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Relating motivation and learning strategies to algebra course results in a foundation programme

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Foundation programmes provide an alternate access route for prospective students whose prior academic results exclude direct entry to undergraduate studies. Bridging courses within foundation programmes address gaps in prior knowledge while developing content knowledge and requisite skills to equip students for the rigour of undergraduate degree study. This study looks for relationships between motivation and learning strategies at course commencement and the final course results of 796 purposively chosen participants across four iterative cycles (cohorts) enrolled in an algebra course within a foundation programme at a private higher education institution in South Africa. Data were collected with the *motivated strategies for learning* questionnaire, and cohort responses were analysed using correlational statistics. Statistically significant differences mainly were detected in the motivation subscales, and the academic performance was largely related to gender and prior mathematics syllabus. Where cohorts are similar, generic interventions designed to equip one cohort may equip others. Specific intervention strategies that target the needs of students based on the needs identified in this study may equip future students to improve their algebraic knowledge.

Contribution: The research contributes by augmenting the exiguous literature of studies of students in algebra courses in foundation programmes who aim to progress to undergraduate degree studies. Investigating relationships between motivation and learning strategies at course commencement and final course results within multiple cohorts promotes the development of flexible, relevant intervention strategies that can be implemented timeously. A study of multiple cohorts further allows for improved validity and reliability in conclusions relating to scalability.

Keywords: Mathematical Literacy; motivated strategies for learning questionnaire; self-efficacy; task value; test anxiety.

Background, context, and purpose

South African higher education institution (HEI) entry requirements necessitate a stipulated minimum academic point score and baseline marks for English and Mathematics. Together, these prior results signal the likelihood of academic success in undergraduate degree options. Foundation programmes, fortunately, provide an alternate access route for prospective students whose prior academic results exclude direct entry to undergraduate degree studies (Kirby & Dempster, 2018). Foundation programme courses address gaps in prior knowledge while developing content knowledge and requisite skills to equip students for the rigour of undergraduate degree study (National Youth Development Agency, 2015). There are different foundation programme models in higher education, one example being a non-credit-bearing, year-long pre-undergraduate programme comprising several bridging courses[1].

Students aiming to progress to undergraduate degree studies in Business Science, Law, Computer and Information Science, or Health Science in the focus foundation programme must complete an algebra course. Pre-entry attributes such as gender, population group, future study course of choice, and selected secondary school subjects, including prior mathematics syllabus, influence students' academic performance (Van Zyl et al., 2012). At course commencement, students' motivation and learning strategies also influence academic performance (Pintrich et al., 1991). Significant gender differences in students' use of motivation strategies and their academic performance have been noted in the literature (e.g., Abdel Meguid et al., 2019; Hamid & Singaram, 2016). Xolo (2007) suggested that assistance through motivation and specialised intervention programmes would benefit disadvantaged students, who in South Africa are 'black people, women, and people with disabilities' (National Youth Development Agency, 2015, p. 21). More

1.Bridging courses have also been referred to as remedial courses or developmental courses in the literature.

recently, Gumede et al. (2017) found that disadvantaged students used inferior studying techniques, but benefitted from strategies that included psychological support. Mathematics teachers play a pivotal motivational and inspirational role in developing disadvantaged students (Khumalo et al., 2022).

Students with Mathematical Literacy[2] report significantly lower motivation levels to learn mathematics (Baumgartner, 2016; Baumgartner et al., 2018) and achieve significantly lower final course results (Baumgartner, 2021) than other students. By contrast, students equipped to harness motivation effectively and apply productive learning strategies improve their knowledge development (Abdel Meguid et al., 2019).

This study relates the motivation and learning strategies, as reported by student cohorts commencing an algebra course within a foundation programme, with final course results. Knowing whether such relationships exist, and for whom, provides input to enhance algebra courses and interventions to improve students' academic performance in algebra while better preparing them for the rigour of undergraduate studies. In so doing, students may develop an adequate skill set that equips them to persevere in their studies rather than dropping out. Data were collected from four iterative cycles enabling cohort comparisons to derive consistencies and draw substantive conclusions. Resulting recommendations are thus hypothesised to be more likely to be effective and scalable for this specific algebra course and foundation programme, and possibly others.

