Understanding university students' perceptions and attributions in linguistically diverse mathematics classrooms

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Thesis submitted to the University of Ottawa

in partial Fulfillment of the requirements for the Master of Arts Education

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Abstract

In recent years, the number of multilingual international students in Canadian university mathematics classrooms is on the rise, and a substantial body of literature has emerged on the topic of language diversity in mathematics education (e.g., Barwell et al., 2019; Chronaki & Planas, 2018; Suh, 2020; Tai, 2021). Whilst much research has been carried out in linguistically diverse settings, no single study exists which explores students' social perceptions of their peers in linguistically diverse mathematics classrooms. In addition, there is scant research conducted in post-secondary classrooms. The primary objective of the study is to fill the research gap by examining the factors that university students consider significant in their mathematics learning and exploring how students attribute both their own and others' successes and failures during mathematical discussions in linguistically diverse university classrooms. The study recruited nine participants from diverse linguistic backgrounds who have or were currently studying mathematics at the postsecondary level. Data collection was conducted through the utilization of group discussion, focus group interviews, and semi-structured interviews. This research contributes to a deeper understanding of university students' experiences in linguistically diverse mathematics classrooms and promotes university internationalization and positive student experiences.

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Introduction

Higher education institutions have been exposed to different cultures and languages as a result of internationalization; consequently, a large proportion of mathematics students worldwide have diverse linguistic backgrounds (Giannelli & Rapallini, 2015; Jeannin, 2013; Jensen & Rasmussen, 2011). More than 800,000 international students held study permits in Canada by 2022; India, China, the Philippines, France, Nigeria, Iran, South Korea, Vietnam, and Mexico are the most common countries of origin (Canada International Student Statistics, 2023). It is expected that the students from these countries bring a language other than English and French to Canada, thereby promoting linguistic diversity in Canadian universities. In addition, science, technology, engineering, and mathematics (STEM) enrollment among international students jumped by nearly 400% from 2010 to 2020 (Canada International Student Statistics, 2023), remaining the most popular field of study for international students. Since the majority of science, technology, and engineering majors require mathematics prerequisites, it is reasonable to conclude that post-secondary mathematics classes in Canada are remarkably multilingual.

Researchers have extensively examined the issue of linguistic diversity within mathematics classrooms and have established that linguistic diversity has a notable impact on peer interactions (Chen et al., 2018; von Grünigen et al., 2012). These interactions, in turn, have implications for students' academic achievements (Kumi-Yeboah et al., 2020; Raley, 2004). However, there is a dearth of research on university students' perceptions in linguistically diverse environments (e.g., Deale & Lee, 2021; Riegle-Crumb & Humphries, 2012). No comparable research has been conducted in the field of mathematics education either. The main objective of this study is to examine the experiences of university students in multilingual mathematics classrooms. Specifically, the study seeks to explore the factors that university students perceive as significant in their mathematics learning, as well as the ways in which students attribute both their own and others' successes and failures. It is hoped that the findings will contribute to our understanding of how students perceive the causes of successes and

failures and provide mathematics educators with a framework for comprehending students' needs in multilingual settings.

My personal educational and linguistic experiences have prompted this research. I have a bachelor's degree in applied physics and a master's degree in TESOL (Teaching English to Speakers of Other Languages). I am also a non-native English speaker who has lived and studied in English-speaking countries for several years. Thus, I am equipped with extensive knowledge and experience regarding mathematics education and language diversity; I am particularly aware of the challenges and issues that arise in a mathematics classroom with a diverse student population. After interacting with a student in my undergraduate mathematics classroom, I developed an interest in students' perceptions. The boy was an international student who rarely participated in class discussions; however, whenever others posed a challenging question to which no one knew the answer, he was always able to provide an accurate response. "Why do you never participate in group discussions?" I asked him. "Well, English is not my native tongue, so I do not know what others will think of my response," he replied. His uncertainty about how others perceived him hindered his confidence and prevented him from participating in the discussion; one bilingual participant in Hwang et al. (2022) made a similar point, stating that she felt "she was wasting others' time" (p. 1145) as a result of her limited language proficiency. In fact, the researcher herself admitted that she was concerned that her students or peers would perceive her as "not competent in mathematics" due to the fact that she was not a native speaker of the instructional language (Hwang, 2023). Consequently, I believe it is of the utmost importance to address the significant factors in the mathematics learning of university students and to investigate how students perceive one another during mathematical discussions. The study aims to answer the following research questions:

1. What are the primary factors that university students perceive as influential in one's mathematics learning within linguistically diverse environments?
2. How do students attribute their own and others’ successes and failures during mathematical discussions in linguistically diverse university classrooms?

The investigation of the research inquiries will contribute to the enhanced comprehension of the experiences of learners in multilingual university mathematics settings, benefiting university students, educators, and policymakers. The thesis will commence by conducting a comprehensive review of the existing literature pertaining to the subject matter of bilingualism and multilingualism, language diversity in higher education, language diversity in mathematics education, and mathematical discussion. This literature review aims to establish a contextual framework for subsequent research. The next section will present the *Attribution Theory* as a theoretical framework to establish a foundation for this study. The following sections will discuss the methodology and data analysis. The concluding sections present the findings and discussion of the research.

Literature Review

The literature review is organized into four sections: bilingualism and multilingualism, language diversity in higher education, language diversity in mathematics education, and mathematical discussion. The initial step in this literature review is to establish a clear definition of multilingualism, as all participants in this study possessed the ability to speak multiple languages and the research was conducted within a multilingual context. Furthermore, the primary objective of this study is to examine the impact of language diversity in mathematics classrooms within the context of university education. This necessitates a comprehensive understanding of the role that language diversity plays in both higher education and mathematics education. Given that the data were obtained via a discourse, it is imperative to engage in an examination of the characteristics inherent in mathematical discussions.

Bilingualism and Multilingualism

Multilingualism refers to the ability to speak and use more than one language (Cenoz, 2013). In the pre-1960s era, the deficit-oriented perspective of multilingualism placed limitations on and hindered the educational advancement of students (Portes & Hao, 1998). Peal and Lambert's (1962) study posed a challenge to the prevailing theory by examining and comparing the performance of monolingual individuals and bilingual individuals on standard intelligence tests. The results indicated that bilingual children, aged 10, attending French schools in Montreal, exhibited superior academic performance compared to their monolingual counterparts in both verbal and non-verbal intelligence assessments. According to Thompson (2013), the paper mentioned earlier from 1962 serves as an early exemplar for highlighting the benefits of bilingualism, moving away from a negative view to a resource-oriented perspective that recognizes the advantages it offers. Ben-Zeev (1977) subsequently provided empirical evidence supporting the enhanced cognitive flexibility and linguistic processing capabilities exhibited by individuals who are bilingual. Furthermore, scholarly research has provided evidence to support the notion that the development of multilingual literacy has proven to be beneficial in facilitating

and expediting the language acquisition process among students (Cenoz & Valencia, 1994; Maluch & Kempert, 2019; Sanz, 2000). Additionally, it has been found to enhance students' attention regulation skills (Bialystok & Majumder, 1998). Dewaele and Wei (2013) posit that individuals with multilingual abilities exhibit a higher level of tolerance towards uncertainty. In mathematics education, Marian et al. (2013) recruited 17 bilingual non-native English speakers and compared them to 14 monolingual English-only speakers, discovering that bilingual elementary pupils performed better on mathematics examinations than their monolingual counterparts. Hartanto et al. (2018) recruited bilingual and monolingual English-only speakers to investigate the relationship between bilingualism and mathematical achievement. The researchers found that bilingualism positively predicted higher mathematics skills. From a neuropsychological standpoint, Stocco and Prat (2014) confirmed the result, demonstrating that multilingual pupils displayed more flexibility in mathematical processes. Mestre et al. (1982) confirmed that university students' improvements in second language proficiency would be followed by better performance on mathematical tasks.

Although recent studies (Martinez & Portes, 2022; Nguyen & Winsler, 2021; Ramos Salazar et al., 2022) have adopted a resource-oriented perspective and discovered considerable bilingual advantages in "educational attainment, occupational prestige, and familial income" (Martinez & Portes, 2022, p. 1825), drawing definitive conclusions would be premature. First of all, these aforementioned studies operated under the assumption that monolingualism was the standard or norm for measuring language proficiency. Second, Hartanto et al. (2018) stated that much research failed to account for socioeconomic level and race/ethnicity characteristics. This study aims to fill this gap by rejecting the assumption that monolingualism is the norm. However, the researcher was unable to account for participants' socioeconomic and racial backgrounds, and the findings suggest that students' backgrounds, particularly those of international students, require in-depth knowledge of the student to determine.

Language Diversity in Higher Education

Universities can “be understood as sites of linguistic diversity in which the institutions’ mediums of communication of instruction come into contact with the diverse linguistic repertoires of their students” (Preece & Marshall, 2020, p. 117). In academic research, it is necessary to distinguish higher education from other levels of education, as many students may have never been exposed to such a diverse environment prior to attending university. As an illustration, it is noteworthy that the University of Ottawa accommodates a substantial number of 7,000 international students hailing from more than 150 countries (Loriggio, 2017). In contrast, the Toronto District School Board, which is one of the largest high school programs in Canada, enrolls a comparatively smaller population of approximately 2,000 international students (Loriggio, 2017). Furthermore, the realm of higher education, particularly in the Anglophone world, has expanded dramatically due to the forces of globalization and improved access to higher education. This development has led to an increase in linguistic diversity (Preece, 2009, 2019). Numerous scholars have endeavored to examine the phenomenon of language diversity through the lens of language-as-resource perspectives (Lin, 2013; Marshall & Moore, 2013; Preece et al., 2018). In an investigation into university students’ foreign language learning experiences, Bruen and Kelly (2017) reported that non-native English speakers perceived themselves to possess an advantageous position compared to native English speakers, despite the fact that the language of instruction was English. The researchers posited that the reason for this phenomenon was that non-native English speakers possessed a more extensive linguistic repertoire, which facilitated their language-learning process. Bozbıyıka and Morton (2023) conducted an analysis of the discourses employed by university instructors, revealing the advantageous utilization of multilingual resources within exemplification sequences. Notwithstanding, it is important to recognize that language diversity may not always be advantageous for university students. According to Preece (2019), the presence of linguistic diversity within universities has varying effects on students based on their socio-economic backgrounds. Preece suggested that individuals from "higher socio-economic groupings" were

more inclined to perceive their multilingual abilities as advantageous, in contrast to students from "working-class backgrounds" (p. 416). Li et al. (2020) argued in a study conducted in China that Chinese universities had failed to "bridge the needs of international students of diverse backgrounds" (p. 529). The researchers expressed skepticism over the feasibility of English as a means to accommodate the linguistic diversity in China, given that a significant portion of both Chinese students and international students lack native or proficient proficiency in the English language. Nevertheless, research on multilingualism in universities “is to this day relatively rare” (Schroedler, 2020, p. 134).

There has been a scarcity of research conducted on the perceptions and attitudes of university students in multilingual contexts. The study conducted by McKenzie and Gilmore (2015) investigated the attitudes of participants toward English speeches delivered by international students. The findings indicated that Japanese university students perceived American and British English as more prestigious, while Japanese English was considered more attractive compared to other speech forms such as Thai English, Chinese English, and Indian English. In a study conducted by Atkinson and Kelly-Holmes (2016), it was discovered that university students in Ireland did not display a positive attitude towards the Irish language, despite its regular incorporation into their everyday activities. The researchers proposed that this attitude was strengthened by the increasing linguistic diversity observed inside the nation. While Hastings (2021) conducted a research project involving three comprehensive interviews to explore the views of Arab undergraduate students regarding their transition to studying mathematics in English, there has been limited focus on investigating the experiences of students in non-English medium classrooms, such as French. Though the current study was conducted in an English-medium context, it reported on the experiences of students in mathematics classes taught in French.

Language Diversity in Mathematics Education

The significance of language in the instruction and acquisition of mathematics has been

acknowledged in a substantial body of scholarly research (Austin & Howson, 1979; LeFevre et al., 2010; Secada, 1992). Mathematics can be described as a "formal language" that encompasses several elements such as numbers, symbols, vocabulary, phrases, and procedures (Ní Ríordáin & O'Donoghue, 2009, p. 47). In recent years, there has been a noticeable rise in the practice of educators and learners participating in multilingual discourse during mathematics instruction (Barwell et al., 2017; Robertson & Graven, 2019). According to Barwell et al. (2016), the field of mathematics education is inherently intertwined with linguistic diversity. Consequently, the importance of language diversity in research on mathematics education cannot be overlooked (Chronaki & Planas, 2018).

The presence of linguistic diversity in mathematics education may suggest the existence of many types of mathematics classrooms. One common context is mathematics classrooms in countries such as the United States, Canada, Australia, and New Zealand, where many students "are learners of the language of instruction or speak it as a second or additional language" (Barwell, 2020, p. 150). The second type of mathematics classroom is commonly observed in nations and areas that have a historical connection to colonialism or possess a global educational framework. Examples of such countries and regions include India, Hong Kong, Uganda, Singapore, and Malaysia, among others. In this particular educational setting, a significant proportion of both students and instructors do not possess native proficiency in the language of instruction, which mostly includes English, Spanish, French, etc. The final type of mathematics classrooms encompasses various dialects of a shared language, constituting a form of linguistic variety (Barwell et al., 2017). For instance, while Mandarin Chinese is spoken by the majority of pupils, Cantonese Chinese is the language of instruction in many Macau (a city on the south coast of China) secondary schools.

The field of mathematics is distinguished by its complex nature, leading to varied research findings about the acquisition of mathematical knowledge in linguistically diverse environments (Barwell et al., 2017; Ní Ríordáin & O'Donoghue, 2009). Several academic investigations have examined the issue of language diversity as a significant hurdle in the field of mathematics

education. The study done by Phillips and Birrell in 1994 revealed a notable discrepancy in mathematics performance between non-native English speakers and native English speakers in elementary schools in the United Kingdom. The researchers held the belief that language was the determining factor for the outcomes. Barton et al. (2005) found that international students with inadequate language proficiency face difficulties in understanding mathematical topics. The researchers noted that some specific features of mathematical discourse contribute to these difficulties for English learners. In addition, Kleemans and Segers (2020) examined the differences between first- and second-language Dutch learners and found that second-language learners had lower scores on advanced mathematics. Nevertheless, these studies failed to consider socioeconomic status as a controlling factor. Additionally, they neglected to incorporate language difficulty as a variable when assessing the participants' performance (Barwell et al., 2017). Excessive linguistic complexity of test items could result in a performance disparity between native and non-native speakers of the testing language (Abedi, 2009; Mestre, 1986). According to Martiniello (2008), an increase in linguistic complexity would render mathematics questions more demanding for English language learners due to the frequent need for translation and code-switching. Though numerous research studies have provided evidence regarding the advantages of code-switching in mathematics educational settings (Arias De Sanchez et al., 2018; Bravo-Sotelo, 2020; Marsh & Maki, 1976; McClain & Huang, 1982; Tamamaki, 1993), it is important to note that excessive and erroneous translation practices can hinder students' learning progress and restrict their ability to fully engage with the instructional language. Some studies, however, did not discover any negative correlations between language diversity and mathematics performance. Bredtmann et al. (2021) found no correlation between the degree of linguistic diversity in the classroom and students' mathematical performance. Ohinata and van Ours (2013) found no evidence that a high immigrant population, who brings additional languages to the classroom, has a negative effect on students' academic performance. Furthermore, a body of research has demonstrated that the implementation of multilingual immersion programs can lead to enhanced mathematics abilities in youngsters (Cummins, 1979). The study carried out by

Bournot-Trites and Reeder (2001) provided evidence supporting the superior academic performance of pupils enrolled in a French immersion program compared to those enrolled in a non-immersion program. According to the findings, it was seen that the students who had obtained their mathematical knowledge in the French language were capable of effectively recalling and utilizing this knowledge in the English language. Furthermore, the researchers discovered that pupils enrolled in the French immersion program exhibited increased motivation, leading to enhanced comprehension of mathematical concepts. This finding is supported by Louis (2020).

To the best of the researcher's knowledge, the study conducted by Kim et al. (2012) is the sole published journal article that examines the topic of language diversity within the context of undergraduate mathematics education. In their study, Kim et al. (2012) conducted a comparative analysis of the discourses pertaining to the concept of infinity among university students who spoke English and Korean. The researchers observed that the discourse employed by English-speaking students had a greater degree of colloquialism and emphasis on the process, in contrast to the discourse utilized by Korean-speaking students. In addition to lexical differences, the researchers hypothesized that Korean students may have received more formal mathematics education prior to enrolling in college. The results of the study demonstrated that mathematical discourses from speakers of different languages exhibit apparent differences, which may impede meaningful learning; consequently, the current research focuses on the effect of language diversity on mathematics learning.

Language diversity in mathematics education is a complex topic, and the backgrounds, experiences, and attitudes of college students introduce unpredictable variables; however, there has been little discussion of undergraduate students' experiences with multilingual mathematics learning (Ní Ríordáin & Flanagan, 2020). It is important for researchers not to “think of homogeneous classes of students who have the majority language as their L1 and teachers who are the ideal native speakers of the target language as a model” (Cenoz, 2015, p. 22). There is no one-size-fits-all model, and researchers should seek relevant models based on the circumstances.

