one positive and one negative. On the positive side, Evan's perspective and teaching approach remained consistent, whether he was instructing on evolution, a more sensitive subject, or human genetics. On the negative side, his strong understanding and acceptance of evolution did not enhance his science classroom discourse.

Evan predominantly asked questions to assess their correctness and to direct students to recall and reproduce previously learned information. It also aligns with arguments in the existing literature that recitations mainly include "test" questions, which involve minimal active student participation (Lemke, 1990; van Zee et al., 2001). Evan's follow-up responses also significantly influenced subsequent student responses. As assessing correctness was the primary purpose of many of Evan's questions, his follow-ups were largely contingent on the correctness of the answer. Evan most frequently accepted correct responses and then asked another question. Although his follow-up strategies varied depending on the accuracy of students' responses, his primary aim was to guide students toward a specific answer. In response to incorrect student responses, he frequently clarified or consolidated the main points in the discussion, then restated the same or similar questions. He often repeated the same or a rephrased question until he received a correct response. This finding aligns with Carlsen's (1991) observation that a teacher's next question may maintain the same content as the question to which a student has provided an incorrect response.

The objectives of assessing correctness and reviewing factual knowledge in most of Evan's questions led to students predominantly recalling information across both the human genetics and evolution units. As mentioned in Chin's work, students seldom used higher-order cognitive skills such as observing, sorting, classifying, and theorizing. These skills were not observed in this study, mirroring the nature of Evan's questions, which did not necessitate using such skills (Chin, 2006).

Conclusions

This study presents a broad picture of a biology teacher's classroom discourse, teacher's and students' interactions in evolution and human genetics units, and some contextual factors that we believed would shape evolution instruction. The study will add to the previous literature as examined science classroom discourse and interaction in teaching evolution compared to other controversial issues.

This study demonstrates that even a teacher with a strong acceptance and informed understanding of evolution may still predominantly utilize teacher-led discourse patterns and pose questions that primarily solicit factual knowledge. Although this study was conducted with just one teacher, a solid understanding of a subject only automatically translates to employing practical discourse in science classrooms. Therefore, the results of our study, along with those of previous studies, indicate the necessity of professional development opportunities for biology teachers. These opportunities should support them in planning to use more productive discourse patterns in their classrooms (Kranzfelder et al., 2020). Because it is vital to acknowledge the complexity of accepting and understanding evolution to foster meaningful dialogue and education, instruction on evolution should approach the topic sensitively. By acknowledging and respecting individuals' diverse perspectives and experiences, educators can help promote a more nuanced understanding of evolution (Glaze & Goldston, 2015).

While this study may offer valuable contributions to existing literature, it has certain limitations. One key drawback of case studies is their limited generalizability, as the findings cannot readily be extrapolated to broader populations (Bloor & Wood, 2006). With only one teacher in this study, the results are not easily generalized to other high school science teachers or classroom environments (Merriam, 2009). Evan's discourse patterns also remained broadly consistent when teaching two contentious units. Observing his teaching methods and discourse patterns across other units might have provided a broader comparison point, allowing for an analysis of potential changes in his dialogues and classroom interactions across different topics.

Notes

This study has been developed based on the doctoral dissertation of the first author.

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Appendix A. Examples for the Purposes of Evan's Questions

Purpose	Examples
Assess correctness	What do we mean by heritable traits?
Check	Okay guys, did you decide on the other side which features you wanted?
Remind	How many chromosomes do we say that remember?
Elicit	How many generations do you think it takes to get your ideal breed of dog?
Fine tune and Restate the question	Q.1. When do you see DNA condensed into chromosomes? (No answer from students) Q.2. Every one of your cells does, come on guys. Think about the cell cycle. What point in the cell cycle our DNA is condensed into chromosomes?
Specify	What is one thing just one thing (specifying one thing here) that is absolutely common to everything that is alive?
Probe	There is a fifty-fifty chance (repeating student's response here). What does that mean R. (calling a student's name) that is fifty-fifty?
Clarify	But 10 times, right? (in response to the student's wrong calculation). So, how many total?
Attention-drive	Is anybody color blind here?
Link	How is that (referring to using coins here) like passing traits on from parents to offspring?
Challenge	If we add the white balls do you think you catch more or less likely color balls?

Appendix B. Sample Excerpt from a Recitation Dialogue

Speaker	Utterance	Move	Purpose of Utterance	Cognitive Process
Teacher	What is the process of cell division that produces gametes? What do we call that?	I	Assess Correctness Remind	
Student 1	Meiosis	R	Reply	Recall
Teacher	Meiosis. How many chromosomes do human gametes have?	E, F, I	Accept Restate Student's Response Assess Correctness Remind	
Students	Three, no two!	R	Reply	Recall Guess
Teacher	Human gametes? How many chromosomes we have got in human gametes?	E, RI	Fine tune Restate the question Assess correctness	
Students	Four, 46, 23	R	Reply	Recall Guess
Teacher	23 yes. Why are there 23? So, the rest of your body cells, every cell is not a gamete has 46. Why do gametes have only 23?	E, F, I	Accept Restate Student's Response Elicit Assess correctness	
Student 3	Because we get 23 from each parent	R	Reply Justify	Recall Explain
Teacher	Yes!	E	Accept	

Note: I, initiate; RI, reinitiate; R, response; E, evaluate; F, follow-up.

Appendix C. Sample Excerpt from a Guided Discussion Dialogue

Speaker	Utterance	Move	Purpose of Utterance	Cognitive Process
Teacher	If you are in the water and have flippers, Why might that be an adaptation?	I	Elicit	
Student 1	Swim faster	R	Reply	Hypothesize Recall
Teacher	Yeah, you might swim faster, more fitness... Do adaptations like that, like flippers, happen overnight?	E, F, I	Accept Restate Student's Response Remind Elicit	
Students	No!	R	Reply	Evaluate
Teacher	Probably not. Let's pick an organism swimming with flippers. Students: seal;... Teacher: Let's say you are a mammal like a seal…most of the organisms in the population have typical hands, and one was born with a weird mutation that led to the webbing between toes. That seal swims 50% faster than the rest of the other seals. Why does seal fitness increase by being able to swim faster than the rest of the seals?	F, I	Accept Inform Probe	
Student 2	Catch more food	R	Reply	Hypothesize Recall
Teacher	It's going to catch more food. If you can catch a significant amount of food, what is likely to happen? I know that in many seals, males are very territorial to fight out other seals to	F, I	Accept Restate Student's Response Probe	

Speaker	Utterance	Move	Purpose of Utterance	Cognitive Process
	mate. So, if you are the seal that was able to catch 25 or 30% more food than the other seals, what does that mean when fighting in your territory?			
Student 2	You are gonna win	R	Reply	Hypothesize
Teacher	You are more likely to win. You have more energy and grow bigger. So, that seal is more likely to pass on this trait. Then your offspring will have that advantage, and the entire population you can see that trait can spread to the population. Does that make sense?	E, F	Accept Restate Student's Response Consolidate Check	

Note: I, initiate; RI, reinitiate; R, response; E, evaluate; F, follow-up.