Literature on the motivation and learning strategies of students commencing algebra courses within foundation programmes, and whether these aspects relate to academic performance at this level, is exiguous. Studies in this area are essential, given the massification of higher education, the enrolment of increasingly underprepared students, and the drive to improve mathematics skills globally, and particularly in South Africa. If strategies that equip students for higher education studies are to be effective, students' motivation and learning strategies relating to algebra should be explored and understood (Al Khatib, 2010).

Literature perspectives

The literature relating to motivation in education and learning strategies is described in this section. After that, a summary of the literature and findings of studies employing the motivated strategies for learning questionnaire (MSLQ) is expounded.

Motivation

Motivation relates to the impetus behind why an individual initiates, directs, and sustains actions to reach a chosen goal, while the desirability of attaining that goal fuels and propels the individual (Deci & Ryan, 2000). Different goals (performance goals versus mastery goals) may engender divergent behavioural and affective results, while different drivers (intrinsic drivers versus extrinsic drivers) may affect the effort that is put into attaining a goal (Deci & Ryan, 2000). Motivation is thus a meta-concept that includes theories and theoretical constructs that suggest rationalisation for different impetuses. Motivation subscales that may jointly or severally progress or inhibit the realisation of a goal, such as academic performance, include intrinsic motivation, self-efficacy, task value, and anxiety (Hattie & Donoghue, 2016).

The degree to which an individual engages in a task for purposes such as personal challenge and mastery rather than performance or reward describes the individual's *intrinsic goal orientation* (Pintrich et al., 1991). Students exhibiting intrinsic goal orientation undertake tasks to enjoy the task rather than visualising the task as a means to an end. Thus, students who report high levels of intrinsic goal orientation towards learning algebra do not simply see it as a means to progress to undergraduate studies or gain employment – they enjoy learning algebra *because* it is algebra. Students' interest and attitude toward learning subjects such as algebra are also driven by their intrinsic goal orientation (Zaharin et al., 2020). Adamma et al. (2018) noted gender differences in intrinsic versus extrinsic motivation impetuses, while Baumgartner (2016) found the intrinsic motivation of students with Mathematical Literacy to be significantly lower than other students.

Task value indicates the individual's perception of the usefulness or importance of undertaking and completing a particular task such as learning algebra. Students who perceive learning the content of an algebra course to be helpful and essential are likely to direct more effort to that learning. Higher perceptions of task value may predict higher involvement (Pintrich et al., 1991) and persistence in learning (You, 2018). Baumgartner (2016) found that students with Mathematical Literacy self-reported lower task value levels and concluded that task value correlated strongly and positively with self-efficacy. However, task value's effect on academic performance remains inconclusive, with significant moderate relationships (Hamid & Singaram, 2016) and statistically non-significant outcomes (Bruso & Stefaniak, 2016) reported.

Self-efficacy involves a personal evaluation of one's competence and capability to complete a task (Schunk, 2012) such as achieving a specified final course result for an algebra course. Self-efficacy beliefs influence effort, persistence, and outcomes such as academic performance and achievement behaviour (Schunk, 2012; Young et al., 2018); they thus have broad explanatory power (Bandura, 1982). Mathematical Literacy students self-report significantly lower levels of self-efficacy than other students (Baumgartner, 2016), suggesting that prior mathematics learning and perceived personal competence influence a student's current personal competence evaluation

2. In the final three years of secondary schooling, South African learners may choose National Senior Certificate Mathematical Literacy, which a subject that focuses on numeracy, spatial, and statistical content as applied into the real world, or National Senior Certificate Mathematics which covers the theoretical aspects of algebra, geometry, and trigonometry required for undergraduate studies.

and academic performance in an algebra course may hence be impacted (Baumgartner, 2021). Moreover, grade disappointment reduces self-efficacy (Young et al., 2018), particularly among low-achieving students, as foundation programme students are hypothesised to be. Strategies to enhance the self-efficacy of students who previously endured failure or doubt their learning ability are thus likely to be valuable (Schunk, 2012).