Mathematical Discussion

Mathematics scholars and educators are convinced of the importance of mathematical discussions (Adler, 1997; Giberti et al., 2022; O'Connor, 2002; Setati, 2005; Sfard, 2008), which can help students "summarize and synthesize the mathematics they are learning" (Garcia, n.d., p. 2) and provide educators with insight into students' mathematical thinking (Szydlik, 2015). During discussions, misconceptions are clarified, and conceptual and procedural knowledge is deepened, thereby enhancing students' "thinking and reasoning skills" (von Renesse & Ecke, 2015, p. 222) and mathematical performance. Callahan et al. (2021) found a positive correlation between student participation in student-led dialogues and their mathematics grades. Turner et al. (2013) argued that "exchanging ideas about problems, solution strategies, claims, justifications, and connections" (p. 199) is fundamental to mathematics learning and assists students in forming positive mathematical identities. According to Szydlik (2015), discussions can alter the dynamic in mathematics classrooms, shifting "the notion that mathematical rules are based on the authority of the teacher to a more inclusive and empowering view in which mathematical understanding is developed by a community of learners" (p. 661). As a result, students are able to identify similarities and differences between one another's contributions to the discussion and generate original concepts and solutions. Moschkovich (1999) discovered that students contributed a variety of viewpoints on mathematical topics during class discussions; the researcher believed that teachers should listen to students' interpretations rather than searching for errors.

Furthermore, mathematical discussions have been proven effective in diverse linguistic contexts. According to Callahan et al. (2021), content-area discussions can improve English language learners' mathematical and linguistic skills. Gutiérrez (2002) concluded that providing opportunities for mathematical arguments encouraged low-income Latino/a students to participate actively in mathematics learning. However, not all students benefit equally from multilingual mathematics discussions (Forman & Ansell, 2002; Lubienski, 2000; Turner et al., 2013). Although mathematical symbols are universally consistent across many languages, the

verbal expression of these symbols varies across different linguistic contexts. According to Sfard (2008), the act of engaging in mathematics discourse necessitates communication, thereby highlighting the constant need for linguistic proficiency in mathematical practice. In the study by Baxter et al. (2001), students with low academic performance encountered significant challenges when engaging in mathematical discussions as a result of their limited capacity to express mathematical ideas. Forman and Ansell (2002) identified that not all participants were "on equal footing" (p. 268) during discussions, as rigorous mathematics instruction through discussions had the potential to marginalize or silence pupils who were less cooperative. Shy and underachieving students may not derive adequate benefits from engaging in mathematical discussions, and there is a likelihood that participation in group discussions could exacerbate their sense of isolation. Educators and researchers must recognize that communication proficiency is not a given (Adler, 2006) and ensure equal student participation opportunities.

Despite the significance of mathematical discussions, orchestrating discussions in a mathematics course for undergraduate students presents formidable challenges to seasoned instructors (Speer & Wagner, 2009; Stein et al., 2008). The tension between teaching individuals and engaging the entire class, the tension between "keeping the discussion on track" and "allowing students to make spontaneous contributions that they deemed relevant" (Lampert, 2001, p. 174), monitoring the pace of discussions, and providing adequate scaffolding in linguistically diverse classrooms are among the most significant challenges educators face. Garcia (n.d.) suggested several techniques for enhancing the quality of mathematical discussions: revoicing, questioning, using wait time, incorporating student thinking, and creating a safe and supportive environment.

Conclusion

In the early literature, both multilingualism and language diversity were approached from a deficit-oriented perspective. The ability to communicate in various languages was frequently associated with impoverished circumstances and a disadvantaged economic position

(Moschkovich, 2007). The presence of language diversity inside mathematics classrooms was perceived as a significant educational obstacle. While there is a growing body of literature that views multilingualism and language diversity as advantageous recently, it is worth noting that a considerable quantity of scholars continues to regard monolingualism as the prevailing norm. In the assessment of the influence of language on academic achievement, scholars consistently adopt a dichotomous approach, wherein participants are systematically classified into two distinct cohorts. Such classifications include international versus domestic students, native versus non-native speakers, bilingual versus monolingual individuals, European Americans versus Asian Americans, and so on. The utilization of a dichotomous approach imposed constraints on researchers, preventing them from seeking other explanations for the observed outcome. For instance, the higher mathematics scores of bilingual pupils may be attributable to their prior educational experiences rather than their bilingualism. In addition, plenty of studies have effectively identified various factors that can impact students' engagement in mathematical discussions, including language competency and personality traits. However, to the best of my knowledge, there is currently no existing research that has investigated mathematical discussions from the perspectives of students at the university level. Hence, the current study refrains from categorizing the individuals into distinct groups and focuses solely on elucidating explanations based on their responses.

Theoretical framework

The goal of the present study is to answer the following research questions:

1. What are the primary factors that university students perceive as influential in one's mathematics learning within linguistically diverse environments?
2. How do students attribute their own and others' successes and failures during mathematical discussions in linguistically diverse university classrooms?

In order to address the first question, this section will initially present the notion of *social perceptions* (Heider, 1964). *Attribution Theory* (Weiner, 2019) will be employed to address the second research question, as it offers a theoretical framework that enables researchers to comprehend how students recognize their achievements and failures. Finally, the concept of *Fundamental Attribution Error* (Ross, 1977) is employed to elucidate the attribution patterns exhibited by certain participants.

Perceptions

Perception is defined as "the way an individual observes, understands, interprets, and evaluates a referent object, action, experience, individual, policy, or outcome" (Bennett, 2016, p. 585), and social perception specifically refers to the perception of another person (Heider, 1964). The concept of perception is multifaceted and should not be conflated with attitude or opinion. Rather, it should be regarded as a collection of sensory experiences that can be shaped by factors such as cultural heritage, socioeconomic standing, and personal attributes (Bennett, 2016). Lindsay and Norman (1977) defined perception as a mechanism that operates "upon sensory information, interpreting, classifying, and organizing arriving information" (p. 3). Heider (1964) distinguished social perception from object perception because "persons are typically perceived as action centres and can therefore affect us" (p. 21). The core of Heider's conceptual framework of perception is "the intentionality of persons" (Malle, 2011, p. 73). Due to the varying nature of their habitats, jobs, ages, marital statuses, etc., "persons" are in a constant state of flux within this concept.

Social perception, “dominated by error and bias” (Jussim, 2015, p. 1), is also “accomplished through various means” (Pickens, 2005, p. 60) such as *halo effect*, *contrast effect*, *projection*, *stereotyping*, *pygmalion effect*, and *impression management*. Halo effect refers to the cognitive bias in which a person forms a general opinion based on a single characteristic (Pickens, 2005). People frequently perceive physically attractive individuals to have superior personalities, such as being more confident, intelligent, and sociable (Batres & Shiramizu, 2022; Forgas & Laham, 2016). In a mathematics classroom, if a student demonstrates advanced language proficiency, other students may erroneously believe that he or she has mathematics skills. In contrast, students with limited language skills may be perceived as underachieving in mathematics and other disciplines. This effect is most pronounced in schools where students come from diverse linguistic backgrounds. Contrast effect is an unconscious bias that occurs when the perception of an individual is influenced by those around them (Caccavale, 2020). Depending on the circumstances, perceptions of a student's mathematical ability can vary. If the student is surrounded by high-achieving peers, his or her mathematical aptitude may be perceived as inferior, whereas if the student is surrounded by low-achieving peers, his or her mathematical aptitude may be viewed as superior. Projection, however, refers to an unconscious cognitive bias that arises when an individual's perception is influenced by their own attitudes and beliefs (Pickens, 2005). According to Robbins and Krueger (2005), it provides a convenient platform for individuals to interpret the actions of others by attributing them to their own "dispositions or preferences" (p. 32). Stereotyping refers to "a conventional image applied to whole groups of people, and the treatment of groups according to a fixed set of generalized traits or characteristics" (Pickens, 2005, pp. 61-62). Some teachers in mathematics education have a tendency to stereotype mathematics as a male domain, thereby underestimating the mathematical competence of females (Keller, 2001; Leyva, 2017; McCoy et al., 2022). Racist stereotypes are also pervasive in mathematics classrooms (Leyva et al., 2021; McGee & Martin, 2011; Schweinle & Mims, 2009). Pygmalion effect, also known as self-fulfilling prophecy, is powerful in social perception (Jussim, 2015); it occurs when a person consistently attempts to meet the

perceptions and expectations of others. It can occur in a mathematics classroom when teachers have different expectations for different students, and their performances vary accordingly. Impression management refers to the deliberate and subconscious behaviours individuals engage in with the aim of shaping the perceptions others have of them (Cooks-Campbell, 2022). Frequently, individuals utilize impression management in order to facilitate the accomplishment of their goals.

Regrettably, there has been a lack of emphasis on the investigation of social perception within the realm of undergraduate mathematics education research. Two pertinent studies have been identified; however, they were not carried out within the context of mathematics. Ali et al. (2008) investigated various students' perceptions of learning environments. The findings revealed that university students of diverse racial and ethnic backgrounds favoured more interactive classrooms. Summers and Volet (2008) explored college students' perceptions of culturally diverse study groups during a semester-long group project. Students' multilingual experiences contributed to their positive attitudes toward multicultural group work, according to the findings. Moreover, numerous scholarly investigations pertaining to social perceptions have performed separate analyses for international and "local" students. In these studies, domestic students were regarded as the standard, thereby imposing an implicit categorization on the cohort of overseas students. The research data might have been compromised by the utilization of this approach, as a result of *reverse perception*. *Reverse perception* refers to the phenomenon in which participants' perceptions of others are influenced by their own beliefs regarding how others perceive them (Heider, 1964). For instance, the individual's perceptions of their peers may vary if they hold the belief that they are perceived as an outsider by their peers. To ensure impartiality, the current investigation did not take into consideration the students' nationality or ethnic heritage.

Attribution Theory

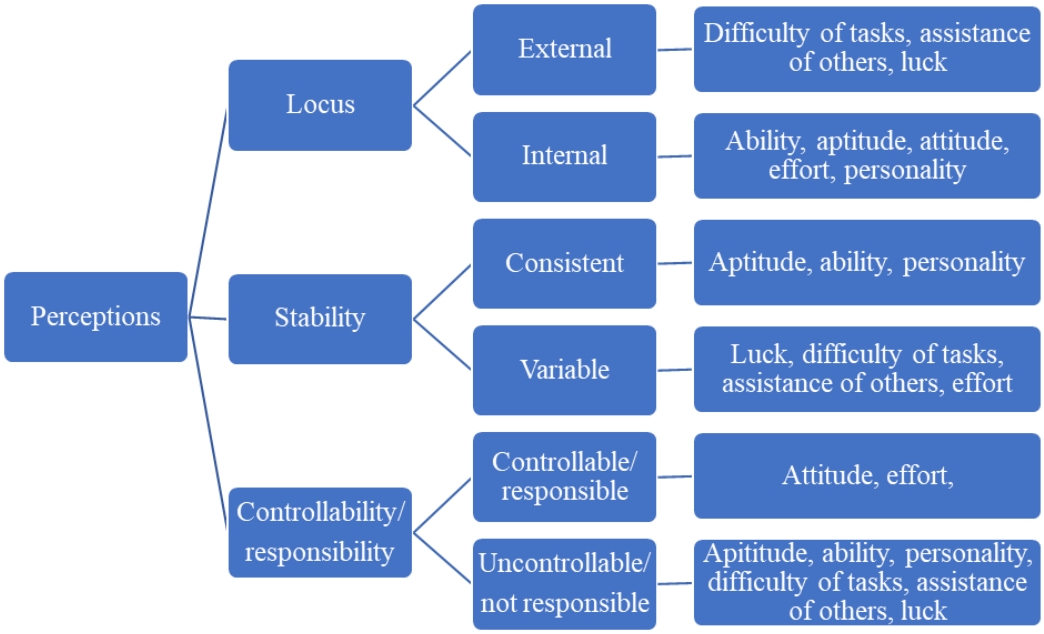
Attribution is a process of causal perception that varies according to ethnicity, age, gender, etc (Digia & Zdravkovi, 2019). 1958 saw the development of the attribution theory of person perception by Fritz Heider (person perception and social perception will be used interchangeably in this thesis). Attribution theory comprises "many interrelated constructs including cognitions, emotions, and behaviours" (Weiner, 2019, p. 604). Swinton et al. (2011) identified, within the framework of attribution theory, that attributions had a substantial effect on the engagement of high school students in mathematics classes. According to the researchers, attributing failure to low ability can result in students being "less persistent" (p. 1497), as they may perceive that their low ability will restrict the beneficial outcomes of their effort. Lee (2019) employed Weiner's attribution theory to investigate the causal interpretations and associated emotions of first-year undergraduate students regarding procrastination. Furthermore, multiple studies have investigated the academic achievements of university students in relation to attributions (Haynes et al., 2008; Hsieh & Schallert, 2008; Perry et al., 2008). However, none of these studies have specifically focused on mathematics education in higher education. Many contributions have been made to the attribution theory. In this study, Weiner's intrapersonal theory and interpersonal theory of motivation (Weiner, 2000) was adopted in order to investigate the perceived causes of success and failure.

Intrapersonal motivation encompasses the internalized emotions and cognitive processes that are self-directed and can be understood through three distinct causal dimensions: *locus*, *stability*, and *controllability*. *Locus* refers to the “location within or outside of the actor” (Graham, 2020, p. 2). Ability, attitude, effort, and personality, for instance, are considered internal causes of success, whereas the difficulty of tasks and the assistance of others are external causes. *Stability* indicates whether a cause is consistent or variable. For instance, aptitude is relatively stable, whereas luck is highly unstable. *Controllability* refers to whether a cause can be voluntarily controlled; attribution theorists believe that ability "is not subject to volitional control" (Graham, 2020, p. 2), whereas effort and mood are amenable. The field of interpersonal motivation

examines the perceptions and evaluations of other individuals, such as peers, teachers, coworkers, and parents, regarding their actions and achievements. Observers will "experience happiness and sadness" and "express anger and sympathy" based on whether the actor is perceived as responsible or not (Weiner, 2000, p. 7). For example, if the actor is responsible for failing an exam or shattering a vase, the observer may display anger as the actor does not fulfill his/her potential. Alternatively, if the two negative outcomes are the result of uncontrollable factors (e.g., inability, illness, etc.), the observer may express sympathy (Weiner, 2000). With positive outcomes, observers will display different emotions as well. On one hand, actors deemed as “low ability but high in effort” (p. 9) always receive the most praise from observers; this is because actors’ performances exceed observers’ expectations. On the other hand, actors with high ability but who do not work hard receive little praise as they do not fulfill their potential. In these instances, the observer acts as both a "judge" and a "scientist" (p. 9) in determining causality.

In the context of my research study, I have formulated a graphical representation (refer to Figure 1) with the purpose of enhancing the process of coding. Three dimensions are shown for one's perceptions in Figure 1: locus, stability, and controllability. Each dimension is separated into two subcategories. For instance, when participants attribute the successes of others to the level of difficulty of tasks, their attributions are categorized as external, variable, and uncontrollable. Conversely, when participants attribute their own successes to personal effort, their attributions are categorized as internal, variable, and controllable. Through the process of comparison, it becomes evident that the individual participant holds the belief that their personal achievements are entirely within their control, whereas the successes of others are perceived as more external and less consistent.

Figure 1



Fundamental Attribution Error

Ross (1977) coined the term *Fundamental Attribution Error* (FAE) to describe the tendency to attribute others' behaviours or outcomes (usually negative) to that person's disposition or natural qualities, while attributing one's own negative behaviours or outcomes to situational factors. It frequently occurs when the impact of external factors is underestimated and the impact of internal factors is exaggerated (Pickens, 2005). Simply put, FAE suggests that individuals are more likely to attribute their own negative encounters to situations, whereas they are more likely to attribute negative conflict with others to their personalities (Flick & Schweitzer, 2021). In a straightforward example illustrating this pattern, student A fails a school test while student B does not. FAE suggests that in this context, student B is more likely to attribute student A's failure to incompetence and a lack of skill than to a situational cause. However, student A is more likely to attribute the failure to situational factors (e.g., student A had a more difficult time studying due to noisy roommates) than to admit he/she is incapable of passing the test. In this context, students whose academic performance is contingent on contextual factors (Pfingsthorn

& Weltgen, 2022) may be viewed as unqualified or not intelligent if they fail a test. In the current study, participants had limited knowledge of one another's backgrounds, making it easier for them to ignore the contextual and situational factors that contributed to the academic failures of others.

Summary

The present study is grounded in the theoretical framework of *social perceptions, the Attribution Theory,* and *Fundamental Attribution Error* (FAE). The behaviours exhibited by the participants can be elucidated through the application of diverse categories employed in the realm of social perception. It also serves as a reminder that researchers must relinquish their personal biases when conducting interviews and analyzing data. The Attribution Theory facilitated the researcher's comprehension of how the participants ascribed causes to achievements and setbacks. After conducting an analysis of the attributions made by the participants, several patterns were identified. For example, participants exhibited a tendency to attribute others' failures to internal factors. The elucidation of these patterns may be facilitated by the use of FAE. The subsequent section of this thesis will present methods.

Methods

Although language diversity in mathematics education has been the topic of substantial research, undergraduate students' perceptions remain largely unexplored. Therefore, I intend to answer the following research questions:

1. What are the primary factors that university students perceive as influential in one's mathematics learning within linguistically diverse environments?
2. How do students attribute their own and others' successes and failures during mathematical discussions in linguistically diverse university classrooms?

