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Perception and experience of non-mathematical (management studies) undergraduates in Sri Lanka towards the interaction with mathematical concepts in their subject disciplines

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Abstract

The purpose of this study is to explore the perceptions and experiences of non-mathematical undergraduate (management studies) students in Sri Lanka as they engage with mathematical concepts within their subject disciplines. The research aims to investigate how non-math undergraduates in Sri Lanka perceive their ability to apply mathematical concepts encountered in their subject disciplines and what experiences and challenges faced by non-math undergraduates in Sri Lanka when interacting with mathematical concepts in their subject disciplines. This study employs a mixed-method approach where quantitative data were collected through a structured questionnaire based on Bandura's Self-Efficacy Theory (1986) and qualitative insights were collected through interviews based on Weiner's Attribution Theory (2005). The findings reveal patterns in confidence levels, emotional experiences followed by success and failures, motivational factors, and perceived difficulties and challenges, in math learning in university courses, offering valuable implications for improving teaching strategies and academic support systems in non-mathematical disciplines, as well as improving prior math knowledge in secondary school. The study contributes to a better understanding of how cognitive, motivational, and emotional factors influence mathematical engagement in higher education settings.

Key words: non-math undergraduates, math concepts, self-efficacy, attributions, learning experiences.

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1 Introduction

A foundational understanding of mathematical concepts is required for achieving academic and professional success in many subject disciplines in the context of higher education (Roick & Ringeisen, 2018). Applying mathematical concepts in core subjects in management studies such as economics, accounting, and operations research can support students pursuing management studies in developing the analytical skills needed for problem-solving and decision-making processes. Despite the benefits of improving mathematical skills, due to reasons that may cause stress and anxiety, such as the risk of obtaining lower marks in evaluations and the risk of failure, many students dislike interacting with mathematical concepts in their subject disciplines (Roick & Ringeisen, 2018).

Various reasons have been identified that influence the math performance of first-year university students such as mathematics anxiety, attitude towards mathematics, academic motivation, prior knowledge of mathematics, approaches to learning and perceived self-efficacy (Zakariya et al., 2022). Among these, the two reasons: approaches to learning and perceived self-efficacy (aligned with Albert Bandura’s self-efficacy theory which defines self-efficacy as individuals’ confidence in their capabilities of performing tasks) received significant attention due to their high probability of promoting students’ performance in mathematics (Zakariya et al., 2022).

Individuals’ beliefs in their ability to perform tasks are referred to as self-efficacy and the mathematics self-efficacy of the students is a significant construct that determines learning mathematics and performing mathematical tasks (Street et al., 2024). According to Bandura (1986), four sources of information influence students’ self-efficacy beliefs which are mastery experiences which refer to the past experiences of individuals' successes and failures, vicarious experiences or experiencing successes and failures of other similar people as peers, verbal persuasion which refers to verbal encouragement by other people and physiological states or experiencing the positive or negative emotions such as pride or stress when doing tasks.

Zakariya (2022) revealed interest, perceived relevance of mathematics, perceived challenges such as mathematics anxiety, and students' perceptions of support received from teachers and supportive sources are affective factors that predict mathematics self-efficacy. The study further stated that there is a significant correlation between self-efficacy and interest, as well as self-efficacy and perceived relevance of mathematics (Zakariya, 2022). When students recognize that mathematics is interesting or relevant to their future studies and career goals, they may be more willing to engage in learning mathematics with greater effort, which can help improve their confidence in their abilities.

In educational settings, Weiner's (2005) attribution theory mainly focuses on what learners attribute as causes of their success and failure experiences in academic tasks (Subotnik et al., 2010). In this framework, Weiner demonstrated three causal dimensions: locus, stability and controllability where causal attributions of individuals can be categorized (Matteucci, 2017). Causal beliefs or the learner's perception of the causes behind their successes or failures can be classified as internal or external according to the locus, stable or unstable according to the stability and controllable or uncontrollable according to the controllability (Matteucci, 2017). Casual attributions are related to emotions and influence motivational behaviour (Matteucci, 2017). So, in the academic setting, students who attribute their success or failure to unstable and controllable factors such as effort, learning strategies and time management have a higher chance of achieving success in academic tasks and staying motivated (Matteucci, 2017).

The ability of undergraduates to engage in math concepts in management studies and successful experiences in math-related tasks can be crucial for overall academic success in management studies. Understanding the perceptions and experiences in math learning and the mathematical self-efficacy beliefs of these students could be significant for designing effective educational strategies for better learning outcomes. Employing Bandura’s Self-Efficacy Theory (1986) and Weiner’s Attribution Theory (2005) as foundational frameworks, the present study focuses on exploring self-efficacy beliefs and causal attributions affecting the mathematical engagement of undergraduate management studies students. The following chapters will further elaborate on the theoretical frameworks, methods, and key findings that address the research questions in this study.

2 Theoretical framework

Theoretical foundations are significant in understanding non-math undergraduate students' perceptions and experiences when interacting with mathematical concepts within their subject disciplines. This chapter outlines two key theories: Albert Bandura's self-efficacy theory (1986) to investigate how non-math undergraduates in Sri Lanka perceive their ability to apply mathematical concepts encountered in their subject disciplines and Bernard Weiner's attribution theory (2005) to examine what are the experiences and challenges faced by non-math undergraduate students in Sri Lanka when interacting with mathematical concepts in their subject disciplines, and relevant insights from those theories to understand individual and contextual influences on mathematical engagement of students. Further, the context of the present study in which investigations are supported by the above two theories.

2.1 Self-efficacy: Theoretical background and empirical support

Individuals' beliefs in their ability to perform tasks are referred to as self-efficacy (Street et al., 2024). According to Bandura (1986) individuals knowledge about their efficacy is based on four sources of self-efficacy information: performance attainments, vicarious experiences, verbal persuasion, and physiological states.

2.1.1 Four sources of self-efficacy information: According to Bandura (1986)

Performance attainments or personal experiences of completing a task are the most significant source of self-efficacy information, where the individual directly engages in the task and experiences success and failure to strengthen the belief in their abilities to perform a specific task. Successful experiences reinforce self-efficacy and often contribute to increasing individual confidence in their capabilities. Also, Initial failures of the tasks due to difficulties can be overcome with continuous effort on tasks where new experiences strengthen skills and allow for the acceptance of challenges in tasks with new strategies.

Vicarious experience refers to strengthening one's capabilities by observing the successes of other similar people. When observers identify themselves with similar capabilities to another successful person, they attempt to improve their performance. Further, observing the success experiences of people who had initial failures and succeeded gradually can enhance self-efficacy beliefs more than observing those who achieve effortlessly in their tasks. On the other hand, observing the continuous failures of other similar people can lower self-efficacy beliefs.

Verbal persuasion or encouragement from others can contribute to people believing in their capacity for successful performances. Even though verbal persuasion is a comparatively less powerful source of information on self-efficacy, there is a greater chance of engaging in tasks with additional effort, as verbal persuasion encourages people to believe in their capabilities. Even though verbal persuasion helps people try hard and recover difficulties, it can also undermine the efficacy beliefs of people when they believe in unrealistic attainments in tasks with verbal persuasion from others.

The physiological state is another source of information on self-efficacy, which focuses on the interpretation of emotional reactions in judging their capabilities. Positive emotional states such as pride, satisfaction, enthusiasm, and calm prepare people to expect success in their tasks, whereas negative emotional states such as stress, fatigue, boredom and anxiety can reduce self-efficacy by generating fearful reactions in people to believe that they might not be capable of doing the tasks.

2.1.2 Related findings

Findings of Özcan & Kültür (2021) revealed a significant positive correlation between mastery experience and course achievement in mathematics (r = .75) which suggests that students with more repeated successes in their past experiences with mathematics tasks are more likely to perform better in the math course. Also, the moderate correlation between vicarious experience and course achievement (r = .43) suggests that observing others such as peers or role models has a positive influence on the course achievement of the students while the weak positive correlation reported between physiological state and course achievement (r = .38) suggests that students who feel more satisfaction and less anxious about math tasks tend to achieve better in math course.

Moreover, the moderate positive correlation identified between mastery experience and test achievement in mathematics (r = .49) and between social persuasions and test achievement (r = .43) suggests that students who have completed math tasks successfully in the past and students who received positive feedback and encouragement from other people such as teachers, parents and peers to tend to achieve better scores on math tests. Also, a moderate weak positive correlation between vicarious experience and test achievement (r = .21) and between physiological state and test achievement (r = .20) suggests that even though these factors can influence math test scores, they have a comparatively lesser impact than the mastery experience and social persuasions.

Thus, these findings implied that, among the sources of mathematics self-efficacy, mastery experience is the strongest predictor of mathematics test achievement and course. In addition, verbal persuasion from people such as parents, teachers and peers and vicarious experience impact mathematics self-efficacy at a moderate level and, physiological state has the weakest influence on mathematics tests and course achievement.

Findings of Gao (2019), concluded a notable difference between the vicarious experience of high self-efficacy students and the vicarious experience of low self-efficacy students. Accordingly, pursuing competition was highlighted by the students with high self-efficacy, where competing with other classmates doing better than them in mathematics motivated their learning, whereas students with low self-efficacy were more likely to avoid comparison with their peers who performed better than them as it lowers their confidence and learning engagement in mathematics. In addition, high self-efficacy students considered successful peers as benchmarks to assess their abilities, while low self-efficacy students considered peer models as sources of guidance to improve their own performance.

Further, when considering verbal persuasion, this study illustrated that students with high self-efficacy in mathematics received positive feedback on their mathematics learning more often, whereas low self-efficacy students received mostly negative comments with very few compliments. Hence, the students with low self-efficacy appreciated little positive feedback, which enhanced their confidence. Also, it has been reported that girls receive verbal persuasion more often regarding their performance in mathematics from their parents when compared with boys in their peer group. It is reported that girls were praised for good marks in mathematics, while boys rarely received comments on mathematics learning, which were neither praise nor criticism from their parents.

Generally, vicarious experience or observational learning tasks are often mentioned as an important source of self-efficacy. However, it was outlined different characteristics of the certain observational model such as to which extent the model aligns with learners' competency level, how reliable the observational learning model and whether guiding is included in the demonstration impact on the effectiveness of the vicarious experience. For instance, depending on the observational model, whether it is an expert model that demonstrates high competency or a peer model that is similar competency as the observer, learners' self-efficacy may be affected as the competency gap can related to discourage the learner when observing an expert model whereas more relevant competencies of peer model can be more effective to enhance the self-efficacy of students.

Moreover, it is identified that there was a limited direct impact from verbal persuasion or feedback from other people that supports strengthening the beliefs of personal abilities, on self-efficacy beliefs. Need for further investigation regarding the effectiveness of the feedback such as feedback type and timing, also suggested based on the investigations as it may provide differing effects on self-efficacy. For example, specific feedback based on the task may provide a positive influence on self-efficacy rather than a general type of feedback on tasks such as “Good work”. In addition, immediate feedback may be useful in practical tasks.

2.2 Influence of self-efficacy in mathematics achievement and performance

In educational settings, self-efficacy generally affects overall performance in educational tasks (Liu et al., 2024). Learners’ beliefs about their ability to accomplish mathematical tasks are referred to as mathematics self-efficacy (Al Umairi, 2024). Higher self-efficacy in mathematics strongly predicts intrinsic motivation or internal determination of a learner to engage in mathematical tasks for personal satisfaction, as well as persistence or willingness to accept challenges in math tasks and continue math learning. So, students with higher mathematics self-efficacy tend to be motivated to engage in engaging mathematical tasks, while taking challenges in tasks that finally promote their mathematics achievement (Skaalvik et al., 2015).

According to Liu et al. (2024) mathematics self-efficacy directly impacts achievement in mathematics and mathematics self-efficacy is a significant predictor of math problem-solving skills. Their study further stated that initial mathematics self-efficacy of the learners is more likely to make them confident to perform similar tasks consistently.

Several studies that investigated the relationship between math performance and the self-efficacy of students deduced that self-efficacy in mathematics is a more significant predictor of math performance than other factors such as anxiety in mathematics and mathematics self-concept or general perception of math ability (Zakariya, 2022). Hence, high math self-efficacy is linked to better performance in mathematical tasks, whereas low math self-efficacy is linked to poor math performance (Zakariya, 2022). Research findings related to students' math course performance in higher education implied that higher self-efficacy in mathematics is positively related to cognitive strategies, such as making associations and meta-cognitive strategies, such as goal setting and planning, that encourage students to apply more appropriate learning strategies in math learning and ultimately enhances their performance in mathematics (Roick & Ringeisen, 2018).

Gao (2019) conducted research to identify different levels of exposure to sources of mathematics self-efficacy in Chinese junior high school students. Findings regarding the mastery experience showed that students with high mathematics self-efficacy possessed rich mastery experience they considered random failures were temporary threats to their confidence and they believed that they could learn more and improve in the future. In contrast, students with low mathematics self-efficacy experienced repeated failures and they developed a belief in their failures in which they perceived a random success as an unexpected situation.

Özcan & Kültür (2021), researched to investigate the relationship between sources of mathematics self-efficacy of high school students and mathematics test achievement and course achievement. The study was conducted with 257 12th-grade high school students and findings revealed that both mathematics tests and course achievement are affected by sources of mathematics self-efficacy.