Test anxiety comprises both cognitive aspects (e.g., worry) and emotional or physiological components (e.g., increased heart rate) (Pintrich et al., 1991). Individuals may experience one or both elements of anxiety relating to test-taking. Mathematics anxiety may compound test anxiety during mathematical test-taking, and both anxieties relate negatively to other aspects of motivation (Federici et al., 2015). Baumgartner (2016) noted that students with Mathematical Literacy reported higher levels of test anxiety than other students. Female students are thought to self-report test anxiety more accurately than male students (Harris et al., 2019), which may explain why studies conclude that female students experience higher levels of test anxiety. Test anxiety has been found to be significantly and inversely related to academic performance (Bertrams et al., 2013; Hamid & Singaram, 2016; Mirzaei-Alavijeh et al., 2020), although Opateye (2014) concluded that higher levels of test anxiety could advance positive attitudes and academic success. Strategies that increase students' efficacy (Hattie & Donoghue, 2016) and develop self-control behaviour (Bertrams et al., 2013) or self-esteem (Mirzaei-Alavijeh et al., 2020) may reduce anxiety. Although interventions that reduce test anxiety could benefit students, students may not self-report a reduction in their test anxiety levels (Harris et al., 2019).

Significant correlations between the aspects of motivation discussed in this section have been found in prior studies (e.g., Bai et al., 2020; You, 2018). For example, students with high self-efficacy and task value demonstrate higher persistence to reach set goals (You, 2018). However, when students with low self-efficacy experience high task value, their test anxiety may increase (Bai et al., 2020). Inter-motivation correlations are essential, since addressing or improving one motivation construct may address others and motivation constructs correlate strongly with academic performance (Adamma et al., 2018).

Learning strategies

Learning strategies encompass the processes students employ to enhance their learning and performance (Hattie & Donoghue, 2016). Credé and Phillips (2011) surmised that surface learning strategies (e.g., rehearsal, elaboration, and organisation) and academic performance are unrelated. However, implementing appropriate and effective cognitive and metacognitive learning strategies at the right time within the learning cycle positively impacts academic performance (Donker et al., 2013; Hattie & Donoghue, 2016). Poor learning strategies contribute to higher failure rates among students, especially those in their first year of higher education studies (Hamid & Singaram, 2016). Learning strategies include rehearsal, elaboration, organisation, critical thinking, metacognitive self-regulation and engagement activities such as peer learning and help seeking. Baumgartner (2021) noted significant strong or medium correlations between the learning strategies of rehearsal, organisation, elaboration, and metacognitive self-regulation, while critical thinking only correlated strongly with metacognitive self-regulation. However, the latent factor structure of the MSLQ could render the learning strategy subscales rehearsal, elaboration, and metacognitive self-regulation indistinguishable (Chen & Smith, 2017).

Rehearsal is the strategy of memorising or rote learning facts (Pintrich et al., 1991). Rehearsal activities are unlikely to connect current and prior information (Pintrich et al., 1991) as memorising engenders surface learning only, although rehearsal may also consolidate surface learning (Hattie & Donoghue, 2016). Derr et al. (2019) advocated for using rehearsal strategies to support at-risk students learning mathematics in transition programmes such as foundation programmes. Furthermore, Baumgartner et al. (2018) found no significant difference between the use of the rehearsal strategy based on prior mathematics syllabus, suggesting that students are likely to engage in rehearsal practices in similar ways, regardless of their prior learning. Although female students reported higher use of all learning strategies than male students, Balam (2015) found no statistically significant difference in these strategies.

Elaboration is a self-regulation strategy that integrates and connects new learning with prior knowledge (Donker et al., 2013), which, in contrast to Credé and Phillips (2011), may enable students to acquire deep learning (Hattie & Donoghue, 2016). Adopting elaboration strategies has been found to impact content understanding positively (Lin et al., 2016) and may improve student performance significantly more than other strategies (Donker et al., 2013). Baumgartner et al. (2018) found no significant difference between using elaboration strategies based on prior mathematics syllabi. Therefore, the researchers argue that elaboration strategies could relate to academic performance, and that students with Mathematical Literacy may connect new and prior knowledge similarly to other students.