The study began with a qualitative approach, which had the advantage of shedding light on undergraduate students' perceptions of themselves and their peers in mathematics classes. To compare how students attributed successes and failures, however, a quantitative method was also employed. In order to simulate a linguistically diverse mathematics classroom, the first stage of the study was to film four students from diverse linguistic backgrounds discussing mathematical questions. Due to possible background noise and the fact that not every student would contribute verbally, it was not feasible to videotape actual mathematics class discussions. The simulation method is advantageous (see, for example, Greitemeyer & Rudolph, 2003; Hareli et al., 2006) and was adopted because "what individuals say they would think, feel, or do in a particular situation maps closely onto how they actually think, feel, and behave in real-world contexts" (Graham, 2020, p. 7). After the discussion, a focus group interview with the video participants was conducted to discover their perceptions of their performances during the discussion. In the second stage of the study, another group of five participants viewed the discussion video individually, followed by semi-structured, open-ended interviews. Semi-structured interviews were utilized because they permitted the researcher to improvise in response to interviewee answers (Kallio et al., 2016) and provided "the needed flexibility to begin with a small number of pre-established questions and then ask follow-up questions" (Kraal et al., 2022, p.214). In a large number of studies aimed at assessing participant perspectives, semi-structured interviews were also employed (Allen et al., 2019; Brands et al., 2012; Croxson et al., 2017; Dew

et al., 2017; Kim & Hong, 2021).

Recruitment and Participants

After receiving approval from the Research Ethics Board, the recruitment posters (refer to Appendix A) were prominently displayed on bulletin boards across multiple buildings in the University of Ottawa. Due to the fact that many potential participants were only interested in Stage 2, the duration of time required to recruit four participants for Stage 1 was approximately three weeks. The decision to limit the number of video participants to four was based on previous research findings by Corrégé and Michinov (2021), which indicated that students in four-member groups exhibited higher learning gains compared to other group sizes. The subsequent interviewing of another group of five participants took two weeks. Two more students expressed interest via email after I began data analysis, so I had to reject them. All participants were University of Ottawa students who had completed *MAT 1320 - Calculus I*. *MAT 1320* is a core mathematics course typically taken by first-year students, serving as a representative sample of the broader mathematics student population. The course consists of Discussion Group and Lecture and covers concepts such as limits, continuity, derivatives, inverse trigonometric functions, definite integrals, etc. The lecture component generally allows more than 200 students, while the discussion sections (taught by teaching assistants) typically accommodate 20 to 30 students. Participants selected a pseudonym for themselves and were compensated monetarily for their participation. Here, I will refer to the participants in the first stage as video participants, and the participants in the second stage as interview participants.

The recruitment process did not differentiate between international and domestic students or native speakers and non-native speakers because many differences among participants are not attributable to their cultural or linguistic backgrounds, but to their personalities. For instance, an international student's quietness in class may be due to his or her introversions, whereas a domestic student's success may be due to his or her diligence; it would be premature to make

assumptions about these two students based on their backgrounds. Similarly, I made no assumptions about the opinions and perceptions of participants based on their backgrounds.

Stage 1

In the first stage, "the King" is a business major in her third year; she is a native Chinese speaker who has received secondary and post-secondary education in English. Diogenes is a fourth-year physics major; his native language is French and has been studying mathematics in French and English in Canada. Red is a third-year software engineering major; his native language is French and has been studying mathematics in French in Canada. Ray is a first-year student in mechanical and software engineering; his native language is Arabic, but he reports that his French is more fluent than Arabic; he has been studying mathematics in Arabic and French in Morocco before coming to Canada. Information about video participants is summarized in Table 1.1.

Table 1.1

Video participants' information

Names	**Majors**	**Years**	**Native language**	**Second and third language**	**Instructional language(s) of secondary education**
The King	Business	3rd	Chinese	English	English
Diogenes	Physics	4th	French	English	French and English
Red	Software engineering	3rd	French	English	French
Ray	Mechanical and software engineering	1st	Arabic	French and English	Arabic and French

Stage 2

In the second stage, Minnie majors in Second Language Teaching – Teaching French as a Second Language (FLS); her native language is English, and she was enrolled in a core French program in Canada. Lion studies mathematics in French; his native language is Serbian, but he is more fluent in English because of school and media. Bilti is studying software engineering in

French; his native language is Arabic, but he is most fluent in French and he has been studying mathematics in Arabic and French in Morocco before coming to Canada. Seer was a mathematics major but switched to communication after the first semester; she was studying mathematics in Chinese prior to university. Joe is in biomedical science; she grew up in Canada and her first language is Chinese, but she is now more fluent in English and speaks French as her third language. Information about the interview participants is summarized in Table 1.2.

Table 1.2

Interview participants' information

Names	**Majors**	**Years**	**Native language**	**Second and third language**	**Instructional language(s) of secondary education**
Minnie	Second Language Teaching – FLS	1st	English	French	English and French
Lion	Mathematics	1st	Serbian	English and French	French and English
Bilti	Software engineering	1st	Arabic	French and English	Arabic and French
Seer	Switched to Communication from Mathematics	1st	Chinese	English	Chinese and English
Joe	Biomedical science	1st	Chinese	English and French	English

Materials

For the first stage, I first collaborated with students and teachers of *MAT 1320* to develop a mathematics worksheet. This worksheet comprised 10 questions encompassing a range of mathematical topics from high school level to university calculus (see Appendix B). The questions were carefully categorized into three levels of difficulty: easy, medium, and difficult. Easy questions, such as finding the equation of the tangent line to a given curve at a given point, aim to motivate every student to contribute, whereas more difficult questions, such as finding the area enclosed by three curves, can reveal students' varying levels of competence, thereby

revealing their successes and failures.

Procedure

Links to a survey were first sent to interested participants. Participants were requested to provide their pseudonyms, as well as disclose their educational and linguistic backgrounds. Additionally, they were given the opportunity to arrange a suitable time for their participation in the research. The participants received emails containing prompts to aid their participation, one day prior to the scheduled time. Both stages of the research were carried out within a designated study room located on the university campus. Prior to commencing, all participants provided their signature on the consent form.

Stage 1

On arrival at the study room, four video participants sat in a semicircle and were given guidelines and discussion prompts (see Appendix C) to promote open discussion. Subsequently, one participant (Red) commenced the proceedings by vocalizing the first question. Red concluded his reading and then asked, "So, we have to find the equation of the tangent line?" Another participant (Diogenes), corroborated Red's question and proceeded to deconstruct the question in order to enhance its comprehensibility. Ray consistently displayed agreement with Diogenes by frequently nodding and employing affirming phrases such as "Yeah" and "Exactly" (Focus group with video participants, line 88). The King periodically asked questions and requested others to verify the accuracy of her work. Other questions were answered in a manner akin to the first: Red read the question, Diogenes offered suggestions and hints, Ray concurred, and the King listened. In between solving questions, the participants discussed their prior mathematical education. While they discussed the questions, I attempted to follow and comprehend their explanations in order to observe how their mathematical knowledge and language proficiency influenced their output. After completing six questions (see Appendix D), the participants decided to end the discussion, which lasted 46 minutes. During the course of the discussion, Diogenes dominated the majority of the speaking time, resulting in few opportunities

for other participants to contribute. Consequently, I decided it was necessary to remove many instances whereby Diogenes expounded upon mathematical concepts (e.g., “The domain of function is just the x values…”). The partial removal of Diogenes's contribution had minimal effect on his overall performance, as he still maintained his position as the most active participant in the final edited video; the level of participation exhibited by the other three participants experienced an increase. The period during which the participants worked on the questions silently was also removed. The final version of the 12-minute-and-11-second video was sent to the participants. Following the discussion, a focus group interview (see Appendix E for focus group interview questions) was conducted; video participants reflected on their performance in the discussion and shared their mathematics learning experiences. A group interview was chosen because it could be conducted immediately after the discussion.

Stage 2

In the second stage, I conducted individual semi-structured interviews with each of the 5 interview participants. Following the participant's signing of the consent form, I proceeded to disclose my personal experiences in multilingual and mathematics learning. This was done with the intention of establishing a sense of security and trust, thereby encouraging the participants to openly express their authentic thoughts and share their own experiences in a similar direction to what I said. Subsequently, the participant proceeded to watch the video without any form of interruption. The participant was then asked about his/her overall impressions of the video and his/her perceptions of each video participant. The objective was to determine how interviewees attributed the successes and failures of others. In the second half of the interviews, participants reflected on their mathematics learning experiences and discussed the factors that contributed to their own success or failure. Following the first two interviews, I felt that the interviewees' (Minnie and Lion) responses were overly general, only describing the discussion (e.g., “…everyone kind of figured out what they needed to do.”) (Interview with Minnie, lines 9-10) and missing comments on each individual. In the last three interviews, in order to elicit their opinions on the successes and failures of others, I re-exposed the interviewees to three video

segments and inquired about their thoughts on that particular moment. The three segments revealed that the video participants had varying levels of participation and English proficiency; consequently, the interviewees were able to comment on their successes and failures specifically. The interview questions (see Appendix F) centered on the mathematics classroom experiences of the participants and how they attributed successes and failures. The interview conducted with Seer was conducted in Chinese because she felt pressured when discussing in English; the interview was subsequently translated by the researcher.

Limitations

One source of weakness in this study was the small number of participants. During a period of two months, I received emails from only eleven potential participants. It is worth noting that two of these individuals only reached out after the data collection phase had already been completed. Despite having different linguistic backgrounds, none of the four video participants were native English speakers. One potential factor contributing to the lack of enthusiasm for participation may be the students' hesitance to engage in discussions regarding mathematical problems while being recorded on camera. As previously mentioned, certain prospective participants expressed their willingness solely to engage in Stage 2, wherein video recording was not included. Another potential factor may have been the students' lack of motivation to engage in mathematical discussions using their second or non-fluent languages. As an illustration, Seer expressed a preference for conducting the interview in Chinese, as she perceived a higher level of comfort in using this language. The participants in Hwang's (2023) study also acknowledged experiencing feelings of insecurity in their second language. There existed a potential scenario wherein numerous individuals lacking proficiency in the English language exhibited interest in participating in the study, yet experienced discomfort at the prospect of employing English and undergoing audio recording. In future investigations, it is imperative for researchers to acknowledge that the utilization of video and audio recordings may deter prospective participants. Additionally, whenever feasible, researchers should endeavour to facilitate participants to

share with individuals who possess mutual linguistic and cultural backgrounds. In the current study, Seer used Chinese words that could not be translated literally. For instance, the phrase "*Ti Hai*" would only be understandable to those who have lived in China for years.

Data analysis

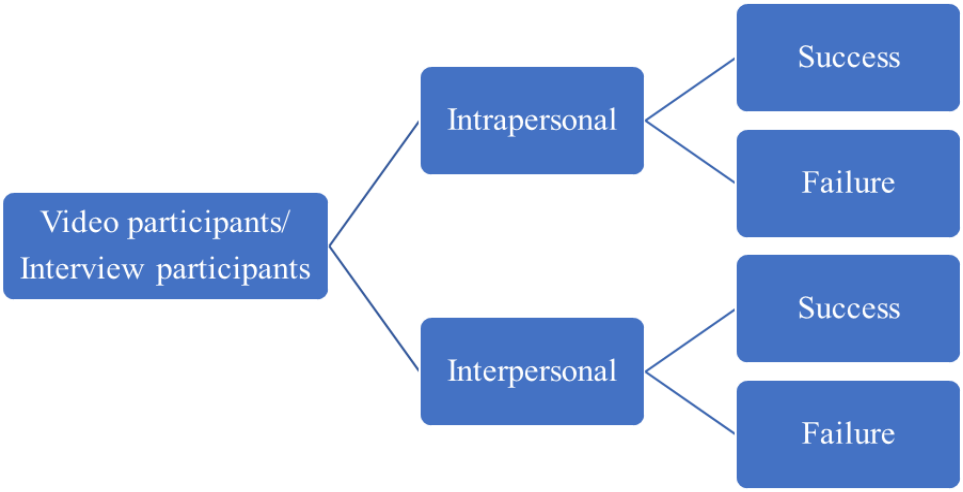
Analyzing the perceptions of participants is complex because it involves how an individual views, interprets, evaluates, and categorizes information (Bennett, 2016; Lindsay & Norman, 1977). The discussion, the focus group interview, and five individual interviews were transcribed and then analyzed. The data were organized and coded using NVivo. NVivo is software for qualitative data analysis that can organize and visualize data and concepts (Hilal & Alabri, 2013).

During the initial phase of coding, I endeavoured to determine which factor appeared most frequently when attributing successes and failures. As a result, I coded at the idea level and assigned each participant's response to a category based on an inductive framework. For example, when the participant said, “I find Calculus One is easy, everything I learned” (Focus group with video participants, line 107) I would assign it to “*Educational experience*” because he/she was attributing successes to prior mathematics learning experiences. And when the participant said, “I just think he wasn’t really confident answering the math questions in English…[because] he had this class in high school all in French” (Interview with Bilti, lines 42-44). I would assign it to “*Language and/or personality*” because he/she was making connections between language issues and personality. The rationale behind integrating language and personality into a unified theme stemmed from the frequent mention of these two constructs by the participants. Although participants frequently identified language or personality as potential causes, it remains unclear which factor they believed to be the primary cause. Additional research is required to investigate the causal relationship between them. After coding all the data, eight themes emerged: aptitude, communication, educational experience, effort, interest, lack of practice, language and/or personality, and luck. The eight themes effectively encapsulate the participants' perceptions regarding the primary factors that influence mathematical achievements and setbacks; nonetheless, they do not clarify the participants' specific attributions of mathematical successes and failures. By adopting Heider's Theory of Attribution, I began the second phase of coding with a deductive framework. I started by separating interview participants from video

participants. Each participant group was assigned two categories: *Interpersonal* and *Intrapersonal*. *Success* and *Failure* were then created as subcategories (see Figure 2).

Figure 2

The second phase of coding



Under each subcategory, three dimensions were created: *locus*, *stability*, and *controllability*. Within each dimension, all the codes were assigned to either external or internal, consistent or variable, and controllable or uncontrollable (see Figure 3). The definitions of the six attributes are defined in Table 2.

Figure 3

The 3 dimensions

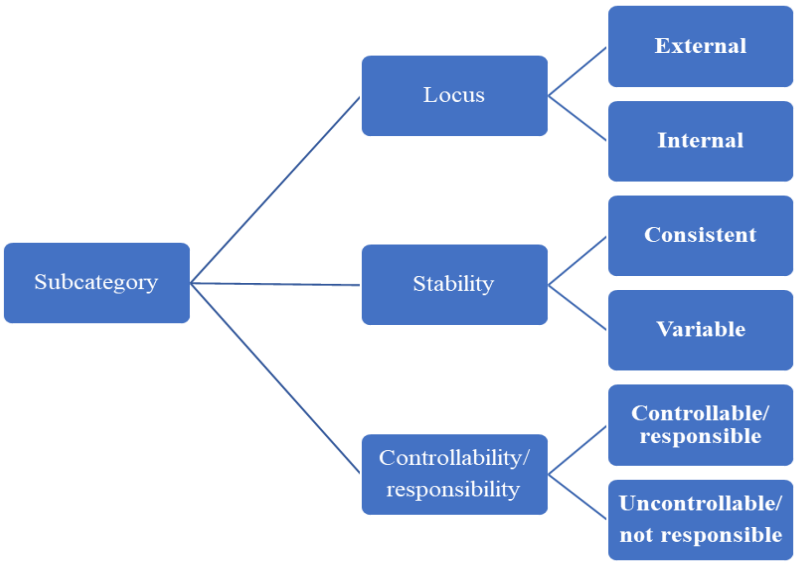


Table 2

Definitions of Attributes

Attributes	Definitions	Samples
External	The location of the cause is outside of the actor (Weiner, 2000).	The problem here is the math being easy in high school the problem is not in [the students] (Interview with Bilti, lines 138-139).
Internal	The location of the cause is within the actor (Weiner, 2000).	And I feel like some creative people would feel restricted by something like science or math where there is just one right answer (Interview with Lion, lines 102-104).
Consistent	The cause stays the same across time and modalities (Karaz & Perlman, 1975).	I think for a lot of people, their attention span is just lower, because our generation, technology and distractions (Interview with Lion, lines 184-185)…
Variable	The cause may change across time and modalities.	…[talking to people] helps me a lot…but in university, I never do that, I think it's because I don't know a lot of people. I think COVID had a play in it (Focus group with video participants, lines 218-222)…
Controllable	The cause is subject to volitional alteration (Weiner, 2000).	I just feel like, oh, [math] shouldn't be hard, so I didn't really study for midterm, but then I did pretty good, I got A plus. Oh it is easy, so I [didn't] study for it, then I failed my final. (Focus group with video participants, lines 108-110).
Uncontrollable	The cause cannot be willfully changed (Weiner, 2000).	I had no idea how to do this. I don't think I have EVER done that question like this (Discussion, lines 221-222.)

For example, Lion stated, “Yeah, in my free time, if I can, I would study, you know, math courses that I haven’t done yet, just cause I find them interesting” (Interview with Lion, lines 207-208). This code was initially assigned to intrapersonal-success because Lion was describing his own actions that contributed to his academic achievement. In addition, Lion described his behaviours as intrinsically motivated because he was interested in "math"; he also described his actions as long-lasting and consistent. Therefore, it was categorized as *internal*, *consistent*, and *controllable*. For an example of the coding manual, refer to Appendix G.

Chi-Square Tests

To determine whether the differences among the factors were statistically significant, the Chi-Square test was utilized. The null (H_0) hypothesis is stated as interview participants identified failures and successes at a similar frequency. For example, when attributing others’ failures, there were 12 references (N=12) for controllable factors and 38 references (N=38) for uncontrollable factors; however, if the interview participants had attributed others’ failures evenly, the numbers of references should have been 25 and 25.

Credibility

I employed two researcher strategies to strengthen the credibility of this study. The first strategy is prolonged engagement, which is "the process of building trust and rapport with informants to foster rich, detailed responses" (Cope, 2014, p. 90). Before the discussion and interview began, I shared with the participants my multilingual experience in mathematics classrooms. Second, I employed persistent observation, which allowed me to concentrate on the feelings and emotions of the participants. I was able to identify the diverse attitudes of the participants. These two approaches raised the study's breadth and depth (Lincoln & Guba, 1985).