The study conducted by Liu et al., (2024) examined the mutual relationship between self-efficacy and achievement in mathematics among high school students. Students who participated in this study have been followed throughout their secondary school and postsecondary school years to collect the survey information for the study. In the results of the study, a much stronger stability coefficient for the mathematics achievement of the student (0.73) has been identified. This implies that mathematics achievement in the secondary school year of the students significantly predicted mathematics achievement in the postsecondary school year of the students. This result emphasized that prior academic performance is a significant factor in promoting achievement in mathematics later. Students are more likely to develop strong beliefs about their mathematical self-efficacy when they feel they have performed mathematical tasks successfully in their previous studies.

In addition, a lower value than the coefficient for mathematics achievement was reported as the stability coefficient for mathematics self-efficacy (0.41). This implies that even though mathematics self-efficacy significantly influences the mathematics performance of the students, its impact is less than the influence of the mathematics achievement of the students. Furthermore, the higher stability coefficient of mathematics achievement of the students suggests that mathematics achievement is more likely to remain stable over time, in which students who perform well in base years tend to perform well in follow-up years. Comparatively lower stability coefficient of mathematics self-efficacy suggests that mathematics self-efficacy is more likely to change over time, which can be influenced by external factors such as feedback or classroom environment.

2.3 Overview of Attribution Theory (Weiner, 2005)

Several attribution theories have been developed throughout time and Weiner's attribution theory (2005), which outlined an association of three causal dimensions to emotions and expectations of a learner, is the foundation to examine the experiences and challenges faced by non-math undergraduate students when interacting with mathematical concepts in the current study.

2.3.1 Development of attribution theories

Attribution refers to a psychological concept that people use to predict and explain their behaviours as well as other behaviours (Houston, 2016). Attribution theories explain how individuals interpret life events by assigning causes to why those events occur according to their perspectives (Perry & Hamm, 2017).

Development of the attribution theories started with Heider's Attribution Theory (1994), which focuses on how individuals explain causes for behaviours (Perry & Hamm, 2017). Following Heider (1994), several attribution theories such as developed such as Jones & Davis (1965) the correspondent inference theory, which focuses on how people conclude a person's behaviour according to their personal characteristics, the covariation model by Kelley (1967), which proposes three types of information used by people to decide the cause of a certain behaviour is internal or external, Weiner's attribution theory of motivation and emotion (1970) which illustrate how people attribute their success or failure experiences to factors such as effort, ability, task difficulty and luck that impact on emotions and future behaviour of individuals (Perry & Hamm, 2017).

2.3.2 Relevance of Weiner's 2005 attribution theory to this study

Weiner's (2005) attribution theory provides an educational relevance framework that supports examining the learning experiences of the students, focusing on learners' perceptions or understanding of the causes behind their successes or failures (Clyatt, 2017). In this approach, competence is identified as a psychological construct that influences individuals' interpretations of their abilities to achieve goals in different fields such as mathematics, athletics and music (Perry & Hamm, 2017). Compared to other attribution theories, Weiner's attribution theory, which was specifically developed with an educational settings focus, is most relevant in this study to investigate how non-math undergraduate students in Sri Lanka attribute their experiences and challenges when interacting with mathematical concepts in their subject disciplines.

2.3.3 The three dimensions in Weiner's 2005 attribution theory and their association with emotions and expectations of learners

Weiner's attribution theory (2005) focuses on how individuals attribute success and failure in their outcomes to specific causes. According to Weiner (2005), there are three causal dimensions: locus, stability, and controllability where all causes can be located. The locus or the location of the cause is internal or external to the individual (Weiner, 2005). Ability and effort are internal causes as they are discovered within the individual, whereas help given by other people and chance are considered external causes as they are located outside of the individual (Weiner, 2005). The duration of a specific cause is referred to as stability, where the causes can be stable or unstable (Weiner, 2005). Math aptitude is recognized as a stable cause, whereas chance is not constant and hence an unstable cause (Weiner, 2005). Controllability refers to whether the cause can be wilfully changed or not (Weiner, 2005). Some causes, such as effort are controllable, whereas aptitude is an uncontrollable cause (Weiner, 2005).

These three causal dimensions are aligned with two significant elements, “expectancy” and “value” which influence the motivation of an individual to promote academic success (Weiner, 2005). Expectancy or expectations map to stability and value or emotions map to locus and controllability (Weiner, 2005). Expectancy refers to learners’ beliefs about their success and failure in future academic tasks (Stephanou, 2012). For instance, if students attribute past success in learning and engaging tasks in mathematics due to their effort and math aptitude, they are more likely to expect future success in learning and engaging tasks in mathematics whereas if they believe failure is due to an uncontrollable cause such as task difficulty, they may tend to develop low expectations in future success in the similar tasks. Value or emotions refer to the learners’ feelings that they experience according to their perception of success and failures in their academic performance (Stephanou, 2012). For instance, if students attribute failure due to a lack of aptitude which is a stable and uncontrollable factor, they may feel shame which may lead to disengagement with work whereas if they attribute failure due to a lack of effort which is an unstable and controllable factor, they may feel guilty and may exert more effort into trying hard in the future.

Emotions significantly predict learners’ future behaviour as emotions influence aspects that promote academic success such as motivation, learning engagement, quality of thinking and self-regulation (Stephanou, 2012). Most of the emotions related to academic settings are achievement emotions, where students experience emotions as a result of self-evaluation or evaluation of others based on their academic outcomes (Paoloni, 2014). Hence, low grades obtained for a test give emotional experiences such as anger or disappointment and the fulfilment of academic tasks gives emotional experiences such as pride (Paoloni, 2014).

Positive emotions such as pride and enjoyment can enhance motivation and engagement in academic tasks whereas negative emotions such as anxiety and shame can hinder motivation to engage in learning tasks. Emotions also influence the self-regulation of learners, where if learners can resist negative emotions such as disappointments, they are more likely to continue with difficult tasks whereas learners who cannot resist negative emotions may disengage with difficult tasks. Moreover, past emotional experiences of learners may impact the prediction of future success and challenges in academic settings.

Success expectations also play a significant role in promoting academic achievement (Stephanou, 2012). A higher probability of success prediction in academic settings enhances task engagement, effective application of learning strategies, determination to continue difficult tasks and successful completion of academic tasks (Stephanou, 2012).

2.4 Causal attributions and mathematics outcomes: insights from Weiner's Attribution Theory

Stephanou (2012) conducted research on students' school performance in mathematics and examined the most important causes as explained in Weiner (2005) for the perceived success and perceived unsuccess in school math performance and students' emotions on their math performance. According to the findings, students mainly attributed their perceived success in math performance to stable and internal factors, whereas they attributed their perceived unsuccess in math performance to unstable and external factors, in which stability was the strongest factor when distinguishing successful and unsuccessful groups. Also, external controllability did not significantly impact student success in math performance. This implies that successful students are more likely to believe in causes such as their own abilities, math aptitude and effort.

Moreover, Students in two performance groups: perceived successful and perceived unsuccessful regarding the performance in mathematics revealed that students experienced various positive and negative emotions where students in the perceived successful group in math performance experienced emotions such as confidence, enthusiasm, happiness and not-angry and students in perceived unsuccessful performance in mathematics experienced emotions such as more angry, not calmness, shame and sadness.

Wolters et al., (2013) examined the causal attributions as predictors of academic functioning. They found that strong correlations exist between how students attribute their success and failure and their engagement, strategies used and performance in learning tasks. Findings explain that students who believe in their ability as the reason for their success experience, as well as students who had rejected a lack of ability as a reason for failure in academic tasks, were actively engaged in academic work with proper learning strategies such as planning and self-monitoring for better performance. Similarly, students attributed their successful experience to positive teacher support and rejected the idea of a lack of effort as a reason for failure, were also showed positive academic performance.

However, students who attributed task difficulty to explaining their failures related to exerting higher effort and used more learning strategies in their learning tasks, despite their low performance. So, these findings proposed positive attributions such as ability and teacher support direct the students to better engagement in learning and use strategies effectively to gain successful learning outcomes and external factors like task difficulty may encourage more effort but are more likely to failure experiences.

Moreover, the findings of the study suggested that learning engagement and the use of strategies have individual impacts by different attributions for success and failure experiences. Accordingly, attributing failure to lack of ability predicted metacognitive strategies such as planning and self-monitoring significantly, where those students linked to used metacognitive strategies less often and showed less tendency to take extra courses in mathematics. Attributing failure to external factors, such as less teacher support predicted cognitive strategies which suggest students related to try to achieve success through structured learning strategies.

Furthermore, attributing success to effort predicted both cognitive and metacognitive strategies where students who believe in effort tend to work hard while using learning strategies effectively. Students who believed their ability was the cause for positive academic outcomes were not shown significant differences in engagement or strategy use. This can be because those students are confident enough to survive only with their ability to succeed without exerting extra effort or using strategies for learning. Attributing success to external factors such as positive teacher support, predicted metacognitive strategies in which students related to a structured and supportive learning environment that encourages self-monitoring and planning in learning tasks to achieve successful academic outcomes.

Khedhiri (2016), researched to investigate the determinants of mathematics and statistics achievement in higher education and outlined three key factors associated with students' performance in mathematics and statistics: the attitude of the students towards mathematics and statistics, help and support given to the students and students' math skills developed from their high schools.

Findings revealed that students had positive attitudes in mathematics and statistics and those who perceived that achievement in math and statistics is important for future career opportunities have scored higher grades for mathematics and statistics. This gives the idea that students' motivation and future career expectations are significant factors for achieving success in math and statistics. Also, this study states the importance of the help and support given to the students from the math help centers by assisting students in understanding class materials and promoting learning outcomes in mathematics and statistics. Therefore, developing math support centers in the colleges by mathematics departments can help for better performance of students. In addition, results have illustrated that the students' math skills developed from their high schools are a significant factor in their success in mathematics for college students. So, it is important for high school math teachers to identify the best methods to support students to promote achievement in mathematics in high school.

In contrast, the study revealed that teaching practice, whether interactive or lecture-style, was not a significant predictor of higher scores in mathematics and math learning at the college and mathematics learning was not influenced by demographic differences among the high schools from which the students came.

2.5 The present study

Math learning challenges can be particularly high among Sri Lankan non-mathematical undergraduates, as there is a discontinuity in learning mathematics as a core subject after secondary school in school year 11 and they should restart again in higher education as university undergraduates. Further, variations in educational backgrounds in secondary school education due to diversity in the distribution of resources and facilities, students might have different perceptions and experiences in learning mathematics during their school years. Moreover, subject content included in the secondary school mathematics syllabus can have an impact on the challenges in math learning and the mathematical self-efficacy of non-mathematical students in higher education.

2.5.1 Learning mathematics during school education in Sri Lanka

School education in Sri Lanka consists of 13 school years starting at age 6 of a student and completed at age 18 of a student. The school education system is mainly comprised of three stages, primary education (school years 1 to 5), secondary education (school years 6 to 11), and Advanced Level education (school years 12 to 13) (Ministry of Education, Sri Lanka, 2020c). At the end of each three school stages students sit for three national examinations: in the school year 5, the grade 5 scholarship and placement examination, then in the school year 11, General Certificate of Education Ordinary Level (GCE O/L) examination, and after that in the school year 13, General Certificate of Education Advanced Level (GCE A/L) examination (Ministry of Education, Sri Lanka, 2013).

Mathematics is a core subject that students learn in Sri Lankan schools from primary to secondary school education. After the school year 11, students do not learn mathematics as a core subject unless their subject stream in Advanced Level education is in the Physical Science subject stream (Ministry of Education, Sri Lanka, 2020c). After the GCE O/L examination, students continue further studies at schools for another two years to complete the General Certificate of Education Advanced Level (GCE A/L) studies or move on to vocational education or the labour market (CONTESSA, 2021).

In the GCE A/L studies, Sri Lankan school students are supposed to select their preferred subject areas among six main subject streams: Arts, Commerce, Biological Science, Physical Science, Engineering Technology, and Biosystems Technology(University Grants Commission, 2025). Several core subjects are offered under each subject stream, depending on the university course requirements (University

Grants Commission, 2025). Students choose three core subjects to study among the subjects offered under each subject stream during their GCE A/L studies, where the Physical Science subject stream offers four main subjects: combined mathematics, physics, chemistry and information technology, which includes mathematics as a core subject (University Grants Commission, 2025). Based on their performance in the GCE A/L examination, students are entitled to enter universities for higher education in their specific subject fields.

Students who have selected subjects other than Physical Science as their subject stream in GCE A/L do not learn mathematics as a core subject during their studies in GCE A/L. Hence, they must utilize the mathematics subject knowledge they learned until their upper secondary education when they interact with mathematical concepts applied in the core subjects in GCE A/L studies such as economics and accounting in the Commerce stream and physics in the Biological Science stream. At the same time, Physical Science students can continue to learn mathematics as the core subject with the subject combined mathematics in GCE A/L while utilizing subject knowledge in secondary school mathematics. Further, when non-math students (who followed subject streams other than Physical Science in GCE A/L studies) enter their university education, they may require the application of mathematical concepts within their subject disciplines.

2.5.2 Factors influencing for diverse math background of undergraduates

Sri Lanka is a country with 25 districts and students are selected to the state universities based on the order of Z-scores ranks in the GCE A/L examination and the district quota system (University Grants Commission, 2025). Z-score is a statistical calculation based on three factors: the Raw marks of students, the Mean of the performance and the Standard deviation for the given subject for the given year (University Grants Commission, 2025). The district quota system has been implemented in the university admission process to make some additional seats for the students in the 16 districts identified as educationally disadvantaged districts (University Grants Commission, 2025).

In Sri Lanka, school education experiences also can be influenced by the varying levels of resources available in schools across different districts of the country. Hence, students can have different learning experiences in their overall school education due to schools in different districts are facilitated with different resources, which results in achieving different competency levels in mathematics in secondary school education (Ministry of Education, Sri Lanka, 2020a). Due to the district quota system in the university admission process, every course offered in each state university is comprised of students from almost all the districts in the country. Hence, in Sri Lankan universities, students often come from diverse pre-university educational experiences with different levels of pre-requisite knowledge required for university education.

In Sri Lankan secondary school education, mathematics is a significant core subject as success in the GCE O/L examination depends on passing mathematics (NIE, Sri Lanka, 2024). Mathematics has been identified as a supportive subject to learn other subjects and in order to promote the performance in mathematics in the GCE O/L examination, a sequence of priorities has been introduced to learn mathematical concepts in secondary school education (NIE, Sri Lanka, 2024). Accordingly, the secondary school mathematics syllabus has defined Essential Learning Concepts in Mathematics for the students in school grades 10 and 11 which have been identified as compulsorily learned to achieve mathematical literacy to examine and understand how mathematics is useful and relevant in society including real-world issues, influence decision making and contribute to study areas such as economy, healthcare, and technology (NIE, Sri Lanka, 2024).

Students achieve different competencies in Mathematics in their secondary school education, and they continue further studies with different levels of knowledge in mathematics (Ministry of Education, Sri Lanka, 2020b). Even though efforts are made to provide equal opportunities in school education in Sri Lanka, disparities in mathematics achievement can be identified in different groups due to factors such as school type, gender, medium of instruction, and school location (Ministry of Education, Sri Lanka, 2020b).

In the GCE O/L examination grading method, results are given with grades of “A”, “B”, “C”, “S” or “W” according to the marks obtained by the students where marks range from 75-100 for “A” pass, from 65-74 for “B” pass, from 50-64 for “C” pass, from 35-49 for “S” pass and from 0-34 for “W” pass (Gazette.lk, 2024). According to the statistics of the GCE O/L examination results, only 15.55% of all candidates in the GCE O/L examination in 2019 scored “A” passes for mathematics 8.96% of candidates scored “B” passes, 21.33% of candidates scored “C” passes, and 20.98% of candidates scored “S” passes (Department of Examinations, Sri Lanka, 2017). Furthermore, all these students with different competency levels in mathematics are finally studying in one common course offered by a certain university. Non-math students may face challenges in their graduate studies when learning mathematical concepts in their subject disciplines due to not meeting the pre-requisite knowledge in mathematics.

2.5.3 Math learning at university for non-math undergraduates

For undergraduate students in Sri Lanka, basic statistics courses are compulsory in many subject fields (Edirisooriya, 2021). Undergraduate first-year management studies students need to study Business Mathematics during their first semester and Business Statistics during their second semester at the university (University of Colombo, 2016). The Business Mathematics course focuses on the fundamentals of mathematics, mathematics of finance, differential calculus with functions of one variable, and integral calculus while the Business Statistics course focuses on probability distributions, statistical estimation, hypothesis testing, correlation, and regression analysis (University of Colombo, 2016). Among these mathematical concepts, first-year undergraduate management studies students do not have prior knowledge of differential calculus with functions of one variable, integral calculus, statistical estimation, hypothesis testing, correlation, and regression analysis in their previous learning experience in secondary school mathematics education according to the Essential Learning Concepts in Mathematics and the mathematics syllabus in the secondary school education (NIE, Sri Lanka, 2024).

Accordingly, during secondary school education students have not learned the basics of some of the mathematical concepts that they are studying in their first-year undergraduate studies. Further, they study mathematical concepts separately in the university's first year after 3-4 years of their secondary school education, where learning mathematics is a core subject.

2.5.4 Mathematics self-efficacy and causal attributions in the present study

Undergraduate management students in Sri Lanka may have different beliefs about their abilities in performing mathematical courses in their first-year studies due to the different levels of mathematics knowledge they acquire during their secondary school education. Due to the different competency levels, students can be influenced by emotional states such as pride and confidence if they have positive past experiences in learning mathematics and anxiety and stress if they have negative past learning experiences. However, they can be achieved in their undergraduate studies with the beliefs of their abilities and the support of external factors such as lectures, peers, and physical resources. Hence, factors such as past experiences, emotional states, and external encouragement may influence the ability to understand mathematical concepts in first-year courses.

Hence, non-math undergraduates' mathematics self-efficacy can be affected by the educational context that they have experienced in learning mathematics. Also, they can attribute the causes behind their success and failure experiences and challenges in learning mathematics in university courses. So, Bandura’s self-efficacy theory (1986) and Weiner’s attribution theory (2005) can provide a solid foundation to investigate that how non-math undergraduates in Sri Lanka perceive their ability to apply mathematical concepts encountered in their subject disciplines and the experiences and challenges faced by non-math undergraduate students in Sri Lanka when interacting with mathematical concepts in their subject disciplines related to the present study.

3 Method

3.1 Introduction

This study aims to investigate the perception and experience of non-math undergraduate management students who are studying similar course modules with different competency levels in mathematics when interacting with mathematical concepts.

This study aims to address two research questions:

1. How do non-math undergraduates in Sri Lanka perceive their ability to apply mathematical concepts encountered in their subject disciplines?
2. What are the experiences and challenges faced by non-math undergraduate students in Sri Lanka when interacting with basic mathematical concepts in their subject disciplines?

It conducts a mixed-method analysis, using a quantitative approach to investigate how non-math undergraduates in Sri Lanka perceive their ability to apply mathematical concepts encountered in their subject disciplines and a qualitative approach to examine the experiences and challenges faced by non-math undergraduate students in Sri Lanka when interacting with basic mathematical concepts in their subject disciplines. The quantitative approach is based on Bandura's self-efficacy theory (1986), while the qualitative approach is based on Weiner's attribution theory (2005).

3.2 Research design

A purely qualitative method or a quantitative method is not sufficient to address the research problem when the aim of the research is broad, and it is appropriate to conduct mixed-method research in such instances (Creswell, 2013). This study uses a mixed-method research design to address the broader research aim by narrowing it down into two research questions. Quantitative methods are used to investigate the perception of the ability of the students and qualitative methods are used to obtain information regarding the experience of the students in detail.

Six types of mixed methods research designs have been identified based on four characteristics: the weight given to the quantitative and qualitative data in data collection, the order of collecting quantitative and qualitative data, the way of analyzing data by the researcher and the point of the study at which the researcher combined the data (Creswell, 2013). The convergent parallel design is one of the six mixed methods designs, where both quantitative and qualitative data are collected simultaneously and then mixed and analyzed the data to address the research problem in the study (Creswell, 2013). Hence, the convergent parallel mixed methods design is used in the current study.

3.3 Participants and the sampling techniques

This study focuses on undergraduate management studies students who have completed their first year in Sri Lankan public and private universities. A sample of 50 students (N=50) participated in the quantitative section of the study. Another 6 participants were interviewed to collect the data for the qualitative section of the survey from the students who participated in the quantitative survey, according to their willingness to participate in the interview.

The participants for the study were selected from the purposive sampling method for this study. Purposive sampling is a non-random sampling method where the researcher can select the sample based on the objective of the study and prior knowledge of the target population (Fraenkel et al., 2012). The prior knowledge of the target population helps the researcher to make judgments regarding the representativeness of the selected sample for the study (Fraenkel et al., 2012). This study employed purposive sampling to obtain the sample for quantitative data collection to ensure that the participants in the sample fulfill the criteria of non-mathematical undergraduate students in management studies programs in Sri Lankan public or private universities. Further, students in a certain management studies program represent almost all the districts in the country due to the university admission criteria as stated in chapter 1 of this study. Hence, when selecting the sample from a management studies program, it can be assumed a higher diversity of the participants which represents students in all the districts in the country.

3.4 Data Collection Methods

3.4.1 Quantitative data collection

A structured questionnaire was prepared based on Bandura's (1986) self-efficacy theory to collect data on students’ perception of their ability to apply mathematical concepts encountered in their subjects. A questionnaire is advantageous to use as an instrument, as it can be given to a large number of participants at the same time (Fraenkel et al., 2012). The questionnaire was given to the participants through social media (WhatsApp) and data was collected through an online survey on Webropol. Personal information collected through the questionnaire with the purpose of contacting students for the interview was separated from the data in the analysis, ensuring the privacy of the participants.

The questionnaire consists of Likert-scale questions to cover the general perception of self-efficacy in mathematical concepts, the perception regarding four sources of self-efficacy (performance attainments/mastery experience, vicarious experiences, verbal persuasion, and physiological and emotional states) identified in Bandura 1986, attitudes toward mathematics regarding the relevance, interest, and perceived challenges and academic support and use of supportive sources. As discussed in chapter 2, undergraduate management studies students can have different beliefs about their math self-efficacy due to gaps in prior knowledge and learning experience from their secondary school. So, aligning with Bandura (1986), the questionnaire aims to investigate non-math students' math self-efficacy influenced by prior learning experiences, instructional support, peer encouragement, and supportive mechanisms to develop or improve math self-efficacy in university math courses.

So, in the initial theoretical design, the questionnaire aimed to measure four main constructs.

A scale with 16 items aims to measure the first construct, 'the general perception of self-efficacy in mathematical concepts studied in the two first-year courses: Business Mathematics (BM) and Business Statistics (BS)'. In the 16 items, 8 items related to measuring the confidence level of undergraduate students about their ability to apply mathematical concepts in Business Mathematics and Business Statistics courses (confidence in BM and BS) and 8 items are related to measuring the student's beliefs about whether they can learn mathematical concepts with adequate effort and practice in the Business Mathematics and Business Statistics courses (Learning attitude in BM and BS). These 16 items in this scale, further classified under four subscales: 4 items measure confidence in BM, 4 items measure confidence in BS, 4 items measure Learning attitude in BM, and 4 items measure Learning attitude in BS.

A scale with 14 items aims to measure the second construct, 'four sources of self-efficacy (performance attainments/mastery experience, vicarious experiences, verbal persuasion, and physiological and emotional states) identified in Bandura 1986', through which self-efficacy is developed. The 14 items included in this scale, further classified under four subscales: 4 items were related to measuring the mastery experience, 3 items were related to measuring the vicarious experiences, 4 items were related to measuring the verbal persuasion, and 3 items were related to measuring the physiological and emotional states.

A scale with 8 items aims to measure the third construct, 'attitudes toward mathematics regarding relevance, interest, and perceived challenges'. The 8 items included in this scale, further classified under three subscales: 3 items were related to measuring attitudes toward mathematics regarding the relevance, 2 items were related to measuring attitudes toward mathematics regarding the interest, and 3 items were related to measuring attitudes toward mathematics regarding the perceived challenges.

A scale with 6 items aims to measure the fourth construct, 'attitude of the students regarding academic support and the use of supportive sources'. The 6 items included in this scale, further classified under two subscales: 3 items were related to measuring the attitude of the students regarding academic support, and 3 items were related to measuring the use of supportive sources.

3.4.2 Qualitative data collection

Among the participants who expressed their willingness to participate in the interview with their contact details, 6 participants were randomly interviewed to collect qualitative data to examine the experience of the students. The interview questions consisted of semi-structured questions based on Weiner's (2005) attribution theory to collect data on how students attribute their experiences and challenges when interacting with mathematical concepts and the coping strategies in detail. Aligning with the context of this study, non-math management undergraduate students in Sri Lanka have studied in the commerce subject stream in their GCE A/L studies and comprised with varied background knowledge in math are studying in common classrooms in the university. Students may have different experiences regarding stable/temporary or controllable/uncontrollable internal and external attributions with their learning math in university courses.

An interview is a useful instrument with the advantage of supporting direct interaction between the interviewer and the respondent where the interviewer can explain any unclear point in the questions to the respondent and using a semi-structured interview, the interviewer has the chance to ask follow-up questions based on the answers of the respondent to obtain more details (Fraenkel et al., 2012). Hence, a semi-structured interview is used in the study as it provides flexibility to adjust predetermined questions according to the conversation to obtain more detailed answers. Interview questions aim to reveal the information regarding the general experience with mathematics in secondary school and in university, internal and external attributions of success and challenges in math learning, emotional and motivational aspects, strategies, coping mechanisms in improving math performance, and the perception regarding the broader impact of math.

Interviews were conducted in person via Zoom and recorded with participants' consent. Interview recordings were transcribed using the website "Digital Europe – AI-Based Multilingual Services" for analysis.

3.5 Data Analysis Methods

3.5.1 Quantitative Data Analysis

The data collected from the questionnaire were analyzed using IBM SPSS Statistics version 29. Collected data through Webropol were exported to SPSS for quantitative analysis and the data were prepared by assigning numerical codes to each response option. Numerical values are given for the gender responses as: Male (1), Female (2), and Other (3), for the GCE O/L result responses: A (5), B (4), C (3), S (2), W (1) and for Likert scale responses on a 5-point scale where strongly disagree (1) to strongly agree (5).

Firstly, the missing values were checked, and it was identified no missing values in the dataset. Secondly, A factor analysis was conducted to recognize hidden patterns in the questionnaire responses. An Exploratory Factor Analysis (EFA) was conducted using Principal Component Analysis (PCA) with Varimax Rotation to explore the underlying structure without prior assumptions. The Principal Component Analysis (PCA) was used as the extraction method. The Rotated Component Matrix was used to examine how items naturally group in the subscales. Thirdly, reliability tests were conducted to ensure the internal consistency of data. Lastly, Item-Total statistics were checked if the reliability did not meet the required value.

Then, Descriptive statistics were conducted. Inferential statistics were conducted with correlation analysis to identify the relationship between variables.

3.5.2 Qualitative Data Analysis

Thematic analysis was conducted to analyse qualitative data collected from interviews. In thematic analysis of qualitative data, themes or patterns (which provide a structure for organizing qualitative data) were identified, analyzed, and interpreted (Clarke & Braun, 2017). Thematic analysis is useful to recognize patterns of data gathered from participants' experiences and views through interviews (Clarke & Braun, 2017). As described in Braun & Clarke (2006), six phases of analysis were used in the thematic analysis of this study. The six phases include: familiarizing with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report (Braun & Clarke, 2006).

Familiarizing with data: As the interviews were conducted in person via Zoom, interview recordings, which were transcribed through the website “Digital Europe – AI-Based Multilingual Services,” were obtained into Microsoft Word files. Interview transcripts were read and re-read to familiarize myself with the data to observe patterns and recognize initial ideas for coding.

Generating initial codes: In the second phase, the Word documents of the interview transcripts were loaded into NVivo 14 software, which was used for qualitative data analysis. An inductive coding method was used to derive initial codes, and after analysing through statements, significant phrases and statements were highlighted and assigned to the codes. Coding was organized using NVivo 14. Each interview transcript was coded separately.

Searching for themes: In the third phase, similar codes from the initial coding were grouped into broader sections and possible themes were recognized. Thematic patterns that reflect participants' experiences, success, challenges and use of support systems in math learning were identified.

Reviewing themes: In the fourth phase, initially identified themes were reviewed and developed further by checking whether all relevant data supported each theme, removing weak themes and combining overlapping themes. Codes were also refined and suitably placed under the themes.

Defining and naming themes: In the fifth phase, after reviewing, some themes were renamed for more clarity. The finalized themes and sub-themes were defined to explain their meaning and significance within the study.

Producing the report: In the final phase, themes were interpreted and related to the research question and Weiner's Attribution theory (2005). Statements of the participants, which illustrate the key findings, were included under direct quotations when reporting results. The results were discussed in support of the existing literature and the broader context of learning math by non-math students in management studies.

4 Results

4.1 Quantitative data analysis

As mentioned in 3.4.1, the questionnaire aimed to measure 4 main constructs: the general perception of self-efficacy in mathematical concepts studied in the two first-year courses: Business Mathematics (BM) and Business Statistics (BS), the four sources of self-efficacy (performance attainments/ mastery experience, vicarious experiences, verbal persuasion, and physiological and emotional states), attitudes toward mathematics regarding relevance, interest, and perceived challenges, and the attitude of the students regarding academic support and the use of supportive sources.

The analysis of data in the four main scales started with the principal component analysis (PCA). Principal component analysis was conducted to determine the underlying factors for the items related to each scale. For instance, the Rotated component matrix was obtained under PCA for the 6 items in the scale that measure the fourth construct, 'the attitude of the students regarding academic support and the use of supportive sources' and checked for clear factor loadings that align with the initial theoretical design. If the results of the factor analysis showed that the items in the scales have different factor loadings than the initial theoretical design, then the factor structure was revised based on the PCA results (a theory-driven design, but data-driven check).

Then, the reliability tests were conducted based on the scales after the factor analysis. So, if the factor loadings aligned with the initial theoretical design, then reliability tests were conducted separately for subscale items as classified in the initial theoretical design and if the initial theoretical design was revised based on the PCA results, then the reliability analysis was conducted separately according to the newly recognized subscale items. Cronbach's Alpha analysis was conducted to assess the internal consistency of the items related to the subscales after checking the loading of the items' factor loadings. Generally, a Cronbach's Alpha value above 0.70 is considered acceptable and indicates good reliability (Tavakol & Dennick, 2011). If the Cronbach's Alpha value was below 0.70, which is the accepted threshold value for good reliability, then the item-total statistics were checked to identify any items to delete to enhance the reliability.

4.1.1 Analysis of data related to the items in the first scale: measuring general perception of self-efficacy in mathematical concepts

Factor analysis was conducted for the items related to the first scale that measures the construct, 'the general perception of self-efficacy in mathematical concepts studied in the two first-year courses: Business Mathematics and Business Statistics'. The principal component analysis was conducted separately for items related to measuring the confidence level of undergraduate students about their ability to apply mathematical concepts in Business Mathematics and Business Statistics courses (confidence in BM and BS) and for items are related to measuring the student's beliefs about whether they can learn mathematical concepts with adequate effort and practice in the Business Mathematics and Business Statistics courses (Learning attitude in BM and BS).

Firstly, the principal component analysis was conducted to determine underlying factors for the items related to the confidence level of undergraduate students about their ability to apply mathematical concepts in the business mathematics and business statistics courses. Results showed that after the Varimax rotation, business mathematics related items strongly loaded on component 1, and business statistics related items strongly loaded on component 2. The Varimax rotation has clarified that component 1 represents business mathematics related items, while component 2 represents business statistics related items (see Appendix 1). This result was in line with the initial theoretical design.

Secondly, Cronbach's Alpha analysis was conducted to assess the internal consistency of the items related to the confidence level of undergraduate students about their ability to apply mathematical concepts in the business mathematics course. The Cronbach's Alpha value of 0.89, which is almost close to 0.9 implies excellent reliability among the items. Cronbach's Alpha analysis was conducted to assess the internal consistency of the items related to the confidence level of undergraduate students about their ability to apply mathematical concepts in the business statistics course. Cronbach's Alpha value of 0.90 implies excellent reliability among the items.

Thirdly, the principal component analysis was conducted to determine the underlying factors for the items related to the students' beliefs about whether they can learn mathematical concepts with adequate effort and practice in the business mathematics and business statistics courses. The results after the Varimax rotation showed that business mathematics related items strongly loaded on component 1 and business statistics related items strongly loaded on component 2 (see Appendix 2). This result was in line with the initial theoretical design.

Fourthly, Cronbach's Alpha analysis was conducted to assess the internal consistency of the items related to the students' beliefs about whether they can learn mathematical concepts with adequate effort and practice in the business mathematics course. The Cronbach's Alpha value of 0.91, which is above 0.9 implies excellent reliability among the five items. Cronbach's Alpha analysis was conducted to assess the internal consistency of the items related to the students' beliefs about whether they can learn mathematical concepts with adequate effort and practice in the business statistics course. The Cronbach's Alpha value of 0.91, which is almost close to 0.9, implies excellent reliability among the three items.

Hence, the items related to confidence level of undergraduate students about their ability to apply mathematical concepts in Business Mathematics and Business Statistics courses (confidence in BM and BS) and items related to measuring the student's beliefs about whether they can learn mathematical concepts with adequate effort and practice in the Business Mathematics and Business Statistics courses (Learning attitude in BM and BS) are highly reliable to measure the first construct.

4.1.2 Analysis of data related to the items in the second scale: measuring four sources of self-efficacy

Factor analysis was conducted for the items in the second scale, which measures the second construct, 'the four components of self-efficacy (mastery experience, vicarious experiences, verbal persuasion, and physiological and emotional states)'.

After the Varimax rotation, the first four items related to mastery experience strongly loaded on component 2, the three items related to vicarious experiences and the four items related to verbal persuasion strongly loaded on component 1. The three items related to the physiological and emotional states were loaded on component 3, component 2 and component 4 (see Appendix 3). This result was not in line with the initial theoretical design.

The results of the factor analysis showed that some items loaded onto different factors than the original theoretical design of the study. As the factor loadings were different than the initial theoretical design, the items in the initial design may not be well fitted for the first classified subscales. In PCA grouping, some unexpected groupings might indicate misinterpretation. For instance, the items related to the physiological and emotional states in the initial theoretical design were loaded on three different components.

Hence, the initial design was adjusted according to the factor loadings in further analysis. The first four items were considered related to mastery experience. The three items related to vicarious experiences and the four items related to verbal persuasion in the initial theoretical design were strongly loaded on one single component, which seems to capture something that shares features of vicarious experiences and verbal persuasion. Altogether, those seven items were considered as related to "encouragement and social support aligned with verbal persuasion" and labelled under that name. The three items related to the physiological and emotional states in the initial theoretical design were removed in further analysis due to the conceptual mismatch with the factor loadings.

Cronbach's Alpha analysis was conducted to assess the internal consistency of the four items related to the mastery experience. The Cronbach's Alpha value of 0.72, which is above 0.70, implies good reliability among the items. Cronbach's Alpha analysis was conducted to assess the internal consistency of the seven items related to encouragement and social support aligned with verbal persuasion. The Cronbach's Alpha value of 0.89 which is almost closer to 0.9, implies excellent reliability among the items.

Hence, the items related to mastery experience and items related to encouragement and social support aligned with verbal persuasion are highly reliable to measure the second construct.

4.1.3 Analysis of the data related to the items in the third scale: measuring attitude toward mathematics regarding relevance, interest and perceived challenges

Factor analysis was conducted for the items related to the third scale that measures the construct, 'the attitudes toward mathematics regarding relevance, interest, and perceived challenges.'

After the Varimax rotation, the first three items related to attitudes toward mathematics regarding relevance and importance strongly loaded on component 1, the two items related to attitudes toward mathematics regarding interest strongly loaded on component 3 and the three items related to perceived challenges strongly loaded on component 2 (see Appendix 4). This result was in line with the initial theoretical design.

Cronbach's Alpha analysis was conducted separately to assess the internal consistency of the 3 items related to the attitudes toward mathematics regarding relevance, 2 items related to the attitudes toward mathematics regarding interest, and 3 items related to the attitudes toward mathematics regarding the perceived challenges. The Cronbach's Alpha value of 0.79 for the 3 items related to the attitudes toward mathematics regarding relevance and the Cronbach's Alpha value of 0.81 for the 3 items related to the attitudes toward mathematics regarding the perceived challenges suggested good reliability and the items measuring each construct well. The Cronbach's Alpha value of 0.63, which is below the accepted threshold of 0.70 for the 2 items related to the attitudes toward mathematics regarding interest, suggested that the correlation between the two items is not high enough to form a reliable scale with only two items.

Then, the Item-total statistics were checked for the 2 items related to interest in the scale. Corrected Item-Total Correlation values were below 0.3 for the two items "I enjoy learning mathematical concepts related to my coursework" and "I am curious to learn how mathematical concepts are applied in management studies" which are related to the attitudes toward mathematics regarding interest. This suggests that these two items do not fit well with the scale. Deleting the item "I am curious to learn how mathematical concepts are applied in management studies" will improve the reliability value to 0.703 (see Appendix 5).

Hence, the item "I am curious to learn how mathematical concepts are applied in management studies" was deleted and the item-total statistics checked again (see Appendix 6). The corrected Item-Total Correlation value for the item "I enjoy learning mathematical concepts related to my coursework" was 0.13 which is below 0.3. This suggested that this item does not fit well with the scale. Deleting the item "I enjoy learning mathematical concepts related to my coursework" will achieve a more acceptable level of internal consistency with a reliability value of 0.73. Hence, the item "I enjoy learning mathematical concepts related to my coursework" was deleted and enhanced the reliability.

Both the items that were deleted from the scale were interest-related items. The remaining items in the scale are related to the attitudes toward mathematics regarding the relevance and the perceived challenges of the students. Deletion of interest-related items that contributed to lower reliability suggested that these items are not strongly aligned with relevance and perceived challenges related items in the scale.

Finally, the items related to attitudes toward mathematics regarding the relevance and the perceived challenges of the students are highly reliable to measure the third construct.

4.1.4 Analysis of data related to the items in the fourth scale: measuring academic support and the supportive sources

Factor analysis was conducted for the items in the fourth scale that measure the construct, the attitude of the students regarding academic support and the use of supportive sources.

After the Varimax rotation, items related to the attitude of students regarding academic support strongly loaded on component 2. The items related to the use of supportive sources for mathematics strongly loaded on component 1(see Appendix 7). This result was in line with the initial theoretical design.

Cronbach's Alpha analysis was conducted separately to assess the internal consistency of the 3 items related to the attitude of the students regarding academic support, and 3 items related to the use of supportive sources. The Cronbach's Alpha value of 0.72, which is above the accepted threshold of 0.70 for the 3 items related to the use of supportive sources suggested good reliability among the items. The Cronbach's Alpha value of 0.61, which is below the accepted threshold of 0.70 for the 3 items related to the attitude of the students regarding academic support, suggested that the items may not be measuring the same construct well. So, even though the factor structure is in line with the initial theoretical design, more items may also be included in the scale.

Then, the Item-total statistics were checked for the 3 items related to the attitude of the students toward academic support. Corrected Item-Total Correlation values, which are above 0.3 for all three items, suggested that the items fit well with the scale and deleting any item will not improve the reliability value more than 0.7 (see Appendix 8).

However, these three items related to the attitude of the students toward academic support are conceptually valid and provide valuable insight into students' learning experience despite their low reliability. Hence, these three items were considered in the scale, which measures the fourth construct of the attitude of the students regarding academic support and use of supportive sources in further analysis of this study.

4.1.5 Descriptive statistics

New variables were computed using the mean values of the items related to each subscale.
The mean value of 18 items in the first scale was computed for the new variable "the general perception of self-efficacy in math courses". In the first scale, the items related to the ability to apply mathematical concepts in the business mathematics and business statistics courses were used to calculate the mean of "confidence in BM", "confidence in BS" and "confidence in both BM and BS". The items related to the student's belief that they can learn mathematical concepts in the business mathematics and business statistics courses with adequate effort and practice were used to calculate the mean of the "Learning attitude of BM", "Learning attitude of BS", and "Learning attitude of BM and BS".

The mean value of 4 items was calculated in "Mastery Experience", the mean value of 7 items were calculated for "encouragement and social support aligned with verbal persuasion", the mean value of each 3 items belonged to the subscales was calculated for the variables "math relevance", "math challenges", "academic support", and "supportive sources".

Results for the descriptive statistics were obtained to provide an understanding of the undergraduate management studies students about their perceptions regarding aspects such as confidence and attitude toward learning mathematical concepts, self-efficacy of learning mathematics, relevance, perceived challenges, and availability of supportive sources in learning mathematics. Descriptive statistics, including mean, standard deviation, minimum, and maximum values, were reported.

Table 1: Descriptive statistics

	Range	Minimum	Maximum	Mean	Std. Deviation
confidence in BM	3.60	1.00	4.60	3.23	.69
confidence in BS	4.00	1.00	5.00	3.25	.77
Confidence in both BM and BS	2.75	1.75	4.50	3.24	.64
Learning attitude in BM	2.20	2.80	5.00	3.84	.57
Learning attitude in BS	3.00	2.00	5.00	3.72	.61
Learning attitude in both BM and BS	2.25	2.75	5.00	3.80	.53
Mastery Experience	2.00	3.00	5.00	3.71	.57
Encouragement, social support, aligned with verbal persuasion	2.29	2.71	5.00	3.85	.60
Math Relevance	2.33	2.67	5.00	3.87	.60
Math Challenges	3.67	1.33	5.00	3.22	.82
Academic Support	2.67	2.33	5.00	3.62	.61
Supportive Sources	2.33	2.67	5.00	4.03	.60

Undergraduate management studies students have a moderate confidence level (mean=3.23) about their ability to apply mathematical concepts in the Business Mathematics course, where they learn the fundamentals of mathematics, mathematics of finance, differential calculus with functions of one variable, differential calculus with functions of more than one variable, and integral calculus. They have a slightly higher confidence level (mean=3.25) about their ability to apply mathematical concepts in the Business Statistics course, where they learn the probability distributions, statistical estimation and hypothesis testing and correlation and hypothesis testing. Further, they showed a balanced confidence level (mean=3.24) about their ability to apply mathematical concepts in both Business Mathematics and Business Statistics courses. However, the larger range of 4.00 and low minimum value of 1.00 for confidence in BS indicated a greater variability in students' perception regarding the confidence, where some students feel very confident, and some are not at all. This signals a subgroup at risk with very low math self-efficacy.

Moreover, a higher mean value of 3.84 in learning attitude in Business Mathematics indicates that students believe that they can learn mathematical concepts with adequate effort and practice. The mean value of 3.80 of learning attitude in both Business Mathematics and Business Statistics courses indicated that overall students have a positive belief that they can learn mathematical concepts with adequate effort and practice.

These results imply that undergraduate management studies students generally believe in their mathematical abilities to interact with mathematics courses.

A moderate-to-high mean score of 3.71 for the mastery experience suggested that students generally think that their past experiences in secondary school (grade 10, grade 11) with mathematics and past successful experiences of doing similar tasks in mathematics contributed positively to their self-efficacy beliefs in mathematics learning in university. A low standard deviation of 0.57 showed fairly consistent responses regarding mastery experience. The mean score of 3.85 for encouragement and social support aligned with verbal persuasion suggested that students value a moderate-to-high level of support and positive feedback from their peers, instructors, or other sources that boost their confidence in math-related subjects.

A fairly high mean (=3.87) of attitude toward the relevance of mathematics indicates that undergraduate management studies students find mathematics relevant to their current studies, future careers, and real-world problems in their specific subject field. The low standard deviation (SD = 0.60) showed consistent responses which implies more agreement among students regarding the relevance. A comparatively lower mean of 3.22 for perceived challenges that students encountered in math learning suggested that students perceived that math is rather challenging, while a low minimum score of 1.33 and wide range of 3.67 implied significant variation in challenges in mathematics; some students find it more challenging, and some students find it less challenging. This suggested the need of differentiated instructions and extra learning supports.

A moderate mean of 3.62 for the academic support suggested that students feel that the guidance provided by lecturers during lectures, the course materials such as textbooks and lecture slides and feedback received on assignments and exams provided reasonable help to improve their learning of mathematical concepts. The highest mean (= 4.03) recorded for the supportive sources indicated that students feel that the availability of online resources such as videos and software and group discussions with peers were strongly helpful sources for understanding mathematical concepts in their mathematics coursework and the responses were fairly consistent with a standard deviation 0.60.

4.1.6 Correlation analysis

The correlation analysis was conducted to identify relationships between students' confidence and learning attitudes in Business Mathematics (BM) and Business Statistics (BS) courses and other factors such as self-efficacy components, math relevance and use of support variables.

Table 2: Pearson correlations of the study variables

	1	2	3	4	5	6	7	8	9	10
1. Confidence in BM	-	.54**	.33*	.18	.50**	.15	.21	-.10	.44**	-.01
2. Confidence in BS	.54**	-	.36**	.45**	.21	-.11	.00	.00	.19	-.16
3. Learning attitude in BM	.33*	.36**	-	.64**	.50**	.40**	.45**	.23	.25	.45**
4. Learning attitude in BS	.18	.45**	.64**	-	.26	.25	.23	.15	.20	.34*
5. Mastery Experience	.50**	.21	.50**	.26	-	.54**	.51**	.10	.33*	.56**
6. Encouragement, social support, aligned with verbal persuasion	.15	-.11	.40**	.25	.54**	-	.62**	.20	.13	.59**
7. Math Relevance	.21	.00	.45**	.23	.51**	.62**	-	.18	.22	.52**
8. Math Challenges	-.10	.00	.23	.15	.10	.20	.18	-	.13	.31*
9. Academic Support	.44**	.19	.25	.20	.33*	.13	.22	.13	-	.09
10. Supportive Sources	-.01	-.16	.45**	.34*	.56**	.59**	.52**	.31*	.09	-

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

There was a strong positive correlation between confidence in BM and confidence in BS ($r = .54$, $p < .001$). This indicates that students who felt confident in their ability to apply math concepts in one subject are more likely to feel confident in their ability to apply math concepts in the other. (The confidence level of undergraduate students about their ability to apply mathematical concepts in Business Mathematics and Business Statistics courses is represented by ‘confidence in BM’ and ‘confidence in BS’)

Learning attitude in BM was significantly correlated with confidence in BM ($r = .33$, $p < .05$), confidence in BS ($r = .36$, $p < .01$). These findings indicate that students who believed that they could learn mathematical concepts with adequate effort and practice in the business mathematics course were also more likely to feel confident in their ability to apply math concepts in both BM and BS. A significant positive correlation was found between confidence in BS and learning attitude in BS ($r = .45$, $p = .001$). This indicates that students who felt more confident in their ability to apply math concepts in the business statistics course also tended to believe they would succeed more in business statistics with adequate effort and practice.

The strongest association was observed between learning attitude in BM (students' beliefs about whether they can learn mathematical concepts with adequate effort and practice in the Business Mathematics course) and learning attitude in BS ($r = .64$, $p < .001$). This finding indicates that students who believed that they could learn mathematical concepts with adequate effort and practice in the business mathematics course were more likely to have a similarly positive learning attitude toward business statistics, where they believed that they could learn mathematical concepts with adequate effort and practice in the business statistics course, too.

Mastery experience showed moderate, statistically significant correlations with confidence in BM ($r = .50$, $p < .001$) and learning attitude in BM ($r = .50$, $p < .001$). This suggests that students with positive mastery experience in math tend to feel more confident in their ability to apply math concepts in BM and possess a more positive learning attitude, where they believe they can learn mathematical concepts with adequate effort and practice in the business mathematics course. However, mastery experience showed weak correlations with confidence in BS ($r = .21$) and learning attitude in BS ($r = .26$). This indicates that the less mastery experience in business statistics-related topics in secondary school education had influenced students' confidence and learning attitude in the business statistics course in the university.

Encouragement and social support aligned with verbal persuasion had strong positive relationships with learning attitude in BM ($r = .40$, $p < .01$). This finding indicates that students who receive higher levels of encouragement and verbal support from their instructors, peers, or others are more likely to believe that they could learn mathematical concepts with adequate effort and practice in business mathematics.

A significant positive correlation was found between math relevance and learning attitude in BM ($r = .45$, $p < .001$). This indicates that students who perceived mathematics as more relevant to their studies demonstrated a more positive attitude toward learning business mathematics. Interestingly, the non-significant or week correlation between perceived challenges in math with confidence in BM, confidence in BS, learning attitude in BM and learning attitude in BS suggested that students' confidence in ability to apply math concepts or their beliefs in improving with adequate effort in math courses was not strongly influenced by their perception regarding difficulty level in math.

A significant positive correlation was observed between academic support and confidence in BM ($r = .44$, $p = .001$). This suggests that students who perceived that they received higher levels of academic support tended to report higher confidence in their ability to apply math concepts in the business mathematics course. Supportive sources had significant positive correlations with learning attitude in BM ($r = .45$, $p = .001$) and learning attitude in BS ($r = .34$, $p = .015$). This suggests that students who reported greater access to support sources were more likely to believe they can learn mathematical concepts with adequate effort and practice in the business mathematics and business statistics courses.

A strong and statistically significant positive correlation was observed between mastery experience and encouragement and social support aligned with verbal persuasion ($r = .54$, $p < .001$). This indicates that students who reported more successful experiences in math-related tasks also tend to receive higher levels of encouragement and social support. This relationship suggests that verbal encouragement from instructors, peers or others may contribute to students' mastery of mathematical tasks. Mastery experience showed strong, statistically significant correlations with math relevance ($r = .51$, $p < .001$). This result suggests that students who reported greater mastery experiences in mathematics also tended to perceive mathematics as more relevant in their studies and future careers.

Mastery experience showed the strongest correlation with supportive sources ($r = .56$, $p < .001$), suggesting that the perception of having helpful resources may be significant in strengthening students' mastery experiences. There was a statistically significant positive correlation between mastery experience and academic support ($r = .33$, $p = .019$). This indicates that students who reported positive mastery experiences also have positive feelings regarding the academic support that they received.

The strongest correlation observed was between encouragement and social support aligned with verbal persuasion and math relevance ($r = .62$, $p < .001$), suggesting the significant role of external encouragement in helping management students to recognize the value and applicability of mathematics in broader contexts. Encouragement and social support aligned with verbal persuasion had strong positive relationships with supportive sources ($r = .59$, $p < .001$). This indicates that students who receive higher levels of encouragement and verbal support from their instructors, peers, or others are more likely to have a positive attitude regarding supportive sources in math learning.

A significant positive correlation was found between math relevance and supportive sources ($r = .52$, $p < .001$). This indicates that students who perceived mathematics as more relevant to their studies are more likely to have higher access to supportive resources to achieve success in their math-related tasks. Math challenges had a modest link to supportive sources ($r = .31$, $p < .05$). This indicates that students are likely to use supportive sources to overcome math challenges.

4.2 Qualitative data analysis

The experiences and challenges of non-math undergraduate students when interacting with mathematical concepts in their subject disciplines were analysed under three major themes: "students' experiences regarding math ability and confidence", "factors influencing success and challenges in math learning", and "strategies and support systems for overcoming challenges". These 3 themes were developed through the thematic analysis of interview data from the semi-structured interview and guided by Weiner's Attribution Theory (2005). The qualitative interviews discovered additional insights beyond the quantitative analysis reflections, expanding the scope of understanding regarding experiences and challenges of non-math undergraduates when interacting with math concepts in their subject disciplines.

4.2.1 Students' experiences regarding math ability and confidence

The analysis outlined five sub-themes: "Confidence in math – Past (secondary school) vs Present (university)", "Emotional experience with math anxiety and fear of failure", "Motivational experiences after success or failure in math", "Learning experiences in other subjects in management studies", and "Perception regarding the ability and challenges".

Confidence in math – Past (secondary school) vs Present (university)

Students had different confidence levels regarding math in their secondary school education, and all of them stated that they are more confident in learning math and taking challenges in math tasks in their university math courses.

"During my school time, I wasn't that confident in my mathematics because I was scared whenever I felt like I had to attempt a question, but that attitude has changed by now." S2

"Before entering university, I had mixed feelings about math. Since starting university, my attitude has changed a lot. Taking advanced classes and learning more has made me feel more confident." S3

"Before university, I had a neutral attitude towards mathematics. I was fairly confident in math during school, but sometimes I found certain topics challenging for me. After entering the university, my attitude has changed because the complexity of the subjects has increased..." S4

"Actually, I'd like to tell this, when I was in school grade 10, I had only 36 marks for mathematics, but in O/Level examination I got an 'A' pass. And now in university, for subjects like statistics and mathematics, I got 'A+' grades.", *"Actually, I am not that confident in mathematics in O/Levels, but*

when I entered my university, I felt more confident, it's of course because of my hard work and great practice." S6

Emotional experience with math anxiety and fear of failure

Non-math undergraduate students experienced negative feelings such as disappointment, embarrassment and hopelessness due to failures caused by the lack of math ability or task difficulties. Participants stated that the lack of math ability and task difficulty tends to cause them negative feelings.

"I feel disappointed when I can't understand a math concept, but I try to remind myself that with practice, I can improve" S1

"I feel embarrassed because I can't answer the question, but the rest of the students in the class can do it" (S2)

"I felt discouraged because the question in the test was so hard to answer. However, I readied well for the test before I got to the test. So, I felt hopeless, and I thought that I would never be good at maths" (S3)

"I feel discouraged because the questions in the test were too difficult to answer, even though I prepared well for the test before I took the test" (S7)

Motivational experiences after success or failure in math

Participants of the interview revealed that they have boosted their motivation after both success experiences and failure experiences in math-related tasks.

Successful experiences that connected with positive emotions such as pride and satisfaction motivated them more in learning and engage in math tasks as generally expected.

"When I solve a difficult math problem, I feel proud... It also gives me a sense of achievement because I know I have improved. Not only that, I feel motivated to try even harder problems." S4

"I feel like I'm really brilliant because I got the concept, and my answer is right. I feel satisfied and happy." S5

Students stated that the difficulties or failure experiences in math tasks enhanced their motivation to improve their math skills, which is typically not expected. Students talked about "study hard", "seek help when needed", "avoid feeling discouraged" which gives an idea about how their motivation was boosted even after difficulties.

"The topics like differential calculus and probability distributions can be tough, but I try to stay positive. When I struggle, it motivates me to work hard instead of feeling discouraged. So overall, the difficulty pushes me to learn more" S3

"The content is moderately difficult. That difficulty has motivated me to study hard and seek help when needed." S7

"During my school time, I wasn't performing well in mathematics. So, it motivated me to try it right now because I'm not late" S3

Learning experiences in other subjects in management studies

Participants stated how they believe the importance of university math courses in learning other subjects in management studies.

"Math has helped me in subjects like accounting, economics, and finance. Since I understand mathematical concepts better, I feel more confident when I work with those subjects." S4

"I actually believe that mathematics is a subject that relates to problem solving. So, I think for a management student, it really needs problem-solving skills...", "math is really helpful for our other subjects like finance, and accounting" S6

"My experience with mathematics in management studies has made me more confident in other subjects that use mathematics. For example, understanding statistics helped me in analysing data in marketing. So, it shows me that I can apply my math skills in different subject areas." S3

Perception regarding the ability and challenges

From their math learning experiences, students expressed how they believe in their ability in math. Participants expressed their challenging experiences, and they have the idea that the challenges are temporary and with more effort and practice, they can do better.

"I would like to believe challenges in math are temporary. If I put in enough effort, I can do better." S1

"It was hard, it is hard, and complicated to understand at the beginning. But if you have that attitude to get good grades and to improve your knowledge, then it's something which is easy to do." S2

"With practice and putting more effort, I can improve." S4

"I believe my challenges are temporary and can be overcome. I have seen improvement over time through the back days and last month. So, my confidence grows when I solve problems. I'm optimistic that I can keep improving with effort and support." S3

4.2.2 Factors influencing success and challenges in math learning

The analysis outlined four sub-themes: "Challenges due to math difficulty", "Challenges due to prior knowledge", "Challenges due to teaching methods", and "Success due to effort and teaching methods".

Challenges due to math difficulty

Participants in the interview shared their views regarding the challenges in learning math due to its difficulty. Most of the participants admitted that math is inherently difficult, and they need more effort and more time to improve, which is challenging to them.

"I feel like mathematical content is inherently difficult. It's a bit complicated. I need to put more effort, need to spend more time to improve" S2

"When I find a hard math topic, I need to spend more time practicing and reviewing examples.", "I have to study lots of subjects, not only math and statistics. So, when I study lots of subjects, I can't spend more time with only those math subjects" S4

"I would say it's basically inherently difficult for most people." S5

Challenges due to prior knowledge

Participants in the interview shared their challenges in university math learning due to a lack of prior knowledge. Participants stated that certain math concepts that they did not learn in their secondary school are too challenging for them to grasp in university.

"When I face difficulties with maths, I think gaps in my prior knowledge is a reason. If I didn't fully understand some math concepts in secondary school, those make me new topics in university." S3

"I believe my prior knowledge from my secondary school has a significant impact on my performance in the university. In school, I learned some math fundamental concepts such as arithmetic, algebra, percentage and other basic concepts. They are very helpful and useful to me at the university. But some topics, such as calculus and hypothesis testing, are more challenging for me because they were not covered in secondary school." S4

Challenges due to teaching methods

Participants expressed the challenges they faced due to teaching methods in university math courses. They have highlighted traditional methods of teaching, insufficient teaching time given for math lectures in their timetables, and unclear explanations. As the non-math students, they need clear explanations on topics with proper lesson planning rather than rushing through the lesson just to cover the topics. Insufficient time slots for lectures caused challenges to understanding math concepts for students.

"The time they spend to describe to us the lesson, to teach us the lesson, is not enough. For students like me, it needs a lot of time and effort.", "Lecturers also didn't have much time because they also needed to go to other classes." S2

"If the lecture goes very fast, I may not understand the deep concepts..." S4

"Sometimes teaching methods are confusing..." S7

Success due to effort and teaching methods

Participants shared how their effort led to a successful experience in math learning at university. Many students believed that their extra effort put on math learning made them successful.

"First, I work hard and practice a lot. A good explanation from the lecturers helped too. Also, studying with classmates made math easier to learn." S3

"Just attending the lecture is not going to work; self-studying and practicing made me successful in math learning." S6

One participant shared a successful experience in math learning due to teaching methods as *"Sometimes it's the lecturers' good explanations or YouTube videos that helped me to successfully learn math concepts."* (S1)

4.2.3 Strategies and support systems for overcoming challenges

The analysis outlined four sub-themes: "Self-study and revision strategies", "Suggestions for teaching improvement", and "Support from lecturers and peers".

Self-study and revision strategies

Participants shared their experiences of self-study and revision strategies, which increased their learning outcomes and engagement in university math courses. Many participants mentioned referring to external resources such as YouTube videos, tutorials and books. Continuous practice in math problems, independent work and attending the lectures continuously also mentioned by the participants. Overall, these self-study and revision strategies are helpful for students to promote math learning outcomes.

"I review my knowledge and practice problems. I asked my lecturers or colleagues for help. Also, I used online resources and videos to get different explanations. I also break down the problems into smaller sections, which helps me a lot in understanding problems.", "Tutoring from friends or online resources was effective because it gave me different ways to understand the materials." S3

"YouTube videos, with very short video durations like two to three minutes or five to six minutes, have helped me a lot to understand mathematical problems. And rather than watching a recording for two to three hours, it saves a lot of time." S2

"I watch online videos just like YouTube videos and other videos and I use textbooks, tutorials given by our lecturers and I discuss with my friends because it will give me a lot of help to understand mathematical concepts." S4

"I try to attend lectures as much as I can. And I watched a lot of recorded lectures... attending lectures consistently helped me." S5

"Self-studying is one of the best methods I've used." S6

Support from lecturers and peers

Non-math undergraduate students shared their experiences regarding the support they received from lecturers and peers for learning math courses at the university. They highly stated about peer support in understanding math concepts.
"And the important thing, which is called "Kuppi", where the peers who have better knowledge about the concept explain it to other friends in the group.", "Also, studying together with peers makes it less challenging." S1

"Whenever exams are closer, I do a lot of questions with my friends. So, when we try questions together, it's easy for me to understand. And whenever peers teach me, I can remember the logic." S2

"My lecturers are helpful, and I can ask questions when I need to." S3

Suggestions for teaching improvement

Participants stated their suggestions to improve teaching methods in math courses for better learning outcomes. According to their viewpoints, many participants stated that including more real-world examples in lessons can improve their understanding of math concepts.

"I would like to say that more real-world examples or step-by-step explanations help more." S1

"I would suggest using more real-life examples to show how maths applies outside the classroom." S3

"I think lecturers should explain difficult concepts more slowly and also explain those concepts using real-life examples." S4

Participants suggested increasing the time to explain math concepts, and small study groups to pay more attention to students.

"I think the teachers, the lecturers, need to spend a little more time teaching the mathematical concepts, and practicing more questions with the students." S2

"I would also recommend smaller study groups for more personalized help and more visual aids to explain concepts better." S3

5 Discussion

This chapter discusses the key findings of the study regarding how non-math undergraduates in Sri Lanka perceive their ability to apply mathematical concepts encountered in their subject disciplines and what experiences and challenges are faced by non-math undergraduate students in Sri Lanka when interacting with mathematical concepts in their subject disciplines.

5.1 Non-math undergraduate students' perception regarding the ability to apply mathematical concepts

Significant views of non-math management studies students regarding their ability to apply mathematical concepts encountered in their first-year two courses, Business Mathematics and Business Statistics, are provided by descriptive analysis. The findings indicate that students have a moderate confidence level about their ability to apply mathematical concepts in the Business Mathematics and Business Statistics courses. Also, a comparatively high mean value in learning attitude in Business Mathematics and Business Statistics courses indicates that students believe that they can learn mathematical concepts with adequate effort and practice. Also, in the interview, the participant's statements such as, *"I would like to believe challenges in math are temporary. If I put in enough effort, I can do better."* (S1) implies that the students possess a positive mindset where they believe they can improve more with adequate effort and practice. Further, a statistically significant link of math challenges to supportive sources ($r = .31$, $p < .05$) indicated that the students tend to use supportive sources to overcome difficulties in math tasks. This suggests that effective supportive sources would be beneficial to the students to enhance their confidence in self-efficacy in math courses further.

Relatively high mean scores of mastery experience and encouragement and social support aligned with verbal persuasion reflect that those play a significant role in building self-efficacy in math. Hence, past experiences in secondary school (grade 10, grade 11) with mathematics and past successful experiences of doing similar tasks in mathematics have positively strengthened math self-efficacy. Supporting this, findings in Liu et al. (2024) investigated that mathematics achievement in the secondary school year significantly predicted the math achievement in the following years. Math achievement may build confidence in math tasks. This emphasizes the significance of prior academic performance in promoting math achievement later.

The moderate rating given by the students regarding academic support suggests that need for better support for math learning with adjustments to existing instructional methods. According to Bartimote-Aufflick et al. (2016) several studies demonstrated that teachers could influence to increase student self-efficacy as university students' self-efficacy increased with effective teaching strategies. Implications of their study highlighted several effective teaching strategies such as guiding students with classroom interaction when using multimedia, such as videos, rather than leaving students themselves to work with resource, providing sufficient scaffolding when teaching topics which are unfamiliar to students, when solving problems demonstrating coping strategies through making errors and correcting rather than solving perfectly that would be suitable for improve university students' self-efficacy.

A comparatively lower mean and higher standard deviation for perceived challenges that students encountered in math learning suggested that students perceived that math is rather challenging, where some students find it more challenging, and some students find it less challenging. This emphasizes the need for more inclusive and adaptive instructional strategies to enhance motivation and self-efficacy in math learning. Such strategies can be employed by providing basic explanations and continuing to advanced extensions when explaining new topics, using short diagnostic tests to identify students' math abilities, providing diverse learning styles through visual aids, verbal explanations, and real-world examples and giving ongoing feedback.

The correlation analysis provides valuable insights into shaping non-math students' self-efficacy in learning mathematics. The significant and strong correlations between mastery experience with both confidence in BM ($r = .50$) and learning attitude in BM ($r = .50$) highlights that successful experiences in past math learning tasks significantly increase confidence in applying math concepts in business mathematics and help to increase the beliefs of students that they can develop more in learning mathematical concepts with adequate effort and practice in the business mathematics. Further, mastery experience showed weak correlations with confidence in BS ($r = .21$) and learning attitude in BS ($r = .26$). This highlights that the students' greater past learning experiences in business math-related topics in their secondary school education than the business statistics-related topics had improved their confidence in university business mathematics course. Similar findings were obtained in Özcan & Kültür (2021), which investigated a significant positive correlation between mastery experience and course achievement in mathematics. This finding highlights the importance of providing a solid foundation in math in secondary school education, where students utilize the mathematics learned in secondary school as a foundation of their further math-related studies in higher education. Also, the need for curriculum design, after recognizing the interconnectedness of secondary school math to further math education.

A strong positive correlation between encouragement and social support aligned with verbal persuasion and learning attitude in BM suggests that encouragement received from peers or instructors plays a significant role in building students' beliefs that they can learn mathematical concepts with adequate effort and practice in the business mathematics course. Also, strongest correlation between social support and math relevance ($r = .62$, $p < .001$) reflects that this social encouragement tends to enhance the perception of the students regarding the relevance of math for their academic and professional development. This supports the findings of Gao (2019) that revealed a positive association between students' mathematics self-efficacy and positive feedback on their math learning. Further, these findings are consistent with most previous studies that agreed that mastery experience and social persuasion are the strongest sources of mathematics self-efficacy (Al Umairi, 2024).

Interestingly, the non-significant or week correlation between perceived challenges in math with confidence in BM, confidence in BS, learning attitude in BM and learning attitude in BS suggested that students' confidence in ability to apply math concepts or their beliefs in improving with adequate effort in math courses was not strongly influenced by their perception regarding difficulty level in math. This finding is aligned with Al Umairi (2024), that explained higher self-efficacy (obtained from four sources of self-efficacy) in students motivates them to continue in difficult learning tasks by accepting challenges until they achieve learning goals. This may indicate that individual coping mechanisms or learning strategies help to rescue the students' self-efficacy from the impact of math challenges.

Although a strong positive correlation was reported between confidence in BM and confidence in BS ($r = .54$), they exhibited different relationships with mastery experience. This suggests that the students evaluate their ability in these two subjects, BM and BS, through different perceptions. For example, confidence in BS showed a non-significant correlation with mastery experience ($r = .21$, not significant), whereas confidence in BM showed a statistically significant correlation with mastery experience ($r = .50$).

There was a strong and statistically significant correlation between learning attitude in BM and learning attitude in BS ($r = .64$, $p < .001$). This suggests that if students hold a positive learning attitude in BS where they believe that they can, they learn mathematical concepts with adequate effort and practice in the business mathematics course are likely to carry that same mindset into business statistics. The significant positive correlation between confidence in BS and learning attitude in BS ($r = .45$) indicates that students who felt more confident in their ability to apply math concepts in the business statistics course also tended to believe they would succeed more in business statistics with adequate effort and practice. This highlights the important role of self-efficacy in building motivation to learning math tasks.

The significant and strong positive correlation between mastery experience and encouragement and social support aligned with verbal persuasion ($r = .54$, $p < .001$) highlights the importance of encouragement and support received from instructors, peers and others in developing students' successful experiences in math-related tasks. In practical terms, this finding supports the inclusion of supportive learning environments in math education where encouragement is continued to maximize students' opportunities to develop confidence in math-related tasks through mastery experiences.

The strong correlations between mastery experience and both math relevance ($r = .51$) and supportive sources ($r = .56$) imply that students who perceive their math learning is relevant for their current academic studies and future career opportunities and who have positive attitude in access to helpful resources related to math tasks are more likely to develop successful learning experiences in math. The positive relationship between mastery experience and academic support suggests that students who have positive feelings about the academic support that they received in math tasks are more likely to have success experiences in mathematics that strengthen their competencies in math tasks.

The strong and statistically significant relationship between math relevance and supportive sources suggests that students who recognize the applicability of mathematics in their current studies and in real-world contexts are more likely to have a positive attitude regarding the support they obtained from various sources in math tasks. Therefore, developing the math curriculum to realize its relevance and establish proper access to supportive sources for math tasks can play a crucial role in enhancing student engagement and self-efficacy in mathematics.

5.2 Non-math undergraduate students' experiences and challenges in math learning

5.2.1 Math learning experiences from school to university to succeed in university math courses

When students transition between two learning environments: from school education to university education, students are expected to be more responsible for their learning at universities, with more independent work rather than the school education supported by school teachers and parents (Kouvela et al., 2018).

The findings of the interviews suggested that students have improved their confidence in math after entering the university, even though they had different confidence levels in the secondary school regarding mathematics. Findings showed that confidence has increased with the realization of the importance of learning math and students' determination to take on challenges in math learning. When students need to deal with university-level mathematics with new mathematical concepts, students tend to put more effort, and they may realize the significance of learning math in management studies than their secondary school time.

According to Weiner's Attribution theory (2005) these beliefs in confidence reflect the internal and unstable attributions, in which when students' ability and effort increase, the confidence level increases from secondary school education to university education. For example, students' statements like *"Actually, I'd like to tell this, when I was in school grade 10, I had only 36 marks for mathematics, but in O/Level examination I got an 'A' pass. And now in university, for subjects like statistics and mathematics, I got 'A+' grades."* (S6) implied the way of their internal attributions like "effort" changes throughout time to enhance their math skills.

In the Sri Lankan educational context, non-math management studies undergraduates possessed mainly secondary school math knowledge to study in university math courses. According to Rach & Ufer (2020) students with overall academic skills, such as logical thinking and problem solving might succeed at university math studies even though they were not at the top math grades at school. Thus, as revealed in interviews, non-math management undergraduates in Sri Lanka also build their confidence in math learning at universities, even though they have different confidence levels in math in secondary school.

As non-math students, participants in the interview have acknowledged the importance of learning first-year math and statistics courses in the university to engage in other subjects in management studies, such as accounting, economics and business finance, where mathematical concepts are needed in learning.

Participants highlighted the importance and interconnectedness of math courses to learn in other subjects and they expressed their positive experiences in utilizing knowledge from math courses in other subjects in management studies. As one student mentioned *"Math has helped me in subjects like accounting, economics, and finance. Since I understand mathematical concepts better, I feel more confident when I work with those subjects."* (S4), which implies that students' ability to understand the math concepts applying in other management studies subjects made them more confidence in learning, as they studied first year math and statistics courses. A subset of the interview participants expressed their desire to include more real-life examples in math courses, and they realized the real-world application of math through these subjects in management studies. Hence, this suggests that the prior learning experience with math and stat courses in the university's first year directly influences the overall performance in management studies.

According to Weiner's attribution theory (2005), the way students attribute success or difficulty to their learning tasks shapes their learning experiences. In this study, students have attributed their successful experiences in learning other subjects in management studies to internal and controllable factors such as confidence and prior preparation. For instance, students' statements like "*Math is really helpful for other subjects like finance, and accounting"* (S6), *"understanding statistics helped me in analysing data in marketing"* (S3) imply that prior preparation with first-year math courses enhanced their confidence in other management studies courses. These attributions promote the perception of math learning and its broader impact positively.

This realization of the students regarding the interconnectedness of mathematical concepts in other subjects of management studies at the university level helps to promote outcomes of the students in their math learning process. This emphasizes the need for curriculum integration to support the students in identifying meaningful connections among subjects. In the Sri Lankan educational context, it is significant to encourage students from their secondary school education with proper pedagogical strategies to identify these connections and enhance the learning engagement and motivation.

Perceptions regarding the challenges and ability in math learning were inquired in interviews and many participants viewed the challenges encountered with math tasks are temporary and they had a positive attitude that they could overcome the challenges and improve their math ability. Participants did not view the difficulties are inherent and they believed that they could improve with consistent practice and using supportive resources. Statements of participants such as *"I would like to believe challenges in math are temporary. If I put in enough effort, I can do better."* (S1), "*I have seen improvement over time"* (S3) indicated that students see their role of themselves as actively engaging in the learning process for better outcomes. Thus, students perceive challenges in math tasks are unstable (temporary) and controllable. These attributions are usually associated with increased motivation and engagement in future tasks.

This mindset of the students with the ability to change and adapt to situations is significant in the Sri Lankan education context, where mathematics is perceived as a 'difficult subject' since secondary school. However, participants in this study showed positive views instead of the typical belief in math learning. Such perception also suggests a favourable learning environment in the university consists of factors such as peer support, supportive learning resources, and lecture encouragement. This highlights the significance of positive learning environments that value effort and growth over time to provide opportunities for students to grow their confidence in learning subjects.

Emotions play a significant role when individuals attempt to overcome difficulties and adapt to situations (Hannula, 2002). Emotions that show up either as positive emotions (pride, happiness, confidence) or as negative emotions (anxiety, embarrassment, disappointment) are closely connected to motivation (Hannula, 2006). Motivational and emotional reactions of the students after success or failure in math-related tasks showed a significant influence on the determination of the students regarding their persistence in math-related tasks.

According to the findings, non-math undergraduates experienced negative emotions, such as disappointment, embarrassment, and hopelessness, caused by a lack of math aptitude and task difficulties. According to Weiner (2005), such attributions are internal and uncontrollable when students experience negative emotions due to a lack of ability in math tasks, and external and uncontrollable when students experience negative emotions due to task difficulty. For instance, statements like *"I feel discouraged because the questions in the test were too difficult to answer, even though I prepared well for the test before I took the test"* (S7) suggest an external and uncontrollable cause for negative feelings due to task failure.

One student shared, *"I feel embarrassed because I can't answer the question, but the rest of the students in the class can do it"* (S2). Such statements suggested low ability, which is an internal attribution, that is linked to feelings of embarrassment and could result in a reduction in future effort to attempt math-related tasks (Weiner, 2005).

This mirrors findings by (Stephanou, 2012), which showed that students mainly attributed their perceived success in math performance to internal and controllable factors such as ability and effort and perceived difficulties in math performance to unstable and external factors such as task difficulty. These findings in (Stephanou, 2012) also implies that successful students are more likely to believe in causes such as their own abilities, math aptitude and effort.

Furthermore, according to the participants, they were encouraged to engage in math-related tasks after experiencing both success and failure in math tasks, which highlighted a positive move in students, due to their understanding of the importance of engaging in math in university courses. Also, participants explained their emotional reactions as pride, confidence, or satisfaction after successful experiences in math tasks, which finally led to enhancing their motivation to continue future math tasks. Statements of the participants such as *"The content is moderately difficult. That difficulty has motivated me to study hard and seek help when needed."* (S7) and *"During my school time, I wasn't performing well in mathematics. So, it motivated me to try it right now because I'm not late"* (S3) concluded that they are more motivated to learn math even after difficulties or failure experiences, with the realization of their capability of doing it.

According to Weiner (2005) these attributions are internal and controllable and imply failures due to the lack of effort. Thus, students encouraged themselves to try harder with more effort to achieve success. This supported the findings of (Wolters et al., 2013) which revealed that if students attributed failure to factors such as low effort, they were more likely to try hard to achieve success through structured learning strategies.

In sum, these statements of the participants on their success and failure experiences suggested the influence of the emotional consequences on the motivational reactions to engage in math-related tasks. Students' emotional responses due to success and failure experiences showed a clear connection to motivation in math learning tasks. Thus, the need for supportive learning environments in university classrooms, especially in math courses for non-math students, is highlighted. Such supportive learning environments encourage the students to think of challenges are learning opportunities rather the low ability and finally enhance their motivation to continue math-related tasks.

5.2.2 Challenges in university math learning and success reasons

Participants of the study stated their views regarding math difficulty, and they perceived that the mathematical content is inherently difficult. The difficulty in the content led them to face challenging situations, to put more effort and spend more time. Participants' statements like "*I feel like mathematical content is inherently difficult. I need to put more effort, need to spend more time to improve"* (S2) and "*when I study lots of subjects, I can't spend more time with only those math subjects"* (S4) implied the challenges they faced due to their perceived difficulty of math content. These attributions, such as the difficulty nature of the content, are linked to external, stable and uncontrollable factors.

These perceptions can result in demotivating the students in math learning. Findings in Ashcraft & Krause (2007) revealed that students who perceive math as inherently difficult are at risk of experiencing math anxiety, which results in avoiding taking classes or career opportunities that include math. Also, math anxiety has a significant effect on motivation (Zakaria & Nordin, 2008). Participants of this study also expressed the consequences that they face due to content difficulty of math content, as they need to allocate additional time for math tasks from the time that they have to engage in overall academic studies. So, if they fail to manage their time with extra work in math learning, they are likely to experience anxiety in math learning. These findings highlighted the significance of pedagogical interventions to simplify the abstract content in math with the inclusion of more real-life applications.

The gaps in prior knowledge in secondary school math learning also affect students and cause them challenging situations when grasping math concepts in university courses. This is the prominent challenge regarding the prior knowledge expressed by the participants. Students shared their difficulties in coping with university math courses as the topics such as calculus, probability and hypothesis testing were either not included in the secondary school mathematics curriculum or not covered sufficiently. This perception of the students regarding the knowledge gap is an external and stable cause.

One participant mentioned, *"In school, I learned some math fundamental concepts such as arithmetic, algebra, percentage and other basic concepts. They are very helpful and useful to me at the university. But some topics, such as calculus and hypothesis testing, are more challenging for me because they were not covered in secondary school."* (S4). This implies that the very basic knowledge in secondary school math has built students' confidence in further math learning, as they are familiar with the concepts. Related to this finding, Khedhiri (2016) also investigated that math skills developed from high school are a significant factor in achieving success in college math courses. However, the new concepts feel strange to learn and non-math students feel less motivated to grasp the concepts. This also supports the findings of (Alreshidi, 2023), which outlined that topic-specific prior knowledge in mathematics is effective in learning math concepts. Further, investigations of (Hailikari et al., 2008) indicated that prior knowledge is a significant predictor for the achievement of students in mathematics in the higher educational context.

Non-math undergraduate students tend to believe they are not clever enough to grasp new math concepts due to the absence of basic knowledge in math topics from secondary school, rather than their lack of effort. Educators and policymakers in Sri Lanka can focus attention on the mathematics syllabus in secondary school and can introduce basic lessons to cover the math concepts that students frequently need in university courses, to make non-math students more confident in math courses.

Participants stated their challenges due to teaching methods in math courses. Teaching methods reflect external, but temporary and controllable attributions in Weiner's Attribution theory (2005), where the difficulty arises from the way the math content is presented to students. Several participants stated that teaching methods are traditional, and sometimes explanations are unclear to understand and confusing. The complicated nature of teaching methods for non-math students, who possessed a limited background in math knowledge, led to challenges in understanding topics.

Participants' statements like *"The time they spend to describe to us the lesson, to teach us the lesson, is not enough"* (S2) and *"Sometimes teaching methods are confusing..."* (S7) suggest external attributions that cause challenges for them in math learning. The perception regarding teaching methods is a barrier to students, enhancing their performance and positive thinking towards math learning goals. These situations can be addressed with student-oriented instructional strategies, such as scaffolding and examples with real-world applications in university math courses.

Students frequently expressed that their extra effort with more practice time on math tasks, actively engaging in math tasks and referring to extra learning materials significantly improved their math learning outcomes. Findings of Poelzer & Zeng (2008), which explored that the "effort" was the most common attribution stated by students for their success, are consistent with the findings of the study. Students' motivation towards learning can be enhanced by encouraging "effort" attribution to develop in them rather than "ability" attribution (Rosevear, 2010). Some students mentioned that good lecturers' explanations also help improve their math learning outcomes. Students' effort aligned with internal controllable attributions and proper explanation of lecturers aligned with external controllable attribution in Weiner's attribution theory (2005), which indicates that the effort of students and proper lesson explanation of lecturers led to successful learning in university math courses.

One participant stated, *"Self-studying and practicing made me successful in math learning." This* implied that personal effort led the student success, and this attitude causes students to experience self-satisfaction from their effort and learning outcome. An increase in self-satisfaction regarding individual work further enhances their motivation (Zimmerman, 2002).

Non-math university students in Sri Lanka possess a limited and varied math educational background from their secondary school education. These experiences of the students highlighted the importance of recognizing individual competency levels by students and accordingly increasing their personal commitment to math learning. Students' goal setting and effort in learning tasks enable them to observe themselves in their performance and achieve learning tasks (Zimmerman, 2002). Also, a need for math lecturers' attention regarding the varied math knowledge background of the students when delivering the lessons.

5.2.3 Importance of support systems and self-directed strategies to overcome math challenges

Findings revealed that students employed a range of support systems and self-directed strategies to cope with challenges in mathematics. They have used blends of both support systems and personal strategies according to their academic difficulties.

Participants responded regarding the self-study and revision strategies to promote the math learning outcomes in university courses. Participants' statements such as *"I review my knowledge and practice* *problems"* (S3), *"I use textbooks, tutorials given by our lecturers"* (S4), *"I watched a lot of recorded lectures"* (S5) are examples of the students' understanding of the active steps to improve math performance. Findings of Poelzer & Zeng (2008) revealed that successful students used their current learning strategies in the next tasks, and unsuccessful students would change their strategies in ways such as redoing some tasks and doing more assignments. Thus, students can make self-analysis regarding the learning strategies that lead to their success in math tasks to identify the most effective learning strategies for them and accordingly continue or adjust their strategies to succeed in math tasks.

The statements of participants reflect that they have recognized the controllability of academic achievement. One participant shared as *"Tutoring from friends or online resources was effective because it gave me different ways to understand the materials."* (S3), indicating that identification of controllability of learning strategies, where students can follow the clearest explanation among different materials which provide the better understanding in math concept for individual competency level. Further, the participants' statement *"YouTube videos, with very short video durations like two to three minutes or five to six minutes, have helped me a lot to understand mathematical problems, rather than watching a recording for two to three hours"* (S2), reflects the idea of controllability of learning strategies to improve performance, where students can manage their limited time with individual coping mechanisms.

Participants of the study presented suggestions for effective instruction in math courses in management studies. From their own learning experiences and perceptions, many participants suggested increasing the clarity of instructions with more practice questions in class, including more real-world applications for better understanding and small group helping for individual students' benefits. These suggestions aligned with Weiner's attribution theory (2005), where teaching methods are external and controllable attributions that play a significant role in the academic outcomes of the students. This supported the findings in (Poelzer & Zeng, 2008) which investigated that students prefer instructors who could relate to them and make the math course meaningful and interesting to them by using real-life related explanations and keeping variety in instruction.

These suggestions of the students highlighted the need for student-centred teaching in math subjects. Educators can consider these suggestions to reduce math anxiety and engage students actively in learning tasks to promote better learning outcomes.

Participants of the interview emphasize the peer support in learning university math courses. Many participants shared that discussions, explanations and collaborative studies with peer groups help them to better understand math concepts. One participant stated, "*studying together with peers makes it less* *challenging"* (S1), which reflects the idea of collaborative learning, with students in similar groups but may have acquired math concepts at varied levels, helping them to identify challenging parts in math learning and identify solutions through discussions. Participants' statements regarding peer and lecturers' support reflect external and controllable attributions in Weiner's attribution theory (2005), which illustrates the importance of effective support for better learning outcomes. Similar findings according to Khedhiri (2016) emphasized the importance of support mechanisms from math help centres by assisting students to understand class materials, to promote math learning outcomes.

In Sri Lankan universities where large class sizes exist in courses, the support mechanisms are significant in addressing individual problems in learning math. The presence of collaborative peer groups and supportive lectures helps students to develop a sense of 'belonging' and 'are supported', which prevents them from math anxiety and academic demotivation.

5.3 Limitations

After conducting the Factor analysis for the quantitative data, the initial theoretical design was adjusted according to the factor loadings. Also, originally intended items to be included in some sub-scales were excluded from the factor structure. To improve the reliability, the two items "I enjoy learning mathematical concepts related to my coursework" and "I am curious to learn how mathematical concepts are applied in management studies", which are related to the attitudes toward mathematics regarding interest, were excluded from the analysis as this suggested that the correlation between the two items is not high enough to form a reliable scale with only two items.

As a result, the final factor solution with remaining items in each sub-scale may offer more reliable measures regarding students' perceived ability to apply math concepts in their subject disciplines. However, the removal of interest-related items imposes limitations as it excludes potentially meaningful dimensions from the sub-scale and narrows the interpretation. Future studies can consider developing stronger measures for attitudes toward mathematics regarding interest to support the existing framework with more items included in the scale.

Also, the exclusion of three items related to physiological and emotional states in the final analysis due to weak factor loadings and low reliability, and combining items intended to measure vicarious experience and verbal persuasion in the final analysis as they appeared to overlap caused limitations by narrowing the conceptual scope of self-efficacy as it may not fully capture all four sources outlined in Bandura's theoretical framework. As a result, the conclusions drawn may reflect a more limited view of self-efficacy, which is dominated by mastery experience rather than a full representation of all four sources.

The generalizability of the findings to the broader student population in higher education in Sri Lanka can be affected by the limited sample of seven participants from a single higher education institution in the qualitative part of this study. Also, response bias is possible due to semi-structured interviews and the use of self-reported data.

6 Conclusion

This study examined how non-mathematical undergraduates in management studies in Sri Lanka perceive their ability to apply math concepts in their subject disciplines and their experiences and challenges when integrating mathematical concepts within their academic disciplines.

The correlation analysis of the present study revealed several meaningful relationships among the study variables. Most notably, mastery experience showed strong positive associations with confidence in applying math concepts in business mathematics, learning attitudes in business mathematics where students believe that they can learn mathematical concepts with adequate effort and practice in the business mathematics course, encouragement and social support aligned with verbal persuasion, math relevance, and supportive sources, highlighting its importance in shaping students' math self-efficacy. Additionally, encouragement and social support aligned with verbal persuasion were significantly linked with students' perception of math relevance, underscoring the significance of social encouragement to enhance the perception of the students regarding the relevance of math for their academic and professional development. A strong association between learning attitudes in BM and BS indicated a consistent academic preference across subjects.

Interview responses of the qualitative study revealed that non-math undergraduate students' confidence in learning math is improved in their university's first year rather than in their secondary school time. Also, prior learning in math courses in the first year directly influenced overall performance in management studies, where math and statistics courses made students more confident to engage in other management studies subjects such as accounting, economics and business finance. Non-math undergraduate students face challenges in learning math due to their perception of the inherent difficulty of math content, lack of prior knowledge in secondary school math education, and teaching methods. Students viewed the challenges encountered with math tasks are temporary. Responses from students indicated that they received strong support from supportive sources such as online resources and peer discussions, and they gave a moderate rating for the academic support they received in learning mathematics. Students understand that mathematical concepts are relevant and important for their studies and future careers. Students perceived that math is rather challenging, where some students find it more challenging, and some students find it less challenging.

These insights highlighted the importance of developing positive self-perceptions and adaptive attributions in non-mathematical learners. Ultimately, the study provides a foundation for curriculum developers and educators to design more inclusive, supportive learning environments in management education as well as to develop a solid foundation from secondary school mathematics for higher education.

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Appendices

Appendix 1 Factor Analysis (PCA) - confidence level of undergraduate students about their ability to apply mathematical concepts in the Business Mathematics and Business Statistics courses

Rotated Component Matrix[a]

	Component	
	1	2
Fundamentals of Mathematics (BM)	.772	.221
Mathematics of finance (BM)	.711	.369
Differential calculus with functions of one variable (BM)	.911	.124
Differential calculus with functions of more than one variable (BM)	.881	.205
Integral calculus (BM)	.782	.249
Probability distributions (BS)	.442	.794
Statistical estimation and hypothesis testing (BS)	.170	.896
Correlation and hypothesis testing (BS)	.184	.933

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

Appendix 2 Factor Analysis (PCA) - student's beliefs about whether they can learn mathematical concepts with adequate effort and practice in the Business Mathematics and Business Statistics courses

Rotated Component Matrix[a]

	Component	
	1	2
Attitude:Fundamentals of Mathematics	.860	.231
Attitude:Mathematics of finance	.843	.255
Attitude:Differential calculus with functions of one variable	.800	.389
Attitude:Differential calculus with functions of more than one variable	.850	.245
Attitude:Integral calculus	.649	.483

Attitude:Probability distributions	.363	.802
Attitude:Statistical estimation and hypothesis testing	.281	.927
Attitude:Correlation and hypothesis testing	.243	.876

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

Appendix 3 Factor Analysis (PCA) - four items related to the self-efficacy (mastery experience, vicarious experiences, verbal persuasion, and physiological and emotional states)

Rotated Component Matrix[a]

	Component			
	1	2	3	4
My past experiences in secondary school education (grade 10, grade 11) with Mathematics have prepared me well for my studies in Mathematics courses in management studies.	-.038	.655	.554	-.155
I feel confident in applying mathematical concepts when I have successfully done similar tasks before.	.559	.492	.156	.168
When I recall solving challenging mathematical problems in the past, it motivates me to tackle similar tasks now.	.547	.601	-.006	.081
Practicing mathematical problems repeatedly in the past in secondary school (grade 10, grade 11) has strengthened my ability to solve them in my coursework.	.060	.818	-.085	.022
Seeing others in my class succeed in Mathematical tasks motivates me to try harder.	.559	.318	-.063	-.601

Watching someone explain how to solve a Mathematical problem makes me feel confident in attempting it myself.	.770	.112	-.019	.202
Group discussions where peers solve Mathematical problems help me believe in my ability to solve them.	.831	.197	.070	-.037
Encouragement from my instructors helps me feel more confident about my Mathematical abilities.	.758	-.029	.263	.270
Positive feedback from peers boosts my confidence in applying mathematical concepts.	.861	.102	-.173	.005
When my instructors tell me I can succeed in mathematics, it makes me believe in my own abilities.	.763	.213	.038	-.225
Discussing Mathematical problems with my peers enhances my understanding and confidence.	.740	.331	-.171	.334
I feel anxious when I encounter mathematical problems in my coursework.	.034	-.079	.926	.001
I feel calm and focused when Solving Mathematical problems in my coursework.	.268	.759	-.060	.079
I experience a sense of accomplishment when I solve a Mathematical problem correctly.	.345	.231	-.074	.771

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 7 iterations.

Appendix 4 Factor Analysis (PCA) - attitude of the students toward mathematics regarding the relevance, interest, and perceived challenges

Rotated Component Matrix[a]

	Component		
	1	2	3

I believe understanding Mathematical concepts is relevant in my studies.	.840	.088	-.019
I believe understanding mathematical concepts is important in my future career.	.861	.140	.005
I believe the mathematical concepts I learn are directly applicable to real-world management challenges.	.787	.007	.281
I enjoy learning mathematical concepts related to my coursework.	.421	-.194	.730
I am curious to learn how mathematical concepts are applied in management studies.	-.066	.141	.923
I feel anxious when I have to deal with mathematical calculations in my courses.	.047	.898	.056
I struggle with understanding mathematical concepts, even when I put a lot of effort into improving them.	-.050	.890	.098
I think the mathematical components of my courses are harder than the other aspects of the course content.	.298	.752	-.195

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 5 iterations.

Appendix 5 Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
I believe understanding Mathematical concepts is relevant in my studies.	24.5000	11.643	.428	.662
I believe understanding mathematical concepts is important in my future career.	24.5000	11.153	.486	.648
I believe the mathematical concepts I learn are directly applicable to real-world management challenges.	24.9400	10.874	.433	.655

I enjoy learning mathematical concepts related to my coursework.	24.7800	12.134	.236	.695
I am curious to learn how mathematical concepts are applied in management studies.	25.0200	11.979	.214	.703
I feel anxious when I have to deal with mathematical calculations in my courses.	25.3000	10.133	.479	.642
I struggle with understanding mathematical concepts, even when I put a lot of effort into improving them.	25.3400	10.311	.407	.662
I think the mathematical components of my courses are harder than the other aspects of the course content.	25.2600	10.278	.443	.652

Appendix 6 Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
I believe understanding Mathematical concepts is relevant in my studies.	21.0000	9.755	.472	.662
I believe understanding mathematical concepts is important in my future career.	21.0000	9.265	.538	.644
I believe the mathematical concepts I learn are directly applicable to real-world management challenges.	21.4400	9.313	.406	.671
I enjoy learning mathematical concepts related to my coursework.	21.2800	10.818	.134	.730
I feel anxious when I have to deal with mathematical calculations in my courses.	21.8000	8.449	.491	.647

I struggle with understanding mathematical concepts, even when I put a lot of effort into improving them.	21.8400	8.749	.389	.679
I think the mathematical components of my courses are harder than the other aspects of the course content.	21.7600	8.309	.511	.641

Appendix 7 Factor Analysis (PCA) - attitude of the students toward academic support and the use of supportive sources

Rotated Component Matrix[a]

	Component	
	1	2
guidance provided by lecturers during lectures	-.141	.835
The course materials, such as textbooks and lecture slides	.025	.781
The feedback received on assignments and exams	.273	.608
The availability of online resources such as videos and software	.817	.085
additional resources (e.g., tutoring, and online videos)	.862	-.168
Group discussions with peers	.720	.182

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

Appendix 8 Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted

guidance provided by lecturers during lectures	7.4600	1.560	.506	.387
The course materials, such as textbooks and lecture slides	7.1600	1.566	.461	.459
The feedback received on assignments and exams	7.1000	2.133	.316	.651