The *organisation* strategy includes using charts or figures and outlining or clustering information to arrange material and thoughts (Pintrich et al., 1991). Hattie and Donoghue (2016) described organisation as a self-regulation strategy but included organisation as a strategy that aids the acquisition of both surface learning and deeper learning. Improved organisation strategies may benefit students, as Keskin and Yurdugül (2019) concluded that there is a negative relationship between cognitive strategies such as organisation and test anxiety.

Critical thinking involves the application of prior knowledge to new content and situations to solve problems or critically evaluate information (Pintrich et al., 1991) and advance deeper thinking (Hattie & Donoghue, 2016). Critical thinking strategies significantly and positively affect perceived content understanding (Lin et al., 2016), which could be why critical thinking has been found to correlate positively with academic performance (e.g., Hamid & Singaram, 2016). Since critical thinking may be domain-specific, it should be developed within the learning of a subject rather than as a separate skill (Hattie & Donoghue, 2016).

Metacognitive self-regulation involves thinking mindfully about thinking and includes adaptable strategies relating to the constructs planning, monitoring, and evaluation of learning (Pintrich et al., 1991). Tock and Moxley (2017) have criticised the subscale, suggesting poor validity of the scale, as three constructs are examined simultaneously. Baumgartner (2016) found that metacognitive self-regulation correlated strongly with cognitive learning strategies, although she also noted the poor validity of the subscale. Metacognitive self-regulation strategies are optimised when students have autonomy in learning-related decisions (Schunk, 2012) and actively participate in their learning processes (Vaculíková, 2016).

Peer learning strategies involve cooperative and collaborative student learning and studying within and outside the classroom to clarify information and deduce insights (Pintrich et al., 1991). Students entering an algebra course within a foundation programme are unlikely to engage in peer learning at the outset (Baumgartner, 2016) although when classroom environments nurture cooperative learning opportunities, students are more likely to report engaging in peer learning activities (Baumgartner, 2021). Peer learning evokes positive experiences (Wang et al., 2017) and could correlate, albeit weakly, with academic performance (Dunnigan, 2018).

Help seeking is the act of soliciting assistance from teachers, peers, or other sources when students feel they do not fully understand a concept (Baumgartner, 2021). Help seeking could correlate strongly with peer learning (Baumgartner, 2016) or form part of the same construct (Chen & Smith, 2017; Credé & Phillips, 2011). Credé and Phillips (2011) postulated that high-performing and low-performing students were unlikely to seek help, either because they did not need help or did not know they needed help, while Baumgartner (2016) concluded that students with Mathematical Literacy reported similar use of help-seeking strategies to other students. Engaging in adaptive help-seeking activities improves the consolidation of deep learning (Hattie & Donoghue, 2016), although Bruso and Stefaniak (2016) did not conclude a statistically significant relationship between help seeking and academic performance.

Self-regulating strategies vary between disciplines (Bruso & Stefaniak, 2016) and motivation to practise self-regulation diminishes when students do not detect value in learning (You, 2018). Early interventions that equip students to improve their motivation toward learning mathematics and the learning strategies they employ to develop their knowledge of algebra could influence their academic performance and final course results. This study considered four distinct cohorts selectively chosen between 2014 and 2019 at a private HEI foundation programme algebra course in South Africa to ensure intervention offerings can support learning within multiple cohorts.

Literature on the motivated strategies for learning questionnaire

Pintrich et al. (1991) developed the MSLQ instrument, as summarised in Table 1, to investigate the dynamic nature of motivation and the use of learning strategies within a course-specific context.

The motivation category comprises three components and six subscales, while the learning strategies category comprises two components and nine subscales. Subscales are examined through several items; for example, task value is investigated through six items and metacognitive self-regulation through 12 items. Subscales have been examined singularly (Tock & Moxley, 2017), severally (Kumar & Bhalla, 2020) and collectively (Baumgartner et al., 2018). In addition to metastudies (Credé & Phillips, 2011; Taylor, 2012) and construct validity testing (Taylor, 2012; Tock & Moxley, 2017), the MSLQ has been employed to study aspects of educational research. Responses from MSLQs have been investigated as predictors of academic performance (Hamid & Singaram, 2016), for signalling suitable support strategies (Lawson, 2019) and to perceive differences between students within cohorts (Balam, 2015) or across cohorts (Kumar & Bhalla, 2020).

The MSLQ has been employed in mathematics education studies in South Africa (Baumgartner et al., 2018; Hamid & Singaram, 2016; Payne & Israel, 2010). Payne and Israel (2010)

TABLE 1: Structure of the motivated strategies for learning questionnaire.

Category codings	[31 items]	[50 items]
Motivation		
Value		
Intrinsic goal orientation	[4]	-
Extrinsic goal orientation	[4]	-
Task value	[6]	-
Expectancy		
Control of learning beliefs	[4]	-
Self-efficacy for learning and performance	[8]	-
Affect		-
Test anxiety	[5]	-
Learning strategies		
Cognitive and metacognitive strategies		
Rehearsal	-	[4]
Elaboration	-	[6]
Organisation	-	[4]
Critical thinking	-	[5]
Metacognitive self-regulation	-	[12]
Resource management		
Effort regulation	-	[4]
Time and study environment management	-	[8]
Peer learning	-	[3]
Help seeking	-	[4]

and Hamid and Singaram (2016) considered whether subscales predicted academic performance. The former study was inconclusive; the latter reported limited correlations. Baumgartner et al. (2018) considered a single cohort. They found that students who matriculated with Mathematical Literacy displayed significantly lower levels of intrinsic goal orientation, task value, self-efficacy and effort regulation, and significantly higher levels of test anxiety than other students in that cohort.

Table 2 provides the Cronbach's alpha coefficients of 10 selected studies that interrogated subscales of the MSLQ. Low Cronbach's alpha coefficients may suggest poor internal consistency, or result from an insufficient number of items in a scale (Pallant, 2007). Most MSLQ subscales contain fewer than 10 items, suggesting an interrogation of the mean inter-item correlations may be appropriate to ascertain reliability (Pallant, 2007).

The motivation subscales task value, self-efficacy, and test anxiety routinely reported alphas greater than 0.70. Learning strategy subscales that regularly yield suitable alphas are elaboration, critical thinking and metacognitive self-regulation. Fewer studies have found suitable Cronbach's alphas for intrinsic goal orientation, extrinsic goal orientation, organisation, time and study environment management, and peer learning (Hamid & Singaram, 2016), and many studies report low alphas for control of learning beliefs, rehearsal, effort regulation and help seeking.

While numerous studies have sought to tailor subscales of the MSLQ to a prevailing cohort to improve factor validity (e.g., Ramírez-Echeverry et al., 2016; Vaculíková, 2016), several subscales consistently report factor validity and correlations between original subscales are often detected in studies. Strategies that address one MSLQ subscale may thus impact others due to the correlations between the subscales (Baumgartner, 2016). Chen and Smith (2017), however, reported concerns about the latent factor structure of the learning strategies category of the MSLQ, finding elaboration items to be indistinguishable from items relating to rehearsal, metacognitive self-regulation, and effort regulation. As such, prior to reporting findings based on analyses of MSLQ data, validity and reliability test results should be reported.

Implementing timely interventions that address motivation and learning strategies, as discussed, could influence academic performance in an algebra course within a foundation programme. As such, the motivation and learning strategies of four student cohorts enrolled to commence a foundation programme algebra course at a private HEI in South Africa were examined to address the research question: *What correlations exist between the motivation and learning strategies and the academic results of foundation programme algebra cohorts?* The research sub-questions to support the research question were:

1. Which of the MSLQ subscales indicated data reliability and validity for further interrogation?
2. How do the four cohorts' MSLQ subscale responses and final course results compare?
3. How do the MSLQ subscale responses and final course results compare based on biographic data?
4. Which MSLQ subscales correlate with students' final course results?

Rationale for the study

Many contributions to the literature can be highlighted here. Firstly, studies of students in algebra courses in foundation programmes who aim to progress to undergraduate degree studies in Business Science, Law, Computer and Information Science, and Health Science at private HEIs in South Africa are exiguous. Secondly, investigating relationships between motivation and learning strategies at course commencement and final course results provides information to develop improved early intervention strategies. A study comparing and contrasting multiple cohorts or iterations also promotes the development of flexible, relevant intervention strategies.

TABLE 2: Cronbach's alphas of the motivated strategies for learning questionnaire subscales in the literature.

Variable	*N*	Cronbach's alpha coefficient by subscale														
		IGO	EGO	TV	LB	SE	TA	Reh	Elab	Org	CT	MSR	TSE	ER	PL	HS
Pintrich et al. (1991)	380	0.74	0.62	0.90	0.68	0.93	0.80	0.69	0.76	0.64	0.80	0.79	0.76	0.69	0.76	0.52
Abdel Meguid et al. (2019)	251	0.63	0.70	0.88	0.70	0.91	0.74	-	-	-	-	-	-	-	-	-
Al Khatib (2010)	404	0.77	0.72	0.87	0.74	0.85	0.75	-	-	-	-	0.83	-	-	-	-
Balam (2015)	139	0.53	0.63	0.78	0.41	0.83	0.76	0.71	0.81	0.69	0.78	0.67	0.71	0.55	0.77	0.49
Baumgartner (2016)	419	0.63	0.64	0.81	0.50	0.89	0.74	0.64	0.74	0.64	0.72	0.68	0.67	0.58	0.66	0.52
Baumgartner et al. (2018)	192	0.62	0.57	0.80	0.42	0.87	0.77	0.59	0.73	0.62	0.69	0.70	0.68	0.58	0.67	0.50
Credé and Phillips (2011)	59†	0.69	0.66	0.87	0.65	0.91	0.77	0.68	0.76	0.70	0.77	0.77	0.72	0.61	0.68	0.59
Hamid and Singaram (2016)	165	0.60	0.62	0.80	0.51	0.88	0.68	0.64	0.80	0.71	0.72	0.77	0.55	0.58	0.72	0.56
Kumar and Bhalla (2020)	1 929	0.69	0.70	0.80	0.57	0.82	0.61	0.66	0.79	0.70	0.75	0.82	0.71	-	0.60	-
Taylor (2012)	91†	0.71	0.68	0.85	0.65	0.88	0.76	0.68	0.76	0.70	0.79	0.78	0.73	0.62	0.68	0.61

Note: Please see the full reference list of the article, Baumgartner, W.L., Spangenberg, E.D., & Lautenbach, G.V. (2023). Relating motivation and learning strategies to algebra course results in a foundation programme. *Pythagoras* 44(1), a781. https://doi.org/10.4102/pythagoras.v44i1.781, for more information.

†, number of studies in the metastudy.

N, number of participants; IGO, intrinsic goal orientation; EGO, extrinsic goal orientation; TV, task value; LB, control of learning beliefs; SE, self-efficacy for learning and performance; TA, test anxiety; Reh, rehearsal; Elab, elaboration; Org, organisation; CT, critical thinking; MSR, metacognitive self-regulation; TSE, time and study environmental management; ER, effort regulation; PL, peer learning; HS, help seeking.

A study of multiple cohorts further allows for improved validity and reliability in conclusions relating to scalability. Finally, investigating relationships between motivation, learning strategies, and course results based on biographic data provides an opportunity to consider similarities and differences within student cohorts in algebra courses in foundation programmes to ensure intervention strategies support all students effectively.

Research methodology

In the focus foundation programme, students wishing to progress to undergraduate studies in Business Science or Law, Computer and Information Science, or Health Science were required to complete, among others, an algebra course. A concern that the actual algebra course pass rate[3] was below 70%, whereas the HEI's preferred course pass rate was 80%, informed the study design, which was comparative and exploratory.

Participants

Four iterative cycles (population of 1136 students) were enrolled in an algