

Discourse as a Generator of Epistemic Relativism in Scientific Argumentation

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Abstract: This study is aimed at identifying the efficacy of social factors in the ways that first-year science students attempt to argue. Argumentation is an essential tool used to produce scientific knowledge. As a linguistic phenomenon, argumentative communication draws on institutional, disciplinary, and agential cultures. Proficiency in argumentation practices is a prerequisite for learning advancement in universities. However, not all first-year university entrants are familiar with principles that guide how senior scholars argue to generate and contest knowledge. In South Africa, a significant proportion of first-year students emerge from social domains in which the structural, agential, and cultural features do not mirror those of universities, which are elite centers of knowledge production. The results of this study indicate that while students from similar geographical and class origins were enabled and constrained in drawing on similar structures, cultures and agency while arguing on campus, all of them did so in distinct ways. The study concludes by highlighting the efficacy of social structures, culture, and agency in how first-year students initially attempt to engage in written and verbal argumentation in the academic year. It also recommends designing curricula that integrate professionals' and students' multiple Discourses to accommodate their varying levels of preparedness for on-campus argumentation.

Keywords: Argumentation, Discourse, Families, Communities, Schools, Agents, Academic Literacy

Introduction

Academic argumentation is an essential discursive tool that novice and senior scholars must apply to advance higher learning institutions. Argumentation is ubiquitous in all disciplines of study, including the natural sciences. Scholarly argumentation differs from nonacademic disputes. This point is vital because not all first-year students in South Africa emerge from social or educational contexts where rhetorical and dialectical practices mirror those of senior scientists and scholars in universities. Disarticulation between students' pre-university orientations to knowledge development and argumentation presents threats to their academic well-being and success. To succeed, students must know the epistemic and argumentation strategies applied to learn and demonstrate mastery of their course content. Indeed, each year, South Africa loses roughly 25,000 of all its first-year students who are unable to complete the academic year (Young 2016). Van Eemeren et al. (2014, 4) articulate the contrast between academic argumentation and nonacademic disputes as follows: “[Academic] argumentation [has] nothing to do with quarrelling, skirmishing, squabbling, bickering, wrangling, haggling, or any other negatively charged verbal activity.” Rather, argumentation, which has developed into its own theory, is governed by principles that shape how interlocutors² manage disagreement in writing and speech (Van Eemeren 2017). Argumentation practices in universities are subsumable in the broad paradigms of rhetoric and dialect (Driver, Newton, and Osborne 2000; Hemberger et al. 2017; Kuhn, Hemberger, and Khait 2015). Scholarly argumentation is rhetorical due to the involvement of public interactions. Academics primarily disseminate new knowledge in conferences, journals, online and physical learning spaces, and media outlets. Pedagogically, rhetorical argumentation is ubiquitous in university lecture halls and labs through discursive interactions. Driver, Newton, and Osborne (2000, 308) stress the significance of rhetorical activities in learning by declaring that “[s]tudents need to develop an awareness of the nature and structure of arguments, but their performance is...enhanced if they...monitor their involvement in group activities.” Group learning, which academic conferences are examples of, enables rhetorical argumentation and interactions. Scholarly argumentation is dialectic in character owing to the function of dialogue in advancing written and verbal warrants (Rapanta 2019; Kuhn et al. 2019; Crowell and Kuhn 2014). Rapanta

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² Interlocutors are individuals who engage in written and verbal argumentation.

(2019, 3) claims that “dialogic practice...promote[s] criticality [in] classroom interaction.” In Hemberger et al. (2017), this claim is supported in their exposition of how the very practice of warranting data fosters interactive dialogue between interlocutors. The relevance of dialectical and rhetorical modes of arguing to academic argumentation is the interplay of shared principles between the three paradigms that senior scholars apply to produce knowledge. As related to this analysis, not all first-year, natural students emerge from sociocultural communities where dialectical and rhetorical principles that are active in academic departments manifest through the same modes of communication (Eybers and Paulet 2021). For example, in Africa, dance, dramatic enactment, and poetry are at the center of scientific epistemic systems. Be that as it may, in contemporary South African science faculties, these epistemic practices feature at the margins of it all. Given the epistemic disjuncture between some students’ pre-university Discourses and on-campus dialectical and rhetorical practices, the aim of the current analysis is to highlight how novice scientists emerge from diverse epistemic cultures that induce congruent and incongruent approaches to academic argumentation in universities.

This study is concerned with the preparedness of South African based first-year science students to apply rhetorical and dialectical moves in their attempts to participate in and understand academic argumentation. Braund et al. (2013, 176) confirm that novice scholars “enter science classrooms with argumentation frameworks already in place, yet...struggle with tasks that require them to propose, support, critique, and refine specific ideas.” The tasks that Braund et al. (2013) designate constitute argumentative moves that are embedded in new secondary discourses that students must master. To reiterate, secondary discourses are professional, often institutionalized methods of arguing that humans acquire as they progress toward their latter phases of adolescence (Gee 2008). In the natural sciences, discursive moves involve “tak[ing] a critical stance” (Wollman-Bonilla 2000, 37) in an argument. Argumentative moves occur when two or more interlocutors engage in dialect (McBurney, Hitchcock, and Parsons 2007). In argumentation theory, the negotiation of rules, precedents, and principles for how interlocutors reason their claims constitute informal logic. Informal logic, which Van Eemeren (2001, 37) labels “procedural logic,” stipulates acceptable and unacceptable moves for advancing claims and counterarguments. As novice members of the academy, not all first-year students in South Africa know about informal logic that guides how senior agents reason and argue. Without this knowledge and the capacity to apply academic literacy skills that convey argumentative reasoning, students’ academic well-being is at risk. As it currently stands, and on an annual basis, South Africa loses roughly 25,000 first-year university students who drop out of the system or do not successfully complete the academic year (Otu and Mkhize 2018). This study’s concerns revolve around many first-year students’ incapacity to effectively apply rhetorical and dialectical principles that shape on-campus argumentation interactions to succeed academically. The purpose of emphasizing South Africa’s first-year attrition rate relates to this analysis’s objective of presenting awareness of rhetorical and dialectical principles in higher education as an essential component of academic success at the first-year level.

In South Africa, numerous studies analyze intersections between students’ Discourses and epistemic orientations with their studies. For example, Bangeni and Kapp (2005, 2020) detail the challenges that students who speak English as an additional language face while navigating universities as new social environments with peculiar knowledge systems. Their studies show students’ conceptions of belonging and home change as they attempt to master new literacy practices essential for written and verbal argumentation in higher education. However, these analyses present general concerns about students’ challenges across disciplines in adapting and modifying their Discourses to general uses of academic literacy. The current study is specifically concerned with how natural science students’ pre-university Discourses shape their rhetorical and dialectical orientations toward verbal and written knowledge generation and argumentation in the university. According to the researchers’ investigations, there are no recent studies with these foci in South Africa. Previous South African inquiries on students’

argumentation center on *teachers'* cultural Discourses and not those of learners (Braund et al. 2007). Braund et al. (2007) agree that teachers' cultural orientations to scientific argumentation determine the extent to which their pedagogic methods enable or constrain students in incorporating their epistemic orientations to knowledge in the classroom. Unlike the current study, the Braund et al. (2007) analysis was based among secondary school teachers and not among first-year higher university students. Therefore, this study's contribution to the field of scientific argumentation is its emphasis on first-year South African natural science students' pre-university Discourses and their impact on students' argumentative development.

Situating the Study

This study is situated in the BSc Extended Programme at the University of Pretoria. The Mamelodi campus is located in a working-class township that is ravaged by unemployment, crime, and poverty. Some of the participants live in the township, while others are bussed into the area from other communities. The data acquisition period occurred between 2018 and 2019. Extended degrees, known as bridging and foundation programs in other institutions, aim to support academically vulnerable first-years (Ogude et al. 2019; Ogude et al. 2020). This study's contextual context relates to its limitations. This study only considers the experiences of first-year students at the Mamelodi campus of the University of Pretoria. It does not include the experiences of other University of Pretoria campuses or South African universities. In addition, the study is restricted to students enrolled in a natural science faculty and does not consider other disciplines.

Methodology and Population Sample

This study applies a qualitative approach to data acquisition and analysis. It is qualitative because it is language-orientated and is interested in extracting meaning from the participants' declarations; it is also qualitative due to its integration and generation of theory to describe and interpret the participants' experiences (Dey 1993). The researchers conducted individual interviews with two cohorts of students over two years. Interviews were conducted on the Mamelodi campus of the University of Pretoria. The purpose of the interviews was to unearth students' interactions with social structures, culture, and agency that shaped their pre-university rhetorical and dialectical interactions. The average length of the interviews was 20 to 30 minutes. The researchers met with the study's participants in the Mamelodi campus library, the Tutor's office and, in some instances, on the campus lawns. When the students missed appointments, arrangements were made to meet them in their dormitories. All interviews took place in the first semester of the academic year to access students' primary Discourses (Gee 2015) [Please note that the reference "Gee (2015)" is cited in the text but not present in the reference list. Kindly provide complete details or delete the citation from the text.] before they were exposed to rhetorical and dialectical practices in their curricula or by senior scholars. The key research question that the study addresses is: How do first-year science students' pre-university intersections with social structures, culture, and agency shape their attempts to demonstrate competency in academic argumentation that involves verbal and written activities in the university? The study employs rhetorical, dialectic, and discourse theories to enhance its presentation of students' argumentation experiences. Rhetorical and dialectical theories highlight and interpret students' dialogic and public discursive experiences before arriving at the University of Pretoria. The data acquisition instrument consists of individual interviews at the beginning of the 2018 and 2019 academic years. The aim was to access students' primary Discourses with minimal exposure to expert argumentation practices on campus. The study employs an interpretivist paradigm to extract meaning from students' declarations as accessed in narratives from their individual interviews (Alharahsheh and Pius 2020). Interpretivist research values the efficacy of culture and social contexts in shaping argumentation experiences

(Alharahsheh and Pius 2020). In this context, the study highlights how cultural properties that shaped students’ pre-university argumentation Discourses mirror or diverge from the culture of arguing in academic contexts. Fifteen first-year natural science students participated in this study. Four of them are from materially well-resourced families and schools that are in suburban regions in South Africa. Six of them come from rural areas; while the remaining five are from urban metro townships (see Table 1 for participants’ characteristics). Concerning the social construct of “class,” this study adopts the perspective that contemporary society is structured hierarchically with members who own and control the tools of production occupying the upper-tier; in addition, there are societal members who do not own material resources and tools of production who make a living by managing or providing the labor for upper-class members.

Table 1: Participants’ Characteristics

| <i>Name (Alias)</i> | <i>Gender</i> | <i>Cohort Number</i> | <i>Geographical Origin</i> | <i>Class Affiliation</i> |
|---------------------|---------------|----------------------|----------------------------|--------------------------|
| Larry | M | 1 | Suburban | Upper-middle |
| Ink | F | 1 | Suburban | Upper-middle |
| Aldoy | M | 1 | Suburban | Upper-middle |
| Kim | F | 1 | Suburban | Upper-middle |
| Richard | M | 2 | Rural | Upper-middle |
| Mary | F | 2 | Rural | Working |
| Shaka | M | 2 | Rural | Working |
| Sara | F | 2 | Rural | Lower-middle |
| Siyabonga | M | 2 | Rural | Working |
| Katlego | M | 2 | Rural | Working |
| Faith | F | 3 | Urban township | Working |
| Chabi | F | 3 | Urban township | Working |
| Violet | F | 3 | Urban township | Lower-middle |
| Nemo | M | 3 | Urban township | Lower-middle |
| Denel | F | 3 | Urban township | Lower-middle |

Source: Eybers and Kruger-Roux

Discourse and Argumentation Intersections

Argumentation is primarily conveyed through linguistic tools that include academic literacy practices. According to Van Eemeren, Grootendorst, and Kruijer’s (1987) theory, argumentation consists of verbal and social activities. Argumentation is verbal in character because interlocutors often employ language in oral interactions to put forth claims, counterarguments, and critical questions. Van Eemeren, Grootendorst, and Kruijer (1987, 2) emphasize the embeddedness of Discourses (Gee 2008) in argumentation as follows: “The social nature of argumentation is most clearly expressed in discourse [emphasis added] between two or more interlocutors.” The concept of discourse is diversely applied across disciplines. This study adopts Gee’s (2008, 155) sociocultural construct of Discourse with a capital “D.” A Discourse, in Gee’s (2008, 15) theory, is:

[C]omposed of distinctive ways of speaking/listening...with distinctive ways of acting, interacting, valuing, feeling,...thinking, believing, with other people and with various objects, tools, and technologies...to enact specific socially recognizable identities engaged in specific socially recognizable activities.

Gee’s (2008) sociocultural construct of Discourses transcends syntaxial analyses of language use. It is a more holistic approach to understanding academic Discourses due to its recognition of culture and identity as active entities in the ways people speak, write, and communicate. Gee’s theory of Discourse (2008) warrants Van Eemeren, Grootendorst, and Kruijer’s (1987) proposition that argumentation constitutes sets of discursive practices. In

universities, the interplay between faculties, academic departments, and researchers' interests is an example of Discourse activity; culture and identity are dynamic in their activities. Sandoval et al. (2019, 1) reason that "developing productive argumentation in classrooms requires organizing a culture in which the practice is meaningful." The assertion is that novice scientists require cultural initiation into argumentation practices. However, in South Africa, where English is only the fourth most spoken language, and epistemologies affiliated with indigenous knowledge systems are prevalent, there are challenges related to inducting students into higher-level argumentation. In their reflection on student development, Kapp and Bangeni (2020, 81) state, "the activity of straddling boundaries and making meaning from a diversity of positions [by students in universities] is situated agentic work." Their stance is that students' attempts to demonstrate mastery of argumentation in the university are shaped by multiple variables. Nevertheless, students' pre-university social environments are noteworthy. Kapp and Bangeni (2020, 81) alert academic development practitioners to homogenous constructs and "deterministic depictions" that can stunt a comprehensive understanding of students' learning experiences. In other words, analyses of students' argumentation activities should not be generalized according to race, gender, and other sociocultural characteristics. In the presence of such deterministic fallacies, the current analysis acknowledges that logical principles that shape rhetorical, dialectical, and argumentative practices may vary between communities.

Academic Literacy and Argumentation Intersections

When argumentation in universities is approached as sets of discursive activities, it is reasonable to designate academic literacy practices as the actual tools that interlocutors apply to generate knowledge. Academic literacy includes, but is not restricted to, reading, writing and critical thinking (Guzmán-Simón and García-Jiménez 2015; von Fintel and Eybers 2020). Guzmán-Simón and García-Jiménez (2015) embed argumentation in their construct of academic literacy practices. This is because, in Van Aalst's (2009) view, discourses, which are communicated through academic literacy practices, fulfill three vital argumentative functions: "knowledge-sharing, knowledge-constructing and knowledge-creating" (Van Aalst 2009, 9). Knowledge sharing in universities is primarily a linguistic enterprise. Argumentative moves are communicated by way of verbal dialectic and through scholars' writing. In Lea and Street's (1998) academic literacies model, discursive argumentation is construable as an epistemic practice. This is because students are required to adjust their pre-university modes of applying literacy practices, including verbal and written strategies, by using methods that were predetermined as acceptable by senior scholars (Lea and Street 1998). It is evident that academic argumentation, including writing, is embedded in on-campus power relationships and disciplinary traditions. In a social realist framework (see Figure 1), the current study highlights how students' attempts to adapt and modify their pre-university modes of applying discourses in the university may analogically be traced to the activities and powers of social structures, culture, and agency. In this analysis, significant social structures that surfaced in students' narratives in the pre-university Discourses are families, communities, and schools (Shanahan 2009). Efficacious agents in students' argumentation are family members, teachers, and peers (Arnold and Clarke 2013; Martin, Rajala, and Kumpulainen 2016). Cultures that surfaced include those of the participants' homes, their local communities, and schools.

Primary Discourse Efficacy in Argumentation

Gee's (2008) construct of primary discourses is essential for approaching the objectives of this analysis. The established goals were to determine the influence of first-year students' families, communities, and schools in their attempts to master secondary discourses that require argumentation. To reiterate, Gee's (2008) framing of discursive practices goes beyond a view of

them as mechanistic verbal and written tools. Instead, “Discourse” (Gee 2008, 157) that involves language utility is approached as embodiments of interlocutors’ identities in argumentation. In the context of this analysis, identities refer to the ethnic, national, and geographic characteristics of the participants (Martiny et al. 2016; Carbone and Orellana 2010). The theoretical implication is that the identities that students embody are contributing variables to epistemic relativism that is experienced in the lecture hall through the ways they argue.

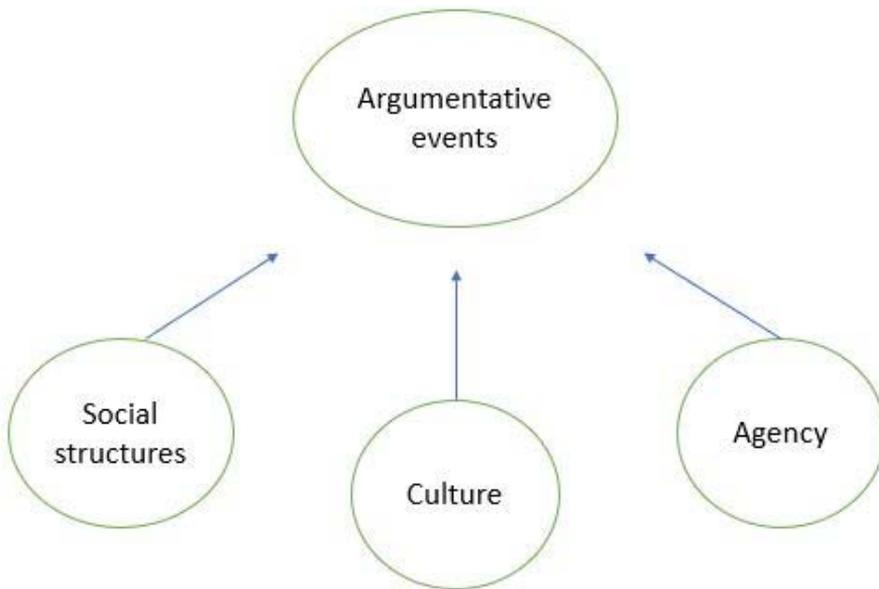


Figure 1: Realist Argumentative Ontology Based on Archer’s (1995) Morphogenic Theory
 Source: Eybers and Kruger-Roux

Archer’s Morphogenic Explanatory Framework

From an academic development perspective, Kapp and Bangeni (2020, 82) advocate an explanatory approach to students’ learning that acknowledges the “complex and contradictory ways in which [they] engage with...*discursively* [emphasis added] available resources.” Explanatory frameworks should aid researchers in guarding against deterministic and essentialist reasoning (Kapp and Bangeni 2020). The current study avoids determinism by employing Archer’s (1995) morphogenic theory to observe and interpret students’ argumentation experiences. By incorporating Willmott’s (1999) conceptual tool of “analytical dualism,” the morphogenic theory enables social scientists to distinguish between the properties and activities of structures, culture, and agency in argumentation events (see Figure 1). Such differentiation negates analytical conflation where structural, agential, and cultural domains are approached as a single ontological entity that shapes how students argue (Willmott 1999; Archer 1995). In avoiding analytical conflation, dualist logic reduces “homogenized and reified” representations of students’ experiences that “separate identity from...processes of learning” (Kapp and Bangeni 2020, 81). Analytical dualism is vital for critical explanations that aim to accentuate the efficacy of students’ cultural diversities in argumentation. For example, Archer (1995) asserts that while social structures, culture, and agency function in interplay with each other, they possess unique powers and tendencies that shape actual human experiences. The current study employs analytical dualism to aid its presentation of unique and diverging configurations of social structures, culture, and agency in students’ experiences of engaging in

discursive and rhetorical argumentation in their pre-university Discourses. When students' argumentative strategies are approached as a "Discourse" (Gee 2008), that is, as ways of being through language use, the morphogenic approach enables researchers to highlight their "epistemic relativism" (2020, 136). Theoretically, epistemic relativism is the inverse of analytical conflation and essentialism. Its analytical purpose is to expose the significantly individualized ways that students approach arguing. According to Rangel and Keller (2011), adverse outcomes of essentialist reasoning are stereotypes and systemic justification [Should this read "are stereotypes of systemic justification"?]. Due to the existence of these social ills among humans, it is necessary to be conscious of them and minimize their effects in scholarly investigations. The linkage between the theory of epistemic relativism, the title of this study and its data acquisition methods is the authors' aim of highlighting how first-year students' origins from diverse pre-university domains generate pluralism in their approaches to academic argumentation.

Presentation of Data

To reiterate, the participants of this analysis were divided according to their geographical origins and class affiliations (see Table 1). The students of *Cohort 1* are from upper-middle-class homes in suburban South African locales. The students of *Cohort 2*, which is predominantly working-class, are from rural areas. In this cohort, Richard is the only participant who is from an upper-middle-class family. *Cohort 3* participants come from urban townships and are from lower-middle-class or working-class families.

Cohort 1—Families and Communities

Families and communities perform significant functions in the development of individuals' primary discourses. Makalela (2018, 825) reasons that languages embody "value systems and cultures." Language is the vehicle, in Makalela's (2018) perspective, in which cultural identities are conveyed. In the context of academic discourse acculturation, Mays (2008, 415) claims that "for many [English language learners], the Discourse spoken within their family unit and community (primary Discourse) varies greatly from those that dominate [public] curriculums." She reasons that by applying Gee's (2001) theory diverse social collectives combine words, actions, values, and bodies into broader epistemic systems. This study aimed to call attention to the social variables, which shaped students' primary discourses, including their families, communities, and schools, as they navigated the new argumentative environment of the University of Pretoria.

One of the distinguishing features of the participants in Cohort 1 is that they grew up with two parents. All their parents, except for Ink, are also members of industries directly or indirectly related to biological and natural science—their professions or manner of livelihood mirror their children's ambitions to become future scientists. For example, Larry wants to study medicine and become a doctor like his father. He highlights the culture of medicine and higher education in his home as follows: "My dad is a doctor and he's the only one that works. My mom has an Honors in psychology, but she didn't decide to continue working as a teacher when my brother and I were born." While Aldoy is not sure about the career path he intends to pursue, he mentions that his father is also involved in scientific discourses and entrepreneurialism. When asked about the nature of his father's business, Aldoy reveals that his father is "very much in solar energy [and] business [with] borehole pumps." Currently, Aldoy and Larry's mothers remain at home to support their children with their studies. Kim, whose mother also stays home to care for her, is pursuing a career that resembles her father's vocation; he buys and sells gym equipment. She describes his influence by stating: "Since I took Grade 9, I've been interested in physiotherapy. And obviously my dad's in the health and fitness

industry.” Ink is the only participant in this cohort who does not attribute influences from her home and family members to her passion for science.

Of note, neither of her parents are members of science-related industries. Ink attributes her scientific passions to a desire to address rampant crime in her local community. She expresses this aim as follows: “I live in Kempton Park and...there is a lot of crime. So, in that aspect...my community has influenced me to pursue a career where I can serve criminal justice.” While Larry, Aldoy, and Kim emphasized and drew on the cultural and agential resources in the structures of their families, Ink drew on variables outside the home. Threats against the security of her community that are caused by crime shape Ink’s motivation to pursue science. Therefore, it is plausible to infer that the agency of criminals in her community and their culture of crime are efficacious variables in her orientation to science. The significance of crime as a productive social variable in Ink’s pre-university Discourse is that instead of constraining her motivation to pursue scientific inquiry, it strengthened and enabled it.

Cohort 2—Families and Communities

The pre-university Discourse experiences of participants in this cohort vary significantly from their peers in Cohort 1. Two of the most sharply defined contrasts between the cohorts are the discursive capacities of the participants’ families and local communities. The participants of Cohort 2, in addition to working under the same Grade 12 curriculum as Cohort 1, experienced material under-resourcefulness and community dysfunctionality as part of their primary discourses. When asked to describe his upbringing, Katlego details his experiences of poverty as follows:

I grew up in a poor family. So, it was very difficult growing up. We had to figure everything for ourselves. So, we didn’t have water. We had to fetch water somewhere, which was far from [our] place. At the other side I was supposed to be study for my matric, so it was difficult.

In addition to experiencing material constraints, Katlego’s family members could not participate in the scientific discourses he had to learn in school. He states: “My mom was the breadwinner since my dad lost his job while I was in Grade 12. She is a domestic worker.” Katlego’s mother was away from home most of the time, and his father did not help him with science studies. Like Katlego, Siyabonga narrates pre-university agential and structural constraints in his scientific development, specifically as related to his home. Siyabonga does not live with his father. He describes his access to and the financial disposition of his home as follows:

My father is in Gauteng (a separate South African province) working in [a] firm. And my mother, she is volunteering in a kindergarten. She doesn’t have a complete payslip. They just thank them at the end of the month.

Being physically separated from his father and as a result of his mother’s nonexposure to expert scientific discourses, Siyabonga could not draw on their agency and the structure of his home to meaningfully advance his argumentation. Like Siyabonga’s experience, Katlego’s epistemic access to scientific Discourses and agency in his family, diverging from participants’ experiences in Cohort 1, was constrained. The remainder of the participants in this cohort report similar agential, cultural, and structural constraints. Sara’s parents sent her to a private school due to the dysfunctional character of her local community. They wanted to remove her from the teenage pregnancy and alcoholism that is rife in their community. Mary’s narrative reflects Sara’s. She says, “The kids at my age—many teenagers [are] getting pregnant. Some of them drink alcohol at a young age.” Shaka also reports a social environment crippled by substance abuse, which he describes as being “full of taverns.” Richard’s case is unique. His parents are

successful farmers who export macadamia nuts internationally. His primary Discourse is characterized by material abundance and immersion in scientific activities embedded in the structures of his family's farm. He declares that his "farming community...actually brought [his] interest to plants." Richard reveals that his objective is to gain knowledge while at university to prepare him to take over his parents' farm.

Cohort 3—Families and Communities

Participants of Cohort 3 are urban and township-emergent first-years. Townships were created by the apartheid government in South Africa to geographically separate Africans from mainstream educational and economic centers (Trotter 2009). Participants of this cohort share characteristics with Cohorts 1 and 2 relating to their families and communities. Denel and Violet's parents have degrees in science and have either worked or continue to work in industries affiliated with scientific disciplines. For example, Violet's mother is a nurse, and her father is a paramedic. Denel's mother attained a master's degree in the United States. In contrast, Chabi's mother is a domestic worker who lives apart from her daughter in Johannesburg for most of the month. Chabi's grandmother raised her. Faith grew up in a small village on the outskirts of a township. When asked to describe her upbringing, Faith reflects that she grew up "the hard way." After being asked to elaborate on her experiences, Faith reflects: "I was raised by a single mom. I lost my father at the age of seven. So, my mother had to raise six kids including me. So, it was hard for her to do everything on her own." Faith's mother is a street vendor and did not have access to expert secondary discourses to assist her studies in science. Noticeably, Nemo does not attribute any efficacy to his parents' agency in the emergence of his scientific orientation and Discourse. Instead, and like Ink of Cohort 1, Nemo's concerns regarding the lack of scientific knowledge in his community motivate his attempts to succeed in science.

Cohort 1—Agency and Schools

Schools (social structures), parents, and teachers (agents) play a significant role in the formation of students' secondary Discourses (Gee 2008). When secondary Discourses are viewed as "professional" modes of being and applying language, then the roles of schools and teachers in exposing students to "specialized knowledge, skills, attitudes, norms and interests" (Irimiea 2017, 117) [Please note that the reference "Irimiea (2017)" is cited in the text but not present in the reference list. Kindly provide complete details or delete the citation from the text.] is undeniable. Soysal and Yılmaz-Tüzün (2018, 1) reason that "teacher discursive moves" model how students argue dialogically. Examples of teacher discursive moves include "knowledge providing-evaluating, communicating...and evaluating-judging-critiquing." Each of these critical functions is integral to argumentation's aim of knowledge generation and contestation. Parental and peer *agency* emerged as equally efficacious variables in students' approaches to scientific argumentation as their teachers. Students oscillated between drawing on off- and on-campus agential resources in varying degrees and ways in the current study.

All participants of Cohort 1 attended private schools in South Africa, except for Aldoy, who was home-schooled by his mother since Grade 4. Their schools possessed the human and physical resources necessary for effective learning in science. Larry's parents moved him and his brother three times before they settled at a school of appropriate quality. He discloses that his final secondary school had science labs where experimentation was conducted. Larry believes his school could produce future scientists because "the amount of work...was a little more because we did a Cambridge system. There wasn't much time for sports." Kim describes the value her school placed on science through the example of its hosting science expos. She says, "You could think of whatever or research an experiment that you want to do." In relation to her school's material resourcefulness, Kim states:

They had a library, also, with lots of books—a couple of computer labs. I think, like, two or three. Quite a few. And also, all the science classrooms were labs. Proper laboratories with...burners and everything. And sports facilities, also very good.

Aldoy describes his secondary school as being influential in his passion for science. When asked if his school played a role in his decision to pursue science at the University of Pretoria, Aldoy states:

Yes, very much so. At the high school, we had experiments and things. We had lecturers who had [ingrained] in us, making sure we had the right measurements, making sure we understand the work. Even when I did badly in a test, the teacher would have to call my mom to come in, and we had to have a meeting with her asking what's wrong. That happened in my last year at school.

As previously indicated, Ink does not attribute significant influence from her family in her passion for studying science. However, she identifies her school in this manner. Ink says, "I found a lot of my interests just by reading or seeing programs on TV that had a big influence on my life, as well as my teachers in school." Kim elaborates on the influences in her pre-university experience by remarking:

My school...had a big impact on my life because they encouraged scientific exploration. They encouraged you to ask the why, and how, and where, and when. So, they encouraged questioning, and because of that, I am—I would like to say that I am quite curious. And so...they did have an impact on my career or career choice.

Cohort 2—Agency and Schools

Except for Richard, who was raised in a wealthy family, the pre-university agential and educational experiences of Cohort 2 diverge from those of Cohort 1. To reiterate, participants of Cohort 2 emerge from rural agrarian-based regions in South Africa. When asked to describe his school, Katlego reflects: "Actually, [in] my school, we didn't have labs and stuff where we could do experiments." Katlego acknowledges his teachers' agency as pivotal in his successful admittance to the University of Pretoria. When asked if his community could produce future scientists, Siyabonga responds negatively. He adopts this stance because it is "full of taverns" and, as he says, "We don't have things like libraries, many things. We don't have facilities in our community. Even the nearby schools." As previously mentioned, Sara's parents sent her away from her community due to what they perceived as its social breakdown. She also expresses how her mixed-raced identity caused isolation from peers. She shares this experience by stating:

It's complicated—actually, I grew up in a complicated way. The reason is I am from—my father is from a certain race, and my mom is from a certain race. So, I got exposed to different types of diversities, whereby some people don't appreciate how you are, while some do. So, it was a little bit difficult.

Sara found more acceptance among her peers and teachers in a boarding school out of town. By drawing on their agency, she was successfully admitted to study science at the University of Pretoria. About her teachers, she says, "They really encouraged us to participate at the science activities."

When asked to describe her community, Mary provides the following details: "The kids at my age—many teenagers—getting pregnant. Some of them drink alcohol at a young age. So, that was the worst. And some of the schools, they would just go there, just an hour and go home. So, that was the worst." The community image Mary illustrates is similar to her peers' in this cohort. On the other hand, Mary appreciates her teachers and acknowledges their influences

on her scientific orientation. Shaka's experience is similar. He remarks that in his hometown, "Everywhere you go, there are clubs and taverns usually." Of his school, Shaka notes, "[W]e never did experiments. So, we were not exposed to those things in a science way." In the place of empirical experimentation, Shaka informs the researcher that he relied on YouTube videos to supplement his epistemic methods. Richard's case is unique in this cohort. He attended a private school that the farmers in his community founded. He describes his school as follows:

We had a computer lab and so on. We had a small library, which we started off with. It's quite a new school. I think this year it's five years old. They expanded all the assets and stuff such as libraries and computer labs, which are growing by the minute.

Unlike his peers from the rural region, but like his peers from the suburban cohort (Cohort 1), Richard's pre-university agential and educational interactions enabled his early exposure to scientific Discourses. Richard highlights an example of these interactions as follows:

In the community, we have a guy, I think this year, at the university of Tukkies, he's finishing up his PhD. As I worked with him and so on, with my uncertainties, he quite motivated me into something I might be interested in.

Cohort 3—Agency and Schools

The agential and educational experiences of Cohort 3 contain aspects that are shared with both previously presented cohorts. Some participants experienced enabling agential relationships with community and school members that fostered their epistemic orientations to science. Structural constraints in some of the other participants' schools, including agential interactions that did not always promote growth in their scientific argumentation, are also presented. For example, Violet depicts the collective agency of her community's members as unfavorable and constraining in her scientific development. This is because, in her words, "girls are not really recognized [in the Indian community]. It's mostly boys. And if you're in an Indian home...the boy does come first." Gender discrimination, therefore, constrained the emergence of Violet's Discourse as a budding scientist. Denel, contradistinctively, could draw on pre-university agency in her school to further her orientation to science. She highlights the efficacy of academic agency by stating: "[L]ooking at...the people in the high school and all the marks they got, I think they have the potential to become really great people in the future." Denel was motivated by the successes of her peers. Their achievements instilled the belief in her that she, too, could succeed in studying science. As previously disclosed, Nemo identifies his community's lack of access to expert scientific discourses as the primary motivating factor in his orientation to science. He declares: "I could see that not a lot of people understood the sciences of agriculture and animal sciences as well. So that was kind of something where I realized...the world needs something like this in it for every community because it helps a lot." Faith also describes a community, which does not possess the instruments and infrastructure required for scientific experimentation. She reflects: "Usually we have to go to other places to get that kind of information." She elaborates on this constraint by pointing out that, "We don't have a community library. Neither do we have computer labs. So, a lot of things are not there." In Faith's reflection, she highlights how students who emerge from educational domains that resemble her home rural community were constrained in terms of their access to expert scientific agency, especially agents with access to secondary scientific discourses (Gee 2015). In this regard, Faith's epistemic orientations to science in the pre-university phase drew on alternative sources of scientific agency. An example of such agency in Faith's experience is her grandmother, an herbalist and traditional healer. Faith informs the researchers that: "My grandmother was a traditional healer," and I want to go into "medicine" like her. Faith's pre-

university Discourse reveals how indigenous knowledge systems in southern Africa equally shape students' pre-university epistemic orientations to science, as do epistemologies that less marginalized do in their schools and universities.

Discussion

This study's objective was not to present the experiences of students who emerge from materially under-resourced communities in a deficit paradigm. Such a paradigm construes students' struggles to succeed academically as resulting from a *lack* of necessary material, cognitive, and cultural capital (Schissel 2020; Gutiérrez and Rogoff 2003). Simultaneously, this study did not aim to minimize the real academic challenges that participants from materially well-resourced backgrounds had to endure. Instead, the analysis sought to draw attention to actual variables that shape students' Discourses and their epistemic approaches to argumentation and disciplinary content in specific and individualized ways. For example, the data of the investigation and students' experiences confirm Bangeni and Kapp's (2005) assertion that first-year South African students traverse distinct homes between their local communities and the university environment. As in the experiences of this study's participants, adapting to new ways of arguing, which includes modification of their thinking, writing, and speaking styles, is an added hurdle in the way of students' success. Nonetheless, by applying Archer's (1995) explanatory framework to interpret students' narratives and experiences, their families, communities, schools, and pre-university agentic interactions proved efficacious variables in their argumentation. While all agents in students' homes, communities, and schools may not participate in secondary discourses that involve argumentation on campus, they remained sources of motivation in students' academic Discourses.

To reiterate, this analysis highlighted data from the initial phase of the academic year. It found that due to the activities of families, communities, schools, and agents in pre-university Discourses, each individual student attempted to demonstrate mastery of argumentation in unique ways. Despite students' individuality as a constant variable that emerged in how each one of them drew on structures, culture, and agency (see Figure 1) to engage in written and verbal argumentation effectively, factors such as social class, geographical region, family education levels, the nature of peer interactions, and the quality of their schools induced either enabling or constraining effects on the emergence of their new Discourses as disciplinary members. In this regard, the study's data confirms the Braund et al. (2007) claim that students' argumentation orientations are influenced by the epistemologies of significant agents, including teachers. For example, most of the participants of Cohort 1, who are from well-resourced homes and members of Cohorts 2 and 3, whose family members worked in scientifically affiliated industries, could draw directly on these agential resources to enhance their argumentation in the university. Archer (1995, 275) conceptualizes such effective alignment of structures, culture, and agency as "double morphogenesis." Examples in this study of double morphogenesis in the experiences of students who were less required to modify or adapt their pre-university Discourses to expert ways of arguing on campus are Larry and Richard. Before arriving at the University of Pretoria, they were immersed in the epistemologies of medicine and agriculture, which also constitute their aspirant future paths.

In contradistinction, students with less access to expert scientific Discourses, scientific artifacts, and cultural activities experienced morphostasis or a constraining of their emerging Discourses as argumentative scientists. The constraining of double morphogenesis in these students' experiences affirms the Braund et al. (2007) postulation that students' agential exposure to argumentation strategies is elaborated in how they attempt to apply rhetoric and dialect toward knowledge generation. Differing levels of exposure to expert scientific Discourses in students' pre-university rhetorical and dialectical experiences of argumentation generate epistemic relativity among first-year science students. A significant number of rural

and township-emergent students could not directly incorporate family and community members in disciplinary, expert, and scientific discourses. In addition, a considerable number of them could not now embed family and community member agency in on-campus argumentation due to their nonexposure to written and verbal discursive practices that are applied in academic departments. Students were coerced into relying on alternative pre-university variables and strategies to adapt to on-campus argumentation in these cases. Often, these epistemic strategies involved the indirect involvement of family and community members through the desire and motivation to use science to rid them of poverty. Emergent in students' narratives, active variables (from the pre-university/primary discourse domain) include the agency of their teachers, who initially exposed them to scientific argumentation in conjunction with pre-university learning methods. Examples of these methods involve supplementing on-campus instruction by watching YouTube videos which many students reported practicing before arriving at the university, reviewing past exam papers, and solitary learning off-campus.

Conclusion

This study adopted the following three principles: (1) Discourses are linguistic, individual, and collective modes of constructing identities (Gee 2001, 2008); (2) diverse Discourses generate epistemic diversity in the classroom; and (3) academic discourses that involve literacy practices rely on argumentation (Halliday and Webster 2004). This study concludes that first-year science students bring individual Discourses, identities, and literacies to universities (Cope and Kalantzis 2000). Students' unique Discourses influence and shape how they initially attempt to employ academic literacy practices in their argumentation strategies. Due to disparate exposure to scientific argumentation and Discourses during the pre-university phase, the diversity embodied in first-year students' identities necessitates the implementation of academic literacy and disciplinary curricula that explicitly introduce them to principles that underscore scholarly argumentation and which senior scholars embrace. South African first-year science students do not emerge from the same argumentation fields. It is recommended that their degrees create spaces where critical principles are made explicitly for them. On top of introducing students to argumentation principles, including consideration of counterarguments, objectivity-subjectivity balance and plagiarism avoidance, the authors recommend implementation of formative and summative assessments that enable learning opportunities for students to draw on the agency of their families and pre-university Discourses, regardless of their geographic, class, and school origins. However, it is recommended that such an inclusive methodology that aims to incorporate students' pre-university Discourses into the curriculum acknowledges the varying capacities that students have in employing written and verbal argumentative moves. To incorporate divergent argumentative competencies in the classroom, this study recommends that course content allow students to engage argumentative topics that focus on professional, scientific Discourses and their relationships to expert communities of practice. Assessments including video design, report writing, and argumentative essays that enable students to weave knowledge from their pre-university Discourses with expert modes of practicing rhetoric and dialect in the curriculum are also recommended. In so doing, curriculum designers may induce learning experiences that integrate students' Discourses, professional aspirations, and argumentation development through the mechanisms of academic literacy practices.

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