The entire sentence or paragraph was coded instead of individual words to ensure the consistency of the coding. For instance:

> *Lion*: You know, there were some people who were able to get by without studying too much. I think that would just be like a natural talent. I know there was one guy in my class who was going into, umm, like social work or stuff, so he doesn't have to take math, he was just good at it. He just didn't want to continue with it. (Interview with Lion, lines 110-114.)

This paragraph was coded into the theme of *aptitude* based on the participant's personal opinion and example.

Results

This section provides two sets of findings in order to address the two research questions. The first part of the results enumerates the eight prominent themes that reflect the key aspects perceived by university students as influential in one's mathematics learning experiences within linguistically diverse environments. In this study, participants discussed their mathematics learning as a continuous process of acquiring knowledge over a period of time. The second set of findings pertains to the concepts of locus, stability, and controllability, within the theoretical framework of the Attribution Theory; several patterns emerged regarding how participants attributed their own successes and failures as well as those of others.

Emerged Themes

Eight topics emerged throughout the initial stages of coding (see Table 3).

Table 3

8 Emerged Themes

Themes	***Number of references***	***Percentage***
Language and/or personality	57	32.76%
Educational experiences	42	24.14%
Lack of practice/forgetting	23	13.22%
Effort	19	10.92%
Interest	13	7.47%
Aptitude	10	5.75%
Communication	6	3.45%
Luck	4	2.30%

One of the most important themes that emerged from the data was related to the participants' previous *educational experiences*. For example, Diogenes and Lion suggested that the secondary mathematics curriculum in Ontario was inadequate in equipping pupils for post-secondary study:

Diogenes: Yeah that's something I also notice all my students, all my classmates who are from other countries, or even from Quebec, they come in here and like: wow, this like first-year second-year math is kind of a joke. (Focus group with video participants, lines 95-97.)

Lion: I felt like they (high school mathematics teachers) were holding our hands through the course… (Interview with Lion, line 47.)

Lion: Maybe it's too easy in high school to get like a ninety-five on a calculus test versus now I can't do that now. (Interview with Lion, lines 54-55.)

Joe and Minnie, who also went to high school in Ontario, have indicated that they received supplementary assistance, which had a positive role in their mathematics accomplishments. Joe received assistance from her family members, who also sent her to after-school "practice classes," (Interview with Joe, line 62) and Minnie was taking "above-grade-level math" (Interview with Minnie, line 91) with excellent teachers. Bilti, Ray, and the King, individuals who pursued secondary education outside of Ontario, held the belief that previous experiences with mathematics facilitated a smoother acquisition of university-level mathematical concepts.

Bilti: I am doing good in university math, the transition from high school to university, for math, it was smooth for me; because the difficulty, I, the things I have studied in high school really helped me. (Interview with Bilti, lines 118-120.)

Ray: …in Morocco, we did like, it was the math was very hard, but you know when you know the methods and the things, when you come in university, so, so easy… (Focus group with video participants, lines 92-93.)

The King: I find Calculus One is easy, everything I learned. (Focus group with video participants, line 107.)

Seer: …math in China is simply harder than here. (Interview with Seer, lines 33-34.)

While Seer acknowledged the perceived difficulty of mathematics education in China compared to Canada, she did not consider herself to have been successful in her mathematics studies at the university level. Seer had a view that her attendance at an "international school" in China did not

confer any apparent advantages over her fellow Chinese peers, although the primary objective of the "international school" was to equip students for future studies overseas, particularly in countries such as the United States, Canada, and Australia.

Language and/or personality emerged as another significant element within the dataset. The reason for combining language and personality was due to the frequency with which these two concepts were mentioned together. Even though there is a strong correlation between language and personality (Hirsh & Peterson, 2009), it is unclear in this study which was the cause, and which was the consequence. During the discussion, Ray expressed a need for assistance in effectively expressing mathematical terminology in English.

Ray: So, it should be, umm, how to say this? (Focus group with video participants, line 179.)

During the interview, Bilti frequently associated Ray's challenges in communication with his timidity.

> *Bilti*: I just think he [Ray] wasn't really confident answering the math questions in English, because…he had this class in high school all in French. So, he is not used to seeing questions in English. (Interview with Bilti, lines 42-44.)
>
> *Bilti*: He [Ray] wasn't confident enough. He had ideas, really great ideas… He had correct answers, but the problem was his confidence. If he was confident like Diogenes, he would correctly give the answer and explain it without being hesitant. (Interview with Bilti, lines 110-113.)

Other interview participants also made reference to language and personality, but they expressed a lesser degree of certainty regarding the relationship between the two.

> *Joe*: [Red was active and vocal]. Umm, I am not sure if that's like a personality thing. (Interview with Joe, line 36.)
>
> *Joe*: [The King] She was quiet, yeah. I think she was less sure about herself, maybe less confident than some of the other ones were… I feel like, if you are not familiar with the language, you might be less confident, and that contributes to your personality. (Interview with Joe, lines 40-41, 116-117.)

Lion: …maybe she (the King) was shy, cause she wasn't saying much. (Interview with Lion, lines 20-21.)

Minnie: Diogenes seemed a lot more confident in, umm, even just speaking in English, whereas some most the other participants like Ray for example, seemed very hesitant in his choice of words. (Interview with Minnie, lines 19-21.)

Based on her personal experience, Joe also asserted that the *personality* of certain individuals undergoes a transformation when they communicate in different languages. For instance, her friends and she experienced a heightened sense of shyness when conversing in their non-native languages (French).

Joe: I know some people who are bilingual, their personality changes when they speak French versus English a little bit. (Interview with Joe, lines 117-119.)

In addition to discussing the relationship between personality and language, participants discussed the role language played in their mathematics education. Red acknowledged familiarity with certain concepts, albeit with a lack of exposure to their written form in English. The King commented that it was necessary for her to switch between languages when tackling mathematical issues of different levels of complexity.

Red: Like the math, math is same whatever language you use, so the problem is just like, uhh, the terms, they are gonna be different and you just have to get used to that. Uhh, like, you know there is a bunch of terms here like I didn't know, but then you explain it to me like, oh I have seen those concepts, I know those, I just didn't know like what they were like [in English]. (Focus group with video participants, lines 164-168.)

The King: Those easy ones, I will calculate in Chinese…But if I do calculus, I will think in English. (Focus group with video participants, lines 205-207.)

A number of interview participants also underlined the diverse range of language proficiency exhibited by the video participants.

Seer: I think the reason she (the King) rarely talked was language. (Interview with Seer, line

2.)

Joe: …but maybe [Ray's] terminology is not as on part with [Diogenes], because [Ray] might have learned math in a different language… (Interview with Joe, lines 5-7.)

Lion: …maybe [Ray] would've had more input, and then he didn't know how to explain it [in English]. (Interview with Lion, lines 23-24.)

Another prevalent theme observed was the *lack of practice*. All video participants indicated that they had experienced a decline in their knowledge of mathematical ideas due to non-usage, while interview participants further attributed their failings to a dearth of practice.

Bilti: …they forgot many things. I think that's because they lack of practice, they don't practice math regularly. (Interview with Bilti, lines 59-60.)

Joe: So it seems like, they all learned this, and to some degree maybe they forgot what they learned. (Interview with Joe, lines 11-12.)

Lion: …he had forgotten a lot of things. (Interview with Lion, line 5.)

Many participants also ascribed their personal achievements to personal *efforts*, while ascribing the failures of others to indolence and insufficiency of effort. For example:

Bilti: For me, I am just a normal person, studying, sometimes hard-working to get a good mark. (Interview with Bilti, lines 132-133.)

Bilti: But I don't understand people that say that Calculus II is impossible for example. For me, they are just lazy, lazy people that trying to find excuses, with all due respect. (Interview with Bilti, lines 127-129.)

Interestingly, the interview participants exclusively linked laziness with students in a general sense, rather than specifically attributing it to video participants or individuals they were personally acquainted with.

Lion: …it's all the mentality. For other people, maybe they don't have that drive, and they would rather be comfortable. (Interview with Lion, lines 90-91.)

A number of interview participants have expressed that there exists a positive association between academic performance and individual *interest*.

> *Joe*: …math is like, if you are good at it, then you like doing it more, and then if you like it, you practice more, and you get better… (Interview with Joe, lines 52-53.)

Nevertheless, the participants in the study did not provide specific details regarding whether success was the cause of increased interest or if it was the other way around.

The themes of *aptitude* (e.g., *Joe*: I have friends who vary a lot in math level, some of them are maybe naturally better at learning quickly…) (Interview with Joe, lines 44-45), *communication* (e.g., *Red*: …talking to people about problems, it helps me a lot.) (Focus group with video participants, line 218), and *luck* (e.g., *Bilti*: Luck it's like just a small portion of success.) (Interview with Bilti, lines 32) were not prominently demonstrated. Refer to Appendix H for additional information.

Locus, stability, and controllability

Upon comparing each dataset during the second phase of coding, the differences among the factors emerged. The Chi-Square test was utilized to determine if the differences were statistically significant. The null (H_0) hypothesis is stated as interview participants identified failures and successes at a similar frequency. If the Chi-Square value is greater than the critical value, the null hypothesis can then be rejected. If the Chi-Square value is smaller than the critical value, the null hypothesis cannot be rejected. Due to the small number of references, the Chi-Square test was only applied to interview participant data; video participant responses were not tested. The same procedure was carried out on all 4 sets of data (see Appendix I for details).

In this section, I will first present the number of codes (see Table 3.1, Figure 4, Table 3.2, and Figure 5) and Chi-Square values for each dimension (see Table 4). I will then provide examples of emergent patterns.

Table 3.1

Interview participants

Interview participants				
Categories / Causal properties	Interpersonal-Failure	Interpersonal-Success	Intrapersonal-Failure	Intrapersonal-Success
	Number of references	Number of references	Number of references	Number of references
Controllability-Controllable	12	6	2	10
Controllability-Uncontrollable	38	13	17	19
Locus-External	12	7	15	12
Locus-Internal	38	12	4	17
Stability-Consistent	22	7	2	9
Stability-Variable	28	12	17	20
Total number of references	**50**	**19**	**19**	**29**

Figure 4

Trend of codes--interview participants

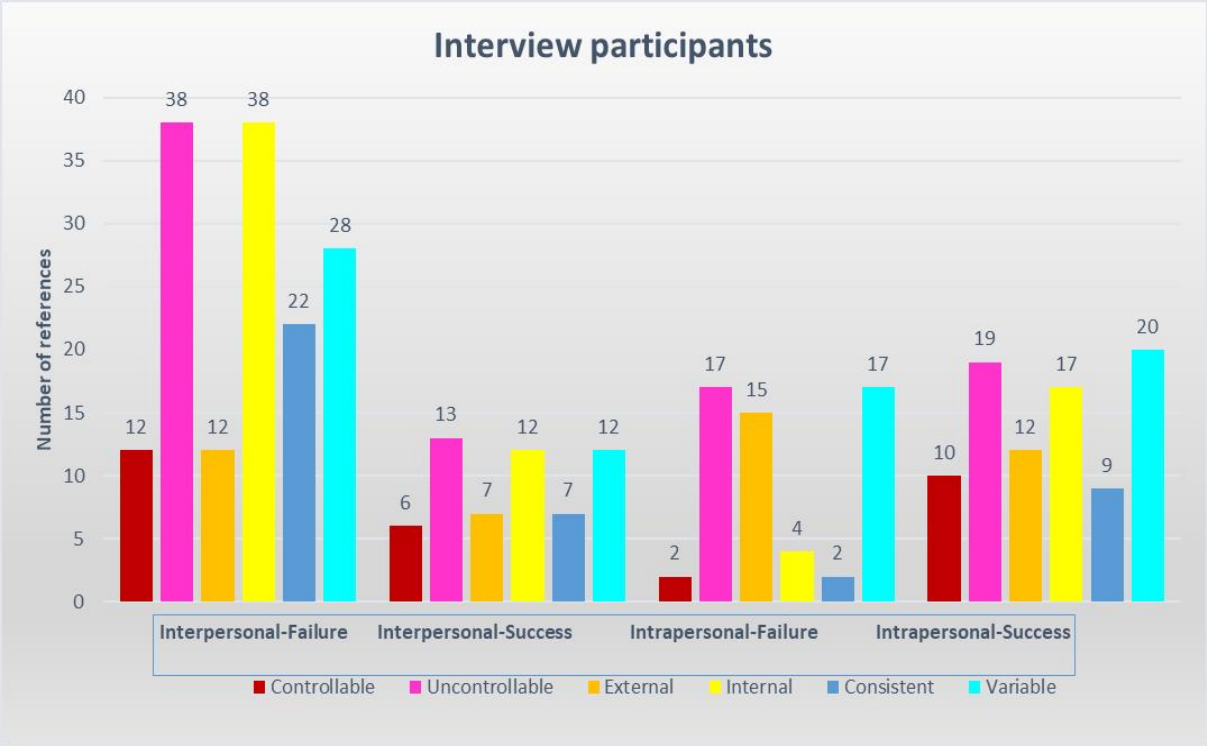


Table 3.2

Video participants

Video participants				
Categories / Causal properties	Interpersonal-Failure	Interpersonal-Success	Intrapersonal-Failure	Intrapersonal-Success
	Number of references	Number of references	Number of references	Number of references
Controllability-Controllable	0	2	2	5
Controllability-Uncontrollable	6	3	17	7
Locus-External	5	2	10	8
Locus-Internal	1	3	9	4
Stability-Consistent	0	0	4	0
Stability-Variable	6	5	15	12
Total number of references	**6**	**5**	**19**	**12**

Figure 5

Trend of codes--video participants

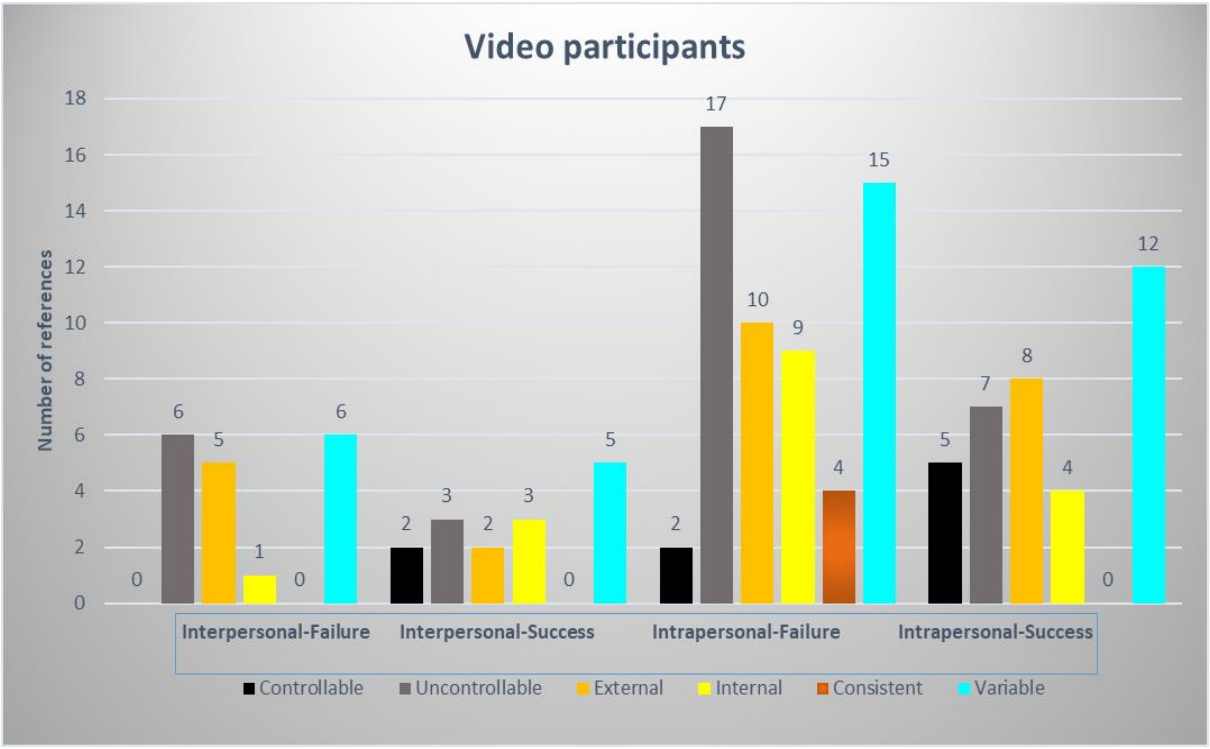


Table 4

Chi-Square values for all 4 sets of data

Chi-Square Values				
	Interpersonal-failure	**Interpersonal-success**	**Intrapersonal-failure**	**Intrapersonal-success**
Controllable vs. Uncontrollable	χ^2 (1, N=50) = 13.52 p<.001	χ^2 (1, N=19) = 2.58 p=.108	χ^2 (1, N=19) = 11.84 p<.001	χ^2 (1, N=29) = 2.79 p=.095
External vs. Internal	χ^2 (1, N=50) = 13.52 p<.001	χ^2 (1, N=19) = 1.32 p=.251	χ^2 (1, N=19) =6.37 p=.012	χ^2 (1, N=29) = 0.86 p=.354
Consistent vs. Variable	χ^2 (1, N=50) = 0.72 p=.396	χ^2 (1, N=19) = 1.32 p=.251	χ^2 (1, N=19) = 11.84 p<.001	χ^2 (1, N=29) =4.17 p=.0411
Degrees of freedom (df) = 2 - 1 = 1 Level of significance (α) = 0.05				
Critical value (cv) = 3.841				

How did participants attribute others' failure vs. their own failure (Interpersonal-Failure vs. Intrapersonal-Failure) during mathematical discussions in linguistically diverse university classrooms?

In examination of the number of codes, it suggests that interview participants spoke more about the failures of others (N=50) than their own (N=19); in addition, they attributed others' failures more frequently to uncontrollable factors than to controllable ones (see Figure 4). The Chi-Square test also confirms that it is unlikely that the difference was due to random chance ($\chi^2(1, N = 50) = 13.52, p < .001$). It is uncontrollable that one forgets or does not forget, and interview participants repeatedly asserted that video participants had forgotten mathematical concepts:

Bilti: …they forgot many things. (Interview with Bilti, line 59.)

Joe: So it seems like, they all learned this, and to some degree maybe they forgot what they learned. (Interview with Joe, lines 11-12.)

Lion: …he had forgotten a lot of things. (Interview with Lion, line 5.)

Also, interview participants attributed failures to luck, teachers, and schools:

Bilti: …sometimes, you know everything, but during exam, you have a tricky question, because you are unlucky, you couldn't answer it, because it's the only part you have little problems in it. (Interview with Bilti, lines 22-24.)

Joe: …and maybe [the professor] is not as organized as the first one. (Interview with Joe, lines 74-75.)

Lion: …I felt like [the school was] holding our hands through the course… (Interview with Lion, line 47.)

Since luck and the quality of teachers and schools are beyond one's control, they are categorized as uncontrollable.

In terms of external and internal factors, participants tended to attribute others' failures to internal factors ($\chi^2(1, N = 50) = 13.52, p < .001$) and their own failures to external factors ($\chi^2(1, N = 50) = 6.37, p < .012$). The distinction is exemplified by the following excerpt:

Bilti: …they are just lazy, lazy people trying to find excuses, with all due respect. They are just trying to find excuses for failure, instead of learning from this failure and doing better next time. (Interview with Bilti, lines 129-131.)

While Bilti attributed his occasional failures to exam difficulty, he was particularly critical of others' efforts, believing that they failed due to internal laziness. Similar patterns emerged in the responses of Seer:

Seer: I got a Chinese friend who dropped Calculus One…failed the first midterm…I think she is just not a math person, not suitable. (Interview with Seer, lines 62-64.)

Seer: Calculus One was hard for me. The professor was, well, not helpful…the teaching assistant didn't appear to be good at math…I think he lacks practice and preparation. (Interview with Seer, lines 47-51.)

Evidently, Seer believed her friend's failure was due to her friend's lack of aptitude, but she reported that her teacher and teaching assistant, both of which are external factors, did not facilitate her mathematical learning.

No significant difference was found between how interview participants attributed others' failure to consistent and variable factors ($\chi^2(1, N = 50) = 0.72, p = .396$); however, they favoured variable factors when evaluating their own failure ($\chi^2(1, N = 50) = 11.84, p < .001$). A notable example is:

Lion: …first semester, [I was] just getting used to the university workload…they were just pushing you more in university. I feel like semester one was pretty bad for me and then semester two is good… (Interview with Lion, lines 56-59.)

Similar to Bilti, who stated that exam difficulty could vary, Lion attributed his failure in the first semester to variable factors; as he adapted to the university workload, he was able to succeed. One of the video participants expressed the belief that her performance in her mathematics class could have been improved had the professor offered solutions to the exams.

The King: There is one more, one more [inaudible] that we do final and midterm, but we get our paper return, it's still the wrong answer we get, like we don't get any correction. (Focus group with video participants, lines 244-246.)

How did participants attribute others' success vs. their own success (Interpersonal-Success vs. Intrapersonal-Success) during mathematical discussions in linguistically diverse university classrooms?

Contrary to how they attributed failures, interview participants spoke more about their own successes (N=29) than others' successes (N=19). However, the Chi-Square values did not indicate any preferences with the exception of whether the participants attributed their own success to consistent or variable factors ($\chi^2(1, N = 50) = 4.17, p = .0411$). For example:

Joe: I guess like, background, because I have people who are able to help me, or as, when I was learning as a kid I had people to help me. The amount of effort you put in [to study] for sure, and then, also because, resource-wise, I am able to do a lot of online searches or use like videos to help me. Some people who don't know how to use these things, or don't have access to these things… (Interview with Joe, lines 179-183.)

Bilti: For me, I am just a normal person, studying, sometimes hard-working to get a good mark. (Interview with Bilti, lines 132-133.)

Lion: Yeah, cause I have been adjusted to the university workload. (Interview with Lion, line 61.)

The three excerpts demonstrate that the participants attributed their success to their own efforts, the resources they had access to, and their ability to adapt quickly; all of these factors are variable because they are susceptible to internal and external change. They would not have been academically successful if they lacked assistance, chose not to work hard, or were unable to adjust to the university workload. Other participants also mentioned additional variable factors, such as altering their mindset and adopting effective learning strategies. Conversely, participants spoke less about consistent factors that contributed to their success. A few participants attributed their accomplishments to language and talent.

Bilti: …for me, it's not necessarily a barrier… (Interview with Bilti, lines 92-93.)

Bilti: French is similar [to English] with letters and the way you write. (Interview with Bilti, line 100.)

Joe: I guess similar languages help you to be more, like, you might be able to guess what certain words mean, even it's not their native language. (Interview with Joe, lines 134-135.)

Ray: …in English, like there is some words understandable, so it's OK. It's the same in French. (Discussion, lines 108-109.)

Minnie: Also, when I was younger, I was a gifted student. (Interview with Minnie, lines 90-91.)

Minnie: I think it was like an aptitude thing. (Interview with Minnie, line 95.)

Bilti, Joe, and Ray did not discuss a person's proficiency in the instructional language; rather, they focused on the similarity between a person's native/fluent language and the instructional language. Given that a person's native or fluent language and aptitude are not easily modifiable, at least within a short timeframe, these attributes are regarded as consistent.

How did participants attribute others' failure vs. others' success (Interpersonal-Failure vs. Interpersonal-Success) during mathematical discussions in linguistically diverse university classrooms?

In examination of the frequencies of data, it suggests that interview participants exhibited a

greater tendency to discuss others' failures (N=50) than others' successes (N=19). In spite of the lack of a preference for attributing the successes of others, interview participants displayed different attitudes. Bilti appeared to be highly appreciative of the efforts of others, as he put it,

> *Bilti*: Oh, firstly, hard work! To achieve this, people can say that he's just naturally smart, but I don't believe in that. (Interview with Bilti, lines 14-15.)
>
> *Bilti*: …but hard work is necessary. It's the key to be like [Diogenes], to know every question. (Interview with Bilti, lines 16-17.)

Bilti used a complimentary tone to express praise and admiration. Although not as impressed as Bilti, other participants also used an encouraging tone and attributed others' success to intrinsic motivation and effort:

> *Joe*: …math is like, if you are good at it, then you like doing it more, and then if you like it, you practice more, and you get better… (Interview with Joe, lines 52-53.)
>
> *Lion*: And they just disciplined themselves and got into a routine where they are not like wasting their time as much, and they can manage time better that they can do university job this and that. (Interview with Lion, lines 196-199.)
>
> *Minnie*: It could be that [Diogenes] did say that he uses the math still all the time, so he is very comfortable with it. (Interview with Minnie, lines 50-51.)

In contrast to other participants' views, Seer displayed a different attitude when commenting on her peers' successes:

> *Seer*: …[my friend] is really good [at math] and helps me a lot. I think that's only because the "Ti Hai" strategy in China trained her… (Interview with Seer, lines 32-33.)

"Ti Hai" literally means "sea of exam questions" in Chinese. In a figurative sense, the "Ti Hai" strategy refers to a technique of learning that requires students to repeatedly and exhaustively practice exam questions without regard to their quality and efficiency; a comparable strategy would be "rote learning." The Ti Hai strategy is frequently accompanied by an exhaustive curriculum (Chen, 2014). The term is typically derogatory and is frequently used to mock diligent students (YIM, 2022). In addition, Seer lowered her voice as she articulated the term, as

if she were saying something inappropriate. Overall, Seer did not believe that her friend's hard work and effort were intrinsically motivated; rather, Seer believed that her friend was "trained" by an external force, whereas other participants believed that others worked hard out of their own volition.

How did participants attribute their own failure vs. their own success (Intrapersonal-Failure vs. Intrapersonal-Success) during mathematical discussions in linguistically diverse university classrooms?

Examining the frequencies of the data indicates that interview participants spoke slightly more about their successes (N=29) than their failures (N=19). Also, compared to how they attributed their failures, interview participants attributed their successes to controllable and internal factors much more frequently.

> *Lion*: …because for me, when something difficult comes I see as a challenge. (Interview with Lion, lines 89-90.)
>
> *Lion*: …I am a bit more like anti-tech, like I don't really use my phone that much. All of my hobbies are outside of technology, so for me, it's easier to just sit down and focus. (Interview with Lion, lines 187-189.)

These excerpts demonstrate that Lion attributed his success to his ability to concentrate, control his actions, and view difficult learning tasks as challenges without the influence of others.

Moreover, participants displayed preferences in all three domains (locus, stability, and controllability) when attributing their own failures.

> *Lion*: In university, I started studying off textbook because that's what I was doing in high school, and I did terribly because the textbook was a bit more random…[the tests] were all like the hardest example of the problems. (Interview with Lion, lines 48-52.)

In this excerpt, Lion indicated that he had relied on textbooks to study mathematics, but that the problems in the textbook were too random and the test questions were too difficult; since neither factor was within Lion's control, this was deemed uncontrollable. Another illustration is as

follows:

> *Seer*: Well, I was excited to learn at first, as a first-year student. But the professor looked exhausted and worn out. (Interview with Seer, lines 53-54.)

Both Seer's and Lion's responses were coded as external because textbooks, exams, and teachers were beyond their control. Additionally, Seer admitted that she was enthusiastic at the start of her college career and implied that she had become more impassive. This shift in perspective rendered the factor variable. In a similar manner, the King asserted that the change in the level of difficulty of the examination resulted in her failure.

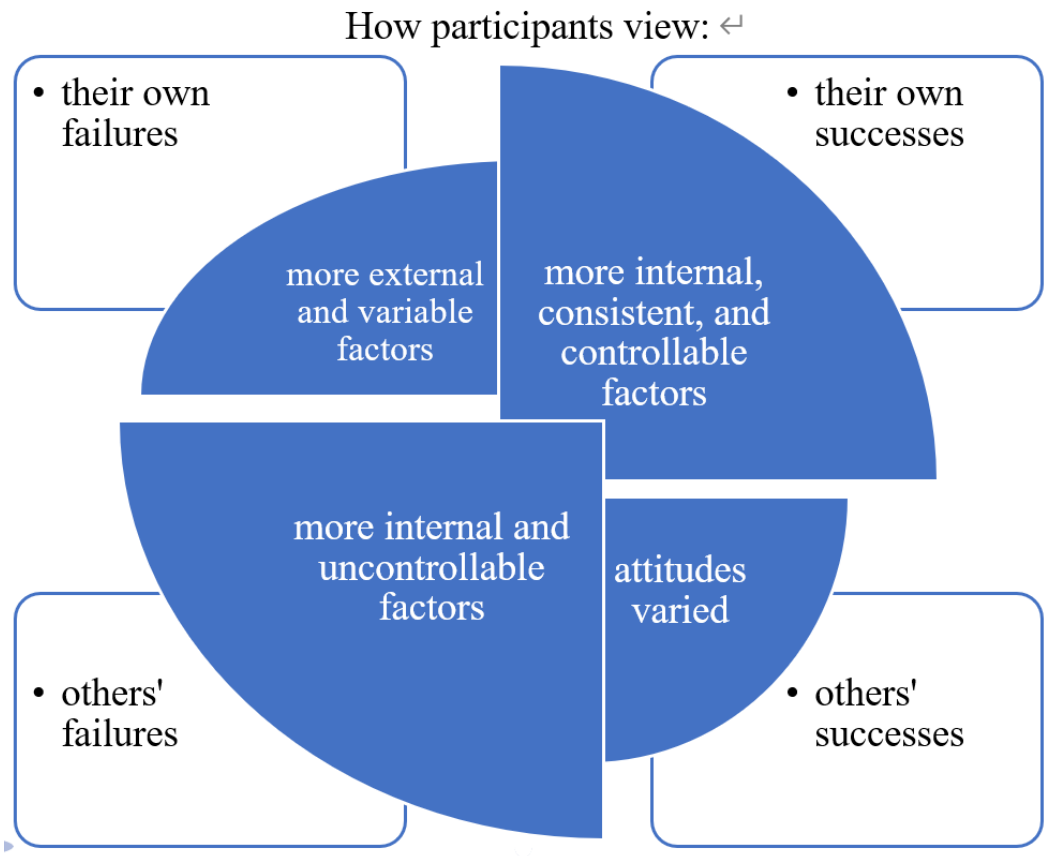
> *The King*: I just feel like, oh, it [math] shouldn't be hard, so I didn't really study for midterm, but then I did pretty good, I got A plus. Oh it is easy, so I don't have to study for it, then I failed my final. (Focus group with video participants, lines 108-110.)

Summary

The results are categorized into two parts: themes and patterns. The eight themes encapsulate the predominant reasons identified by participants when attributing successes and failures, thereby emphasizing the perceived influential factors in mathematics learning. Prevailing themes include *educational experiences*, *language and/or personality*, *lack of practice*, *effort*, and *interest*. The diverse patterns illustrate the ways in which participants attributed their own and others' successes and failures. Overall, the interview participants discussed others' failures more than their own failures, their own successes more than others' successes, others' failures more than others' successes, and their own successes more than their failures. In other words, participants appeared to discuss their successes and others' failures more. When discussing their own successes, participants emphasized internal, consistent, and controllable factors. Participants placed greater emphasis on external and variable factors when discussing their own failures. When discussing the failures of others, participants stressed internal and uncontrollable factors. Participants' attitudes varied when discussing the successes of others. Figure 6 depicts the patterns that have developed from the collected data.

Figure 6

Patterns Emerged



Discussion

The first section will discuss the influential factors pertaining to the process of mathematics learning. The subsequent section will analyze the patterns observed in participants' attributions of both their own and others' achievements and setbacks.

Influential Factors in Mathematics Learning

This study identified eight factors that participants perceived to have a significant impact on mathematics learning in linguistically diverse settings. The participants' frequent mention of personality with language (N=57) is arguably the most intriguing finding. For example, a number of interview participants held the perception that Ray and the King exhibited introverted and unconfident traits due to their comparatively limited English language proficiency. Joe also identified herself as "shy" when communicating in her non-fluent language, French. The absence of personality assessments made it challenging to adequately explain this outcome; however, insights may be gleaned from the responses of other participants in the present study. In the second stage, Minnie and Lion, both proficient English speakers, reported that they were unwilling to speak in French-taught classes out of fear of being judged for their lack of language proficiency. Hence, it is plausible that the aforementioned participants, namely Ray, the King, and Joe, may have encountered instances of discrimination from other proficient speakers, thereby exacerbating their reluctance to engage in verbal communication. Over time, this initial reluctance evolved into a consistent pattern, thus influencing their personality and manifesting traits such as shyness and introversion, which prevented students from participating in mathematical discussions. There exist similarities between the findings obtained in the present study and those reported by Iheduru-Anderson (2020); a participant reported experiencing fears regarding potential judgement and disapproval of her leadership position due to her skin colour and accent. Coppinger and Sheridan (2022) also found that English learners enrolled in a French university expressed fears regarding potential negative evaluations from their peers, leading to anxiety. Consequently, a subset of students may not derive advantages from participating in

discussion within linguistically varied settings. To solve this problem, Diogenes set an excellent example by encouraging others to explain their solutions. During the discussion, Diogenes said he was “curious” (Discussion, line 156) to see Ray’s approach to a specific question, prompting Ray to provide a comprehensive and constructive explanation. Also, when Ray struggled with mathematical terminology in English (e.g., …but in Calculus Two, we have, umm, I don't know how in English we say, serie et suite?), other participants were willing to assist him. These instances are in accordance with the concept put forth by Szydlik (2015), positing that student-led discussions possess the capacity to alter the dynamics within mathematics classrooms. According to Szydlik (2015), the approach encourages a more inclusive and empowering perspective, wherein the comprehension of mathematics is cultivated through the collective endeavours of a cohort of students. Furthermore, it presents a challenge to the conventional notion that the legitimacy of mathematical principles is exclusively derived from the instructor's expertise.

Another intriguing discovery regarding language is the diverse linguistic repertoires that some participants could employ during mathematical discussions. Ray, a fluent French speaker, stated that certain English mathematical terms were "understandable" because they were "the same in French;" Diogenes, a native French speaker, remarked, "Yeah, fortunately, lots of the famous mathematicians and physicists are French" (Discussion, lines 110-111). The participants' answers align with the findings of Bruen and Kelly (2017), who observed that non-native English speakers held a perception of having an advantageous position relative to native English speakers, despite the language of instruction being English. Bozbıyıka and Morton (2023) also noted that the use of multilingual resources could be advantageous for university instructors when creating illustration sequences. In addition, the comprehensive utilization of students' linguistic repertoires can effectively facilitate the achievement of learning objectives and promote the development of students' cultural and linguistic identities (Stille & Cummins, 2013). Hence, it is crucial to recognize the linguistic assets that students possess upon entering educational institutions (Preece & Martin, 2009). Nonetheless, the challenge is the tensions

"within faculty perspectives between recognizing the legitimacy of students' language practices on the one hand, and upholding institutional language norms and standards on the other" (Van Viegen & ZappaHollman, 2020, p. 179). According to a participant, Lion, in the current study, he expressed his perception that his teaching assistant appeared to be "angry" (Interview with Lion, line 289) at him due to his comparatively lower level of proficiency in the French language. The teaching assistant's attitude may have been influenced by the dedication to maintaining linguistic norms within the classroom. This occurrence is not uncommon, as Lion observed that he and his peers have experienced multiple situations where individuals displayed contempt towards their proficiency in the French language. This matter holds significant gravity as it has the potential to discourage individuals with an interest towards the French language, or even foster a sense of aversion towards it.

The analysis reveals that the theme of *educational experiences* emerges as the second most frequently mentioned factor in the dataset. The perceptions of the participants' previous mathematical learning experiences constituted a notable distinction. The participants who had attended high school in Ontario expressed a general perception that their previous mathematics education did not adequately prepare them for college. For example, one participant was especially critical of the mathematics curriculum (e.g., … I am really disappointed with the Ontario Curriculum for mathematics, like it's very inadequate to me.) (Focus group with video participants, lines 79-80). On the other hand, participants such as Bilti, Ray, the King, and Seer perceived their mathematics learning in foreign countries as being more challenging, rigorous, and effective. Bilti, for example, mentioned that the topics studied in his high school education greatly assisted him in his academic pursuits. This discrepancy may partly be explained by the comparatively lower requirements for high school mathematics teachers in Ontario, as noted by Stokke (2015). There is a potential correlation between high school teachers who lack completion of university mathematics courses and their ability to establish connections between the subject matter they are teaching and other mathematical concepts emerged in college. Consequently, this may result in inadequate preparation of students for the demands of

university-level mathematics. In addition to the influence of teachers, it is probable that certain international students were, in a certain way, “properly” streamed before college. Chinese high school students are required to make a decision between pursuing studies in the liberal arts or science departments in their first year of education (Li, 2023). Similarly, Moroccan high school students are provided with the opportunity to opt for a core curriculum focused on mathematics education (Education System in Morocco, n.d.). Since students who studied in the science department or followed a math-intensive curriculum are more likely to pursue math-related majors in foreign colleges, they may have an advantage over those who were improperly or not at all streamed during secondary education. While it is true that Ontario had also implemented streaming prior to 2021, it is worth noting that students enrolled in the Applied stream had limited options and were more likely to feel that the school offered no value for them, leading to a higher likelihood of dropout (Understanding De-streaming, n.d.). Comparatively, streaming in China or Morocco places a different emphasis while remaining unrestrictive to students' options for employment or education. Further investigation is needed to explore and contrast various streaming methodologies across regions.

While the frequency of the theme of *communication* was comparatively lower than other themes, it holds significant implications for effectively facilitating mathematical discussions. According to the participants, teaching and tutoring in a group discussion are considered the most effective methods of learning due to the reinforcement of knowledge. The proposed solution has the potential to address the inherent tension between teaching individuals and engaging the entire class. In instances where the size of a class exceeds optimal levels, instructors frequently have the difficulty of effectively engaging every student in the class. Through the use of student-led discussions, the classroom is partitioned into multiple smaller groups, hence facilitating more student engagement and participation. However, instructors must be cognizant of the possibility that a single student will dominate the discussion. In the current study, Diogenes spoke the most, but he continuously encouraged others to contribute. His expertise as a teaching assistant enabled him to stimulate thought and participation in others. Had

Diogenes not allowed room for others to participate, the discussion would have devolved into a commonplace lecture, wherein just a single student would have engaged in talking. Furthermore, it is imperative for instructors to foster an environment that encourages students to actively engage in questioning. According to the participants in the current study, it was emphasized that actively seeking assistance rather than passively waiting for answers is a crucial aspect of facilitating the learning process in mathematics. Frequently, students, particularly those with lower academic performance, exhibit a tendency to abstain from engaging in discussions due to a perception that their contributions lack value. Nevertheless, it is equally important to ask questions during a discussion. The study brought forth significant concerns that mathematics instructors should be mindful of. The primary issue that emerged was the tension between the desire to maintain a focused discussion and the inclination to permit students to make impromptu contributions that they considered to be relevant (Lampert, 2001). During the discussion, the participants periodically digressed from the worksheet and engaged in conversations relating to their prior experiences with mathematics education. While these talks were found to be beneficial to the overall study, they also resulted in a decrease in the efficiency of the discussions. Second, one participant believed that discussions were only beneficial when there was "someone who [understood] the concept." Hence, it is recommended that instructors intentionally allocate one to two students with above-average academic performance to each student-led discussion group.

This section examines various significant factors that influence the acquisition of mathematical knowledge among students. The intricate relationship between language and personality suggests that students' personality and willingness to communicate in their non-fluent languages may be affected by their fear of being judged. The responses provided by the participants also demonstrate the advantages of students' varied linguistic repertoires. However, it is important to note the tension between acknowledging the legitimacy of students' language practices and preserving the language norms. The participants expressed criticism towards the mathematics education in Ontario, possibly attributing it to the comparatively lower

qualifications required for high school mathematics teachers in the province. There is also a possibility that the streaming system in Ontario may have been insufficient. Finally, the findings underscore the significance of engaging in group discussions while also shedding light on the challenges associated with their facilitation.

Differences in Attributing Successes and Failures

The findings of this study indicate that students in linguistically diverse university classrooms exhibited different patterns in attributing their own and others' successes and failures during mathematical discussions. The participants demonstrated a pronounced cognitive bias that aligns with the characteristics of the Fundamental Attribution Error (FAE). When participants perceived both their own and others' failure (*Interpersonal-Failure versus Intrapersonal-Failure*), they were more likely to attribute others' failures to internal factors and their own failures to external factors. The results presented in this study are consistent with the conclusions drawn from previous research on FAE. According to Riggio and Garcia (2009), undergraduate students tended to attribute the causes of a “bad day” (p. 2) more to dispositional factors rather than situational factors. One potential rationale for this cognitive bias could be individuals' inclination to ascribe accountability to observed factors rather than unobserved factors (Edwards & Edwards, 2022). In the current investigation, the individuals who participated in the interviews possessed knowledge solely about the video participants as depicted in the video clip, while remaining uninformed about their individual circumstances. For instance, the interview participants (acting as observers) were unaware that one of the participants in the video had not been exposed to the concept of integrals during their high school education, unlike the rest of the video participants. As a result, the interview participants exhibited a higher tendency to attribute failures to the element that was observed, namely the individual. However, upon introspection on their own failures, they were able to identify discernible elements such as the inherent complexity of the academic tasks and the guidance provided by their instructors.

In accordance with prior literature (Taskiran & Aydin, 2018), the present study observed that

participants exhibited a tendency to attribute their personal achievements to variable factors, such as effort and external support. Furthermore, existing literature has indicated that accomplished students tend to place emphasis on internal factors, such as aptitude and effort (Benzehaf et al., 2018; García, 2021). It is noteworthy to observe that the participants exhibited varying attitudes when assessing the accomplishments of others. The majority of participants expressed appreciation for the personal efforts of others; however, Seer showed a contemptuous attitude. First, while other participants' statements were similar to "She/He worked hard, so she/he succeeded," Seer claimed that her friend was *being trained*. When referring to what *trained* her friend, Seer used the derogatory term "Ti Hai." She seemed to hold the belief that her friend's success was only a result of the traditional Chinese learning technique (*Ti Hai* strategy) and stressful mathematics curricula, and implied that her friend should not receive credit for her academic success. Second, Seer's voice was passive and lowered, as if she were speaking something impolite. As someone who possesses a shared cultural background with her, I am confident to believe that it was because she was aware that the term was derogatory and that her friend would not be pleased to hear this attribution. In general, Seer did not regard her friend's success as being valuable or consistent, but rather as transitory and devoid of significance. Seer's negative attitude may have been influenced by her bias against students enrolled in traditional educational institutions in China. These students are frequently viewed as lacking "the abilities of independent and critical thinking, problem solving, and innovation" (Education in China, 2019, Section 4). As a result, Seer perceived her friend’s academic success as less praiseworthy. However, Seer did not praise the “non-traditional” educational institutions in China, either. Seer attended a well-funded international school situated in South China. Such international schools, in contrast to traditional schools, primarily employ English as the medium of instruction (Bunnell et al., 2016). These educational institutions, often established in countries where English is not the primary language, are anticipated to provide students with an above-average level of education (ISC, 2014) through an instructional methodology that prioritizes student engagement and aligns with their individual interests. The potential enhancement of students'

preparedness for studying abroad could be achieved through the implementation of foreign curricula in international schools. Ironically, Seer was not adequately prepared for university mathematics. The mathematics education offered by Seer's high school was deemed inadequate in terms of its competitiveness, as Seer perceived it to be too “relaxing.” After comparing her responses, it can be seen that Seer was critical of the overburdening curriculum in Chinese traditional schools, but at the same time, blamed “international schools” for their lack of competitiveness. She also attributed her personal academic failings in university to professors and teaching assistants. To conclude, Seer tended to attribute both successes and failures to the environment. The intriguing outcome can be partially attributed to the holistic mindset observed among individuals of East Asians (Norenzayan & Nisbett, 2000). According to the researchers, the East Asian mentality places emphasis on the context in which the object/person is situated and attributes causation based on the interplay between the object/person and its surrounding environment. In contrast, “Westerners” (p. 134) are more inclined to perceive causality as an inherent quality of the object or person itself. The primary factor contributing to this cultural difference can be traced back to ancient civilizations. The researchers indicated that ancient Chinese societies adopted a collectivist social structure whereas countries such as ancient Greece were more individualistic and less field-dependent. These social psychological elements continue to endure in contemporary times (Norenzayan & Nisbett, 2000). However, it is important to consider that Seer's attributions may have been influenced by additional factors, including personality traits. Further investigation is required to provide a clearer understanding.

Moreover, the level of participation of video participants affected how they were perceived. According to the interview participants, Diogenes and Red were the most active, while the King and Ray were the least active. It was also believed that Diogenes and Red possessed exceptional proficiency in the English language, as there were no comments made regarding their linguistic abilities. The King and Ray were perceived as less fluent English speakers with "some language problem." During the discussion, Ray was "definitely on the quieter side" (Interview with Joe, line 4); it was only after repeated encouragement from other participants that he spoke at length

about a particular question. Ray's comprehensive and precise explanation engendered a positive perception of his competence, with his accomplishments being ascribed to his diligence, educational background, etc. Without this component, Ray would not have been viewed as an academically successful student. The King, on the other hand, "wasn't saying much" and was unable to explain her thought process. While the interview participants refrained from explicitly characterizing the King as lacking mathematical competence, they expressed uncertainty regarding the factors contributing to her achievements or failings. For instance, Bilti felt ambivalent about the King's lack of participation. In addition to the impact of language proficiency on the participation of participants, their perception of how others would perceive them may also have a potential influence on their level of participation. According to previous research (Dallimore et al., 2004; Rocca, 2010; Wade, 1994), students who actively engage in discussions believe their peers find their ideas valuable, leading to increased motivation to participate. In the present study, Ray displayed a high level of confidence in the accuracy of his proposed solutions, which subsequently increased his willingness to actively engage. Ray may have come from a classroom environment in which the instructor had a similar linguistic background (i.e., French) to him, whereas the King did not. According to Henson and Denker (2009), when students perceive their instructors to have similar backgrounds, they are more likely to participate. Although the reasons for their varying levels of participation are uncertain, the level of participation affected how others attributed their successes and failures.

This section initially examines the tendency to attribute the failures of others to internal and dispositional factors, while attributing one's own failures to external and situational factors. This pattern aligns with the concept of the FAE. Next, the examination focuses on the attitudes of participants towards the achievements of others, possibly influenced by the cultural context of the individual. Finally, the researcher posited that the degree of participation could potentially influence the perception of the "actor" by others.

Unexpected Findings

These findings are not directly related to the research questions, but they have implications for future investigations.

Native language vs. Fluent language

In the present study, eight of the nine participants could not be simply categorized as "native speaker" or "nonnative speaker" of a particular language; rather, their linguistic profiles required much more specific descriptions. The majority of the participants indicated that their native or home language was not their most proficient. Bilti and Ray's native tongue is Arabic, but they are more fluent in French; Joe and Lion are more proficient in English than in their native tongues. Diogenes, a native French speaker, is more comfortable with the English language when solving and contemplating mathematics, and the King stated that she preferred to use English when solving more advanced mathematics. These results indicate that multilingual students can be fully proficient in the instructional language despite the fact that it might not be their native tongue. Nonetheless, some studies continue to link multilingual students with a lack of instructional language proficiency. As illustrated by the literature review, the study conducted by Marian et al. (2013) revealed that bilingual elementary pupils exhibited superior performance on mathematics assessments compared to their monolingual counterparts. Although the researchers used a detailed questionnaire (Marian et al., 2007) to characterize the linguistic profiles of the participants, they failed to account for the possibility that some participants' first languages may have deteriorated, especially among those who learned English in early childhood. In addition, Kleemans and Segers (2020) identified L2 learners based on their home language use. The researchers failed to consider the possibility that the child's mastery of the Dutch language surpassed their skill in their home language. Hartanto et al. (2018) also relied solely on participants' home languages (other than English) to determine bilingualism. This approach made the assumption that individuals who were bilingual had a lower level of familiarity with the English language, and it also eliminated bilingual pupils who had English as their first language.

It is possible that these bilingual individuals were on par with the monolingual English speakers in terms of their command of the language. However, the researchers made the assumption that bilingual participants would possess a lesser level of English ability compared to monolingual participants.

This finding provides insight for recruiting participants in linguistically diverse settings, as the linguistic profiles of many potential participants are complex. For instance, if a study attempts to only recruit native speakers of a language to investigate how they acquire a second language, the researchers must carefully consider what it means to be "native." If being a "native speaker" means being exposed to the language after birth first and speaking it as part of one's childhood development, then the number of eligible participants would be very small (only one participant in the present study would be eligible). If being a "native speaker" only refers to being perfectly fluent in a language, then the various ways in which participants acquired high language proficiency could potentially distort the results. Liddicoat (2016) maintained that the classification of individuals as "native" or "nonnative" speakers has become complicated in contemporary times due to the diverse ways in which people acquire languages. Moreover, Gao (2014) contended that the stress placed on the concept of "native speakers" can potentially establish a hierarchical structure that bestows greater authority and higher status upon them.

This subsection explores the complicated linguistic environments found within university mathematics classrooms. The responses from the participants' suggest that multilingual students have the potential to achieve full proficiency in the instructional language, even if it is not their native tongue. Nevertheless, certain researchers continued to hypothesize that bilingual participants would exhibit a lower proficiency in English in comparison to their monolingual counterparts. While this particular section may not have a direct correlation to the research questions, it is crucial for researchers and educators to exhibit awareness regarding the varied linguistic backgrounds of students.

Complex linguistic and educational profiles of students

This study is a snapshot of a wider picture depicting the intricate linguistic and educational profiles of university students in Ottawa, Canada. Participants, such as Diogenes and the King, frequently employed different languages in their pursuit of studying mathematics and science disciplines. The educational backgrounds of the two Chinese international students are also multifaceted. One of them had previously pursued studies in Uganda before arriving in Canada, while the other had attended a Chinese "international school." While it is commonly presumed that Chinese international students excel in mathematics due to the ability of their teachers and the Chinese mathematics curriculum and policies (Wang & Lin, 2005), these two participants did not appear to have superior mathematics understanding. Hence, it is imperative for mathematics researchers and educators to refrain from making assumptions about students' linguistic and educational backgrounds without conducting thorough investigations.

French-taught classrooms

The participants' negative experiences in French-taught mathematics courses were another unexpected finding. Two proficient English-speaking participants expressed uneasiness regarding the opinions of other competent French speakers; one participant went as far as asserting that he was subjected to perceived rudeness from others due to his limited skill in French. Shockingly, one of the individuals who was "rude" (Interview with Lion, lines 255) to the participant was a university teaching assistant. The situation described is disconcerting given that the university's stated objective is to advance principles of equity, diversity, and inclusion; yet a student has encountered instances of discrimination from a member of the faculty. The sole focus on the experiences of non-native English speakers in English settings, while neglecting those of native/fluent English speakers, serves as a reminder to teachers and researchers that prejudice is a pervasive phenomenon.

Recommendations for future research

Incorporating a more extensive sample size would serve as a means to address the inherent limitations and yield outcomes that possess greater generalizability. One effective method to encourage student participation is to provide the option of conducting one-on-one interview sessions in various languages. This allows potential participants to feel more at ease and confident, as they can choose to conduct interviews in their native or fluent languages. In addition to expanding the sample size, future research could consider filming discussions in an actual university mathematics classroom and, if possible, recruiting students from the same class to conduct one-on-one interviews. Such a video recording would necessitate more resources and improved filming techniques to reduce the impact of background noise and other unforeseen factors. More broadly, research is required to comprehend speakers whose native languages have received little attention from researchers in mathematics education (e.g. Tagalog, Tamil, Serbo-Croatian, etc.).

Conclusion

This research contributes to understanding university students' experiences in linguistically diverse mathematics classrooms by addressing the two research questions:

1. What are the primary factors that university students perceive as influential in one's mathematics learning within linguistically diverse environments?
2. How do students attribute their own and others' successes and failures during mathematical discussions in linguistically diverse university classrooms?

The results of the study reveal eight key factors that participants perceived to have a significant impact on an individual's acquisition of mathematical knowledge: *language and/or personality*, *educational experiences*, *lack of practice*, *effort*, *interest*, *aptitude*, *communication*, and *luck*. The various patterns that emerged from the findings also suggest that participants attributed their own successes and failures and those of others very differently. In summary, the interview participants discussed others' failures more frequently than their own, their own successes more frequently than others', others' failures more frequently than others' successes, and their own successes more frequently than their failures. In other words, participants appeared to discuss their own and others' successes and failures more frequently. Participants highlighted internal, consistent, and controllable factors when discussing their own accomplishments. When discussing their own failures, participants emphasized external and variable factors. Participants, when discussing the failures of others, emphasized internal and uncontrollable factors. When discussing the accomplishments of others, participants' attitudes varied.

Despite the limitations, this study provides valuable insights into the factors that university students consider significant in their mathematics learning and how they attribute their own and others' successes and failures in multilingual undergraduate mathematics classrooms by examining and comparing the responses of the participants. This study's findings may be beneficial to both mathematics learners and teachers. It is hoped that students can be objective when reflecting on their academic progress. Teachers ought to acknowledge that there is a tendency to attribute students' failures to internal factors. Consequently, teachers should take into

account the impact of external factors when addressing the needs of underperforming students. In addition, it is important for both students and teachers to reflect on their inclination to pass judgment on individuals who lack proficiency in the instructional languages, namely English and French. This study has also raised many questions that require additional investigation. For example, the relationship between language and personality and how they affect a person's ability to learn mathematics requires substantial research. The issue of balancing the need for focused discussions and the desire to accommodate spontaneous student contributions poses a significant challenge within mathematics classrooms. The complexity of the linguistic repertoires and educational profiles of participants also presents enormous challenges to researchers. Furthermore, as far as the researcher is aware, there has been no prior investigation that has utilized Weiner's (2000) interpersonal and intrapersonal theories of motivation in the context of undergraduate mathematics education. The study presents a theoretical framework to elucidate the factors influencing students' attributions and contributes to the existing body of research on students' perceptions of their peers in higher education.

In conclusion, this study addresses a gap in the existing research by investigating the factors that university students perceive as important in their mathematics learning. Additionally, it explores the ways in which students attribute both their own and others' successes and failures during mathematical discussions in linguistically diverse university classrooms. This study enhances the comprehension of university students' encounters within linguistically diverse mathematics classrooms, while also fostering the internationalization of universities and cultivating positive student experiences.

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Appendix A: Recruitment posters

uOttawa

PARTICIPANTS NEEDED for research in MATHEMATICS EDUCATION

You are eligible if you

- speak more than one language;
- have studied math in a second language;
- have taken **MAT 1320 Calculus I;**
- are comfortable with discussing math concepts in front of the camera.

Benefits

- Participants will be able to review learned mathematics knowledge;
- participants will receive a **$10 gift card**.

Participation involves

- completing an **online survey** (takes no more than 3 minutes);
- **filming a video** solving mathematics problems with other participants;
- participating in a **group interview** after video filming.

Notes

- An MA student, [redacted] is conducting the research under the supervision of Professor [redacted]
- the study will be conducted **in English**;
- the discussion will be **videotaped** and remain confidential.

Location

- Study rooms, Learning Crossroads (CRX), University of Ottawa

FOR MORE INFORMATION

- Please contact [redacted] (subject line: math education-video)

[redacted]

uOttawa

PARTICIPANTS NEEDED for research in MATHEMATICS EDUCATION

You are eligible if you

- have taken or are taking **MAT 1320 Calculus I;**
- are comfortable with sharing your experiences in math classrooms.

Benefits

- Participants will receive a **$10 gift card;**
- participants will be able to reinforce mathematical understanding.

Participation involves

- completing an **online survey** (approximately 5 minutes);
- watching a 10-minute video of students discussing mathematical questions;
- participating in a 20-minute **in-person interview** after watching the video.

Notes

- An MA student, [redacted] is conducting the research under the supervision of Professor [redacted]
- the study will be conducted **in English**;
- you will receive a link to the survey and interview scheduling page;
- it is on a first-come, first-served basis;
- the interview will be **audio-recorded** and remain confidential.

Location

- Study rooms, Learning Crossroads (CRX), University of Ottawa.

FOR MORE INFORMATION

- Please contact [redacted] (subject line: math education-interview)

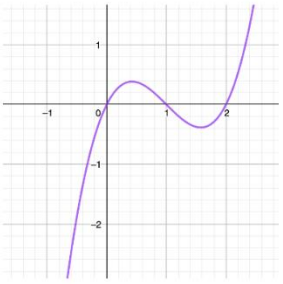
[redacted]

Appendix B: Mathematics worksheet

1. What is the equation of the tangent line to the curve $f(x) = 2x + 3x^2$ at the point (1, 5)?

2. Use the graph to identify the following:

Let $f(x) = x(x-1)(x-2)$ be shown below:



Identify the following:

- Degree
- End Behaviour
- X-Intercepts
- Domain & Range

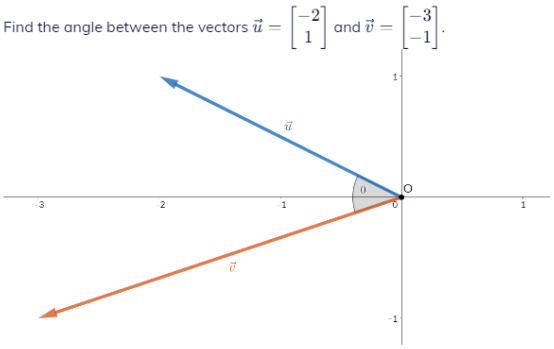
3. Evaluate the following indefinite integral: $\int \sin^4 x \cos^3 x dx$

4. Determine and sketch the domain for $f(x, y) = \sqrt{20 - x^2 + 4x - y^2 + 2y}$

5. Find the eigenvalues of $A = \begin{bmatrix} -3 & 3 \\ 2 & -4 \end{bmatrix}$

6. Find the equation of the line that comes as close as possible to passing through the points: $(0, 1), (2, 3), (3, 4), (4, 7)$.

7. Find the angle between the two vectors:



8. Find the area enclosed by the curves $y = \sqrt{x-4}, y = 1, x = 13$.

9. Write the chain rule for $\frac{\partial z}{\partial u}$ if $z = f(x, y, u, v), x = x(u, v)$ and $y = y(u, v)$.

10. Position, velocity, and acceleration

Example: Position, Velocity, and Acceleration

An object is moving and its position is governed by this equation $x(t) = 5t^2 - 3t + 1$.

What is the average velocity in time interval [0,2] seconds? Find the velocity at $t = 3$.

Appendix C: Guideline and prompts for video participants

1. Ensure familiarity with the selected topic or problem.

2. Discuss the subject with others in the same manner as you would in a typical mathematics class.

3. Since the objective is to simulate a group discussion, it is acceptable and even preferred to make errors.

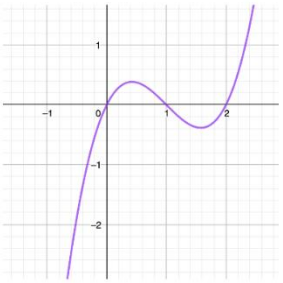
4. If you need to pause the discussion to work on the issue, please do so.

Appendix D: Mathematics Questions in the Discussion

1. What is the equation of the tangent line to the curve $f(x) = 2x + 3x^2$ at the point (1, 5)?

2. Use the graph to identify the following:

Let $f(x) = x(x-1)(x-2)$ be shown below:



Identify the following:

- Degree
- End Behaviour
- X-Intercepts
- Domain & Range

3. Evaluate the following indefinite integral: $\int \sin^4 x \cos^3 x dx$

4. Determine and sketch the domain for $f(x, y) = \sqrt{20 - x^2 + 4x - y^2 + 2y}$

5. Find the eigenvalues of $A = \begin{bmatrix} -3 & 3 \\ 2 & -4 \end{bmatrix}$

6. Find the area enclosed by the curves $y = \sqrt{x-4}, y = 1, x = 13$.

Appendix E: Focus group interview questions

1. What do you think of the discussion?
2. Do you think your performance would improve if there were only numbers and equations?
3. Do you feel there is a gap from high school to college?
4. What role does language play in math learning?
5. Would you feel more comfortable doing math in French/Chinese/Arabic?
6. Do you have a language that you prefer to use when you do math?
7. Do you think that being able to discuss with others would help?

Appendix F: Individual interview questions

1. What is your overall impression of the video?
2. In the video, do you think the students delivered a successful and insightful mathematical discussion? Why?
3. In your opinion, which students made the most significant contribution? Why?
4. In your opinion, which students did not make a significant contribution? Why?
5. In your opinion, which students appeared to be more achieving than others? Why?
6. In your opinion, which students appeared to be less achieving than others? Why?
7. Why do you think they/he/she appeared more or less achieving?
8. Do you think you are high-achieving in your class?

Appendix G: Coding Manual

Codes	Descriptions	Locus, stability, and Controllability
Bilti: Ray had good ideas. I just think he wasn't really confident answering the math questions in English, because as he said earlier, he had this class in high school all in French. So, he is not used to seeing questions in English.	This is an interpersonal observation regarding another person's failure. The interviewee connected Ray's lack of confidence to his English proficiency.	*Locus*: internal. *Stability*: consistent. *Controllability*: uncontrollable. *Rationale*: personality is a person's own characteristics, and language is an individual's skill set; both personality traits and language skills are not easily modifiable within a brief timeframe; one cannot easily alter his or her personality or language skills because they are beyond his or her control.
Lion: I can't speak for computer science students, but I know that a lot of people who want to go to computer science, their problem is: I don't want to do math.	This is an interpersonal observation regarding others' failures. The interviewee was convinced that many students who failed calculus lacked an interest in mathematics, so they switched to computer science as their major.	*Locus*: Internal. *Stability*: variable. *Controllability*: controllable. *Rationale*: those computer science students' decision was prompted by their own volition; it is possible for the students' attitudes toward mathematics to shift within a short time period; those students chose not to "do math."
Joe: I have friends who vary a lot in math level, some of them are maybe naturally better at learning quickly, so	This is an interpersonal observation regarding others' successes. The	*Locus*: internal. *Stability*: consistent. *Controllability*: uncontrollable. *Rationale*: the interviewee's friends had the aptitude to learn faster and

they pick up faster, they understand these things better.	interviewee believed that the academic success of her friends was due to their innate abilities.	understand better, which is an internal and consistent characteristic; they cannot control if they possess the aptitude, thus, it is uncontrollable.
Minnie: …I was really lucky to have really great teachers in high school…I think my teachers in high school did a very good job at, at least trying to prepare us, so I think if you are lucky enough to get a teacher that cares about your university success, then it does prepare you well.	This is an intrapersonal observation regarding one's own success. The interviewee attributed her academic success to her high school mathematics teachers.	*Locus*: external. *Stability*: variable. *Controllability*: uncontrollable. *Rationale*: the assistance from others is considered external, and its quality may vary based on the teachers and schools over which the interviewee had no control.
Seer: Calculus One was hard for me. The professor was, well, not helpful, and I didn't really listen in the lecture. He was struggling, too! He might think teaching is intolerable. So I mainly relied on the discussion class, but the teaching assistant didn't appear to be good at math. For example, he would make mistakes when calculating, just like many "foreigners" do. I think he lacks practice and preparation.	This is an intrapersonal observation regarding one's own failure. The interviewee attributed her academic failure in university to her professor and teaching assistant.	*Locus*: external. *Stability*: variable. *Controllability*: uncontrollable. *Rationale*: the reasons are similar to the previous code: assistance from others is considered external, and its quality may vary depending on professors and teaching assistants over whom the interviewee had no control. The only difference was that the interviewee did not receive the same level of assistance as the previous interviewee (Minnie).

Appendix H: Emerged Themes

Educational experiences

Bilti: I am doing good in university math, the transition from high school to university, for math, it was smooth for me. Because the difficulty, I, the things I have studied in high school really helped me. For example, in calculus one, we had integrals, I already had an idea about it.

Bilti: Sometimes the transition can just be hard from high school to university. The problem here is the math being easy in high school, the problem is not in them. Why, why are they trying to limit, just because they are in high school?

Red: Wait, which one is high school?

Diogenes: The area.

Red: Yeah I didn't do any integrals in high school.

Ray: Oh, I did a lot.

The King: I did all these in high school.

Diogenes: I am really disappointed with the Ontario Curriculum for mathematics, like it's very inadequate to me.

Red: For high school?

Diogenes: Mhm, it's really bad. Umm, and I think one of the issues is if you did high school in Ontario, and you go to university where they have to like standardize all across the country but you wanna be like competitive with other universities across the world, you get slain with the scary thing like: by the way you should already know how to take an integral between these two curves, and you are just: well, I didn't go through this in high school because reasons that [inaudible].

Ray: I did like, in Morocco, we did like, it was the math was very hard, but you know when you know the methods and the things, when you come in university, so, so easy, I found, yeah.

Diogenes: Yeah that's something I also notice all my students, all my classmates who are from other countries, or even from Quebec, they come in here and like: wow, this like first year second year math is kind of a joke.

Red: I thought, Calculus One was easy, cause half the course were I did in high school, and integrals we only did basic stuff, so, easy. The only thing I learned was pretty basic, so.

The King: High school we did AP Calculus, AP is like college calculus, so and the school I went to was American system, so everything is like AP.

The King: I find Calculus one is easy, everything I learned.

The King: Yeah, that's really difficult. And then the math two I took is totally different from math one in uni[versity]. I don't know why it's totally went to a different direction, lot of words…

Joe: …I have friends who vary a lot in math level, some of them are maybe naturally better at learning quickly, so they pick up faster, they understand these things better. But a lot of it also has to do with how much practice they did as a kid, like... Most of my friends who are quote-unquote: good at math, like get good grades in these classes, have done some sort of math as a kid, whether that's competitions or some kind of classes ahead.

Joe: I think in school, at least, I have been doing good at math. But it's only because I failed outside of school first. Like as a kid, I struggled a lot learning ahead, so that when I am in class, I do good, because I have already struggled on this before.

Joe: I think so, umm, it builds up. I guess like, background, because I have people who are able to help me, or as, when I was learning as a kid I had people to help me. The amount of effort you put in for sure, and then, also because, resource-wise, I am able to do a lot of online searches or use like videos to help me. Some people who don't know how to use these things, or don't have access to these things might not do.

Lion: Ok, I think that physics and math students are probably the most competent in the video. And that I would attribute to their major, cause in physics and math, that's math intensive.

Lion: I would say we are all in first year, and the jumping difficulty from high school mathematics to university, you know, I know there is some people who enter the program and they forgot all the trig, they forgot all the algebra, and that's what calculus is built upon. So for them, the difficulty of Calculus One and Calculus Two is also going back,

Lion: So, in my case, calc one in high school was good, and I did learn a lot, but it was very relaxed. So, we had a lot time for the test, we had, I felt like they were holding our hands through the course, if they are making it easy…I had nineties in calc one in high school, and then I failed my first midterm in calc one [in university]. Maybe it's too easy in high school to get like a ninety-five on a calc test versus now I can't do that now.

Lion: When I told my calc teacher that I wanted to do math, he was, uh, impressed, he was like: ok, good, you are doing good, whatever. But, I don't think that they were too interested in pushing students to... If you were doing, like if you paid attention and you cared, they would do their best to make sure you do good. But they weren't there to be like a motivational speaker.

Minnie: And then for Red as a software engineering, I know that, so that could be why he is more at ease to share, even though he is not sure, and just trying to figure things out in a team, cause in engineering, it can be hard to try to figure things out yourself all the time, so that could be why.

Minnie: Yeah, I always really loved math, so I took all the math I could have taken in high school, and I was really lucky to have really great teachers in high school…I think my teachers in high school did a very good job at, at least trying to prepare us, so I think if you are lucky enough to get a teacher that cares about your university success, then it does prepare you well.

Minnie: [laughs] yes. But, I don't know, if you have a teacher that is just teaching the curriculum, maybe it would be better not in a pandemic situation.

Seer: I have this Chinese friend, she is really good and helps me a lot. I think that's because she practiced tons of math questions in China, and math in China is simply harder than here.

Seer: The Chinese way is more efficient and simple whereas here is more inflexible/rigid. I feel it is a cultural difference.

Seer: I think in high school, I didn't do as much math practice as in junior high. My high school was an "international school" that mainly prepares students to study abroad, and it wasn't competitive.

Seer: For example, I am better at memorizing, which is not very useful here in Canada. Here, you have to know the basics in order to succeed. Calculus one was hard for me. The professor was, well, not helpful, and I didn't really listen in the lecture. He was struggling,

too! He might think teaching is intolerable. So I mainly relied on the discussion class, but the teaching assistant didn't appear to be good at math. For example, he would make mistakes when calculating, just like many "foreigners" do. I think he lacks practice and preparation.

Language and/or Personality

Bilti: One of them named Red, he didn't understand what was end behaviours and some terms because he studied them in French.

Bilti: He firstly was confident about what he was saying. When he said something, he was confident about it, that he was right,

Bilti: Ray had good ideas. I just think he wasn't really confident answering the math questions in English, because as he said earlier, he had this class in high school all in French. So, he is not used to seeing questions in English. But he gave really good ideas. And for Red, he also said that he studied math in French, he said that, but he was great. If I saw him answering the question, I wouldn't say this guy has never studied math in English.

Bilti: Maybe, because of his confidence in speaking in public, or having a camera, because it's not always so normal to speak [in front of] a camera. It needs training, public speaking and all that, [inaudible] soft skills.

Bilti: For me, the theory I can give is she can be not comfortable speaking with a camera pointing at her. Or it's just a language problem.

BIlti: It [language proficiency] will affect firstly, because it will be harder for them communicate the ideas. I used to communicate the math ideas in French, so it's like, maybe it's new for

them to express themselves, their math ideas in English. But for me, it's not necessarily a barrier [inaudible], just answer in English.

Bilti: He wasn't confident enough. He had ideas, really great ideas. But he went to explain, he had correct answers, but, the problem was, his confidence. If he was confident like Diogenes, he would correctly give the answer and explain it without be hesitant.

Bilti: Yes, if I was like medium in math, I wouldn't be so confident. Because I wouldn't have solid ideas to like share to be confident about. I just, I can't just be confident about something I don't master.

Red: So yeah, I just, I know those concepts, those words I haven't seen them in English, so I just didn't know about them.

Ray: But it's OK, in English, like there is some words understandable, so it's OK. It's the same in French.

Ray: I think because it's not the same, what we learned. Like in Calculus one, we have a lot of derivatives and integrals, but in Calculus two, we have, umm, I don't know how in English we say, *serie et suite*?

Red: Like the math, math is same whatever language you use, so the problem is just like, uhh, the terms, they are gonna be different and you just have to get used to that. Uhh, like, you know there is a bunch of terms here like I didn't know, but then you explain it to me like, oh I have seen those concepts, I know those, I just didn't know like what they were like [in English].

Ray: It's good, like uh, I feel [inaudible] balanced. I can speak, yeah. When I, um, much, um, I can much express myself in French because I studied it in high school, just in French, you know. Also, in Arabic, but French more. Yeah, it's good, yeah, I think, it's fine.

The King: When I say four times four, I think in Chinese, it's sixteen, like but in Chinese. Those easy ones, I will calculate in Chinese. But if I look at all these, I will do it in the language I learn. Cause I learn those basic in China, so I am more familiar in that one [language]. But if I do calculus, I will think in English. So that's how I switch between.

Joe: It looks like number two (Diogenes) was definitely very confident about what they were saying,

Joe: I think four (Ray) is definitely on the quieter side, and it seems like he also, definitely knows what he is doing, but maybe his terminology is not as on part with person number two, because he might have learned math in a different language, or at least it seems to me.

Joe: Number three (Red) also mentioned at some point that he doesn't know what the term *end behaviour* means, and number one (the King) asked what *degree* meant. I think that could also be a language question, cause Red said that he knew the concept of end behaviour, but just didn't know the terminology.

Joe: She [the King] was quiet, yeah. I think she was less sure about herself, maybe less confident than some of the other ones were. Like she's asking from a learning perspective.

Joe: I feel like, if you are not familiar with the language, you might be less confident, and that contributes to your personality. I know some people who are bilingual, their personality changes when they speak French versus English a little bit. Like they are very confident and

extroverted when they speak French, but when they speak in English, because one, they don't have the right vocabulary to express themselves, so they talk a lot less. And two, they feel insecure about themselves, they don't wanna put themselves out there, so they seem more introverted.

Joe: …I am definitely more shy about it (French), even though I try to maintain the same, like, I don't know, it didn't come out the same way as my English for sure.

Joe: I guess similar languages helps you to be more, like, you might be able to guess what certain words mean, even it's not their native language.

Joe: …all three of them were saying like: oh yeah, I take my classes in French, I took my high school class in French. And then one didn't say anything; maybe because one doesn't relate to these, but also maybe because their languages are not similar.

Joe: …you are not only learning the math, you are also learning the second language along with it, that makes it a lot harder.

Lion: …maybe [the King] was shy, cause she wasn't saying much…

Lion: Ray said that he did math in French, and so did Red. But Red was fluent in English, it seems like, so, maybe the first-year math student would've had more input, and then he didn't know how to explain it,

Lion: So for me, I am a bit more like anti-tech, like I don't really use my phone that much. All of my hobbies are outside of technology, so for me, it's easier to just sit down and focus.

Lion: But when I entered university, I did Calculus One in French when I started, and it was too hard because I couldn't understand their accents.

Lion: Yeah... When I was watching the video, I felt like Ray, I felt like I have been in that situation where I have the answer but I don't know how to say it, or I don't wanna say it. So I thought maybe he held back, because of the language barrier.

Minnie: Diogenes seemed a lot more confident in, umm, even just speaking in English, whereas some most the other participants like Ray for example, seemed very hesitant in his choice of words. But, he did use like writing and actually showing the math to help him there, but I did get the sense that he was maybe feeling a little bit stuck sometimes or frustrated; whereas for Diogenes, I didn't get that at all.

Minnie: Diogenes was very extroverted, very outspoken.

Minnie: But also, I do know that when people are very high-achieving, sometimes they would only share when they are one hundred percent sure. So I think maybe that could be the case for Ray as well, just because, if you are someone who likes to do things the right way, who likes to achieve very highly, you are like also very careful about what you think might be wrong. So that's a possibility as well.

Minnie: Umm... I think she [the King] might have been a little bit shy, and also not quite as confident in the material.

Minnie: It could be, I know in my experience, I am a little bit of perfectionist in my second language as well, so it could be he participated less just out of fear of saying something wrong.

Seer: This girl is definitely Chinese. I think the reason she rarely talked was language,

Seer: Ray knew how to do it but didn't talk much, and I thought it was a language thing because he had an accent. But given that Red is also a non-native English speaker, so it wasn't a language thing for Ray, it was his personality.

Seer: Yeah, maybe Ray has some language problem, but not as bad as the Chinese girl. I think it's more personality.

Seer: Well, I feel language doesn't really affect math learning. Because math is all about numbers and symbols. I got friends whose English was really bad, but got A plus for Calculus One.

Seer: Language is not important to SOLVING math questions, but important to discussing for sure.

Seer: Well, maybe I don't really discuss with "foreigners," so I am not sure... It feels like Chinese students like to team up with other students from China. I think we don't have the "language advantage" that "foreigners" have. They are way more outgoing and confident.

Seer: I feel Ray is a bit shy. He knows stuff, but not very willing to talk. It's more a personality thing.

Lack of practice/forgetting

Bilti: Yeah, they forgot many things. I think that's because they lack of practice, they don't practice math regularly

Bilti: …she just forgot, she didn't practice for long, she just forgot. That's something normal.

Ray: Yeah, exactly, I took it and I forgot. I don't remember.

Red: I had no idea how to do this. I don't think I have EVER done that question like this, I don't.
Ray: It's in Calculus two.
Red: If it's Calculus two then I must have been some place like... I guess I just don't remember.

Red: it went well, umm, clearly, I don't remember, there is a lot of things I don' remember, but, like, with them explaining it, like I can understand, but like, doing it just like only me then I had a really hard time. Like, just doing the problems by myself, like there is a lot of things I don't remember.

Diogenes: It's more of a memory thing, like, everyone is like well-taken some calculus classes at some point or another,

The King: I just feel like: oh, it shouldn't be hard, so I didn't really study for midterm, but then I did pretty good, I got A plus. Oh it is easy. So I don't have to study for it, then I failed my final.

Red: Can I add, like, you are in physics, right? So, you know you do integrals and calculus and you do them in your physics classes, too.
Diogenes: I am more familiar with it cause I am using it more.
Red: Yeah, me, I only use, this, this stuff in Calculus two, that's the only course I used it. So, I don't see much of it outside of Calculus, so, I am just not exposed to it as a lot, so it's a bit harder.

Joe: So it seems like, they all learned this, and to some degree maybe they forgot what they learned. But two seems the most, like seems to remember the most variety of questions I guess, if that makes sense.

Joe: …it seems like it's not that the others don't know this math, they definitely learned it; umm, but they were, maybe forgetting what certain words meant or formulas.

Seer: …maybe she forgot how to do the questions.

Effort

Bilti: For me, hard work is necessary. Yes, for people that are naturally smart, they need less hard work than others, but hard work is necessary. It's the key to be like him [Diogenes], to know every question. Math only needs practice, without practice, you can't do nothing. Practice and luck.

Bilti: To be smart, you have to work hard. You can't just be smart like that.

Bilti: But I don't understand people that say that Calculus Two is impossible for example. For me, they are just lazy, lazy people that trying to find excuses, with all due respect. They are just trying to find excuses for failure, instead of learning from this failure and doing better next time, they just say it's impossible, and that people who succeed are just geniuses, which is not true.

Bilti: For me, I am just a normal person, studying, sometimes hard-working to get a good mark. They say: oh I can't do math, it's not suited for me, I can't, I am not a math guy. Which is not true, you just didn't sit and practice and discover all the things in math. You just limit yourself with the statement: I can't do it.

Joe: I have friends who vary a lot in math level, some of them are maybe naturally better at learning quickly, so they pick up faster, they understand these things better. But a lot of it also has to do with how much practice they did as a kid, like... Most of my friends who are quote-unquote: good at math, like get good grades in these classes, have done some sort of math as a kid, whether that's competitions or some kind of classes ahead.

Joe: It's like, math is like, if you are good at it, then you like doing it more, and then if you liking it, you practice more, and you get better, so it's like a...

Joe: Hmm, I think even that though, being able to suddenly understand the question, normally come from you having done a lot of practice beforehand.

Joe: I think in school, at least, I have been doing good at math. But it's only because I failed outside of school first. Like as a kid, I struggled a lot learning ahead, so that when I am in class, I do good, because I have already struggled on this before.

Lion: Well, I was working like twenty hours a week for first semester, and you just, the biggest in university is learning to manage your time. Because if you manage your time well, you cannot [inaudible] job, studies, extracurriculars, like you know. Some people they feel like they are not allowed to have hobbies, because the university, other people they do the opposite [inaudible] they just doing their hobbies and then also schoolwork. Time management is huge in university.

Minnie: Umm, I feel like I am understanding the content, and doing a lot of studying throughout the semester,

Seer: I have this Chinese friend, she is really good and helps me a lot. I think that's because she practiced tons of math questions in China, and math in China is simply harder than here.

Seer: I think in high school, I didn't do as much math practice as in junior high. My high school was an "international school" that mainly prepares students to study abroad, and it wasn't competitive.

Seer: But I feel, well, I am not super talented, but the fact is, I didn't work very hard.

Interest

Joe: So maybe at first it's not by choice, but it picks up, it's like, math is like, if you are good at it, then you like doing it more, and then if you liking it, you practice more, and you get better, so it's like a...

Joe: Ok. I definitely didn't like math as a kid, but because I was forced to do it earlier. When I went to do it in school, I liked it better, because it wasn't hard anymore [laugh].

Joe: Yeah, definitely do. I think when you have a better learning environment, or if you have a professor who is really good at explaining concepts, you are more motivated to practice, because, I guess math is like if you enjoy and do a lot of practice, you get better, and that kind of spirals upwards. But a lot of people are discouraged when they have a professor who is maybe not so good at teaching, and then they kinda drop it, or they don't try as hard.

Lion: I can't speak for computer science students, but I know that a lot of people who want to go to computer science, their problem is: I don't want to do math.

Lion: I would think that it's all the mentality because, in my case, I did not like math at first. I had that negative attitudes towards it, so I wasn't good. And then in grade eleven, I just had

a different mentality, I was like: I wanna do good, I want a ninety. And I studied it, and I liked it a lot because I was getting good at it. So I think that when you feel rewarded, and you feel like you start to understand, then it's a lot easier to like it.

Lion: Yeah, interest in mathematics, I think that a lot of people find, it's some, it's, there is only one answer, that's right or wrong. You can't be creative.

Lion: And I feel like some creative people would feel restricted by something like science or math where there is just one right answer.

Lion: Yeah, in my free time, if I can, I would study, you know, math courses that I haven't done yet, just cause I find them interesting.

Lion: [laughs] yeah, academic is my hobby though, so...

Minnie: Yeah, I always really loved math, so I took all the math I could have taken in high school, and I was really lucky to have really great teachers in high school.

Minnie: I think, I just, I love the challenge of it [mathematics].

Minnie: Cause I have to do a lot of like creative work in my other courses, so when I get to math, it's like: oh perfect, I don't have to think, I will just have to figure it out.

Aptitude

Bilti: Yeah, I would say ten percent. Ten percent luck, twenty-five percent natural IQ, and the other percent left is just hard work. And it can change from a person to another.

Joe: I have friends who vary a lot in math level, some of them are maybe naturally better at learning quickly, so they pick up faster, they understand these things better.

Lion: You know, there were some people who were able to get by without studying too much, I think that would just be like a natural talent. I know there was one guy in my class who was going into, umm, like social work or stuff, so he doesn't have to take math, he was just good at it. He just didn't want to continue with it.

Minnie: Also, when I was younger, I was a gifted student. So I did like above-grade-level math when I was in elementary school, so I think that kept me interested in it, because I was always challenging myself.

Minnie: Well, it was, originally, I think it was like an aptitude thing

Seer: I got a Chinese friend who dropped calculus one. She was confident at first, but failed the first midterm. She was very hardworking though, more hardworking than me. I think she is just not a math person, not suitable.

Seer: But I got a friend, as I said, who worked so hard but failed. Another girl didn't work as hard, but got better results on the tests. So I think it's like, some people have the "mathematical thinking" thing, and some people don't. Like social science thinking versus science thinking.

Communication

Bilti: I like something about Red, when he didn't know something, he asked for explanation, which the King didn't do it, she just sits there and waiting for the answer. I like that, it's also a skill, to know how to ask for help.

Diogenes: It really does rely on people making their own social circles, and not social circles that are very huge, you need them to be at most five-ish for that to really work. And by the act of teaching it, kind of reinforce it in your brain more than just learning it.

Red: I agree, like I think, talking to people about problems, it helps me a lot. Like I remember in high school I always do, like, one of the main ways I studied was like, studying with some other people and talking about problems and stuff. It was really fun, but in university, I never do that, I think it's because I don't know a lot of people. I think COVID had a play in it, you know I had to rely on myself for like what, two years maybe.

Red: I think talking to other people would help.

Ray: Yeah, exactly, same. It's like, uhh, yeah.

Ray: Yeah, I think it's better, like, to discuss with them in another language, because they can, like, yeah you know, they can like uhh, to know the course in the both languages so, you know, he could improve himself. Yeah.

The King: So, discussion is good but only if, like, there must be someone who understands the concept.

Red: Yeah, I think for math especially, you need to, you can't rely on just talking to people, you have to also practice. I think doing both is better than only one.

Joe: Maybe, if it's group work-oriented, I think it helps to learn with someone who's on the same level as you. Yeah, I think teaching in a, in an environment where you are meant to teach, like if you are tutoring somebody, I think that's the best form of teaching to learn, because it's just you and you're explaining your thought process.

Luck

Bilti: Sometimes I'm lucky, sometimes I'm not. Depends, some exams are...

Bilti: In high school, for me, it's like I am really lucky and I [inaudible] studied this in high school, because it gave me an advantage here in university.

Appendix I: Chi-Square tests

Table 1

Chi-Square test for Interpersonal-Failure

Interpersonal-Failure					
	Observed	**Expected**	**O - E**	**$(O - E)^2$**	**$(O - E)^2/E$**
Controllable	12	25	-13	169	6.76
Uncontrollable	38	25	13	169	6.76
χ^2 (1, N=50) = 13.52, p<.001					
External	12	25	-13	169	6.76
Internal	38	25	13	169	6.76
χ^2 (1, N=50) = 13.52, p<.001					
Consistent	22	25	-3	9	0.36
Variable	28	25	3	9	0.36
χ^2 (1, N=50) = 0.72, p=.396					
Degrees of freedom (df) = 2 - 1 = 1 **Level of significance (α) = 0.05**					
Critical value (cv) = 3.841					

Table 2

Chi-Square test for Interpersonal-Success

Interpersonal-Success					
	Observed	**Expected**	**O - E**	**$(O - E)^2$**	**$(O - E)^2/E$**
Controllable	6	9.5	-3.5	12.25	1.29
Uncontrollable	13	9.5	3.5	12.25	1.29
χ^2 (1, N=19) = 2.58, p=.108					
External	7	9.5	-2.5	6.25	0.66
Internal	12	9.5	2.5	6.25	0.66
χ^2 (1, N=19) = 1.32, p=.251					
Consistent	7	9.5	-2.5	6.25	0.66
Variable	12	9.5	2.5	6.25	0.66
χ^2 (1, N=19) = 1.32, p=.251					
Degrees of freedom (df) = 2 - 1 = 1 **Level of significance (α) = 0.05**					
Critical value (cv) = 3.841					

Table 3

Chi-Square test for Intrapersonal-Failure

Intrapersonal-Failure					
	Observed	**Expected**	**O - E**	**(O - E)²**	**(O - E)²/E**
Controllable	2	9.5	-7.5	56.25	5.92
Uncontrollable	17	9.5	7.5	56.25	5.92
χ² (1, N=19) = 11.84, p <.001					
External	15	9.5	5.5	30.25	3.18
Internal	4	9.5	-5.5	30.25	3.18
χ² (1, N=19) =6.37, p=.012					
Consistent	2	9.5	-7.5	56.25	5.92
Variable	17	9.5	7.5	56.25	5.92
χ² (1, N=19) = 11.84, p<.001					
Degrees of freedom (df) = 2 - 1 = 1 Level of significance (α) = 0.05					
Critical value (cv) = 3.841					

Table 4

Chi-Square test for Intrapersonal-Success

Intrapersonal-Success					
	Observed	**Expected**	**O - E**	**(O - E)²**	**(O - E)²/E**
Controllable	10	14.5	-4.5	20.25	1.40
Uncontrollable	19	14.5	4.5	20.25	1.40
χ² (1, N=29) = 2.79, p=.095					
External	12	14.5	-2.5	6.25	0.43
Internal	17	14.5	2.5	6.25	0.43
χ² (1, N=29) = 0.86, p=.354					
Consistent	9	14.5	-5.5	30.25	2.09
Variable	20	14.5	5.5	30.25	2.09
χ² (1, N=29) =4.17, p=.0411					
Degrees of freedom (df) = 2 - 1 = 1 Level of significance (α) = 0.05					
Critical value (cv) = 3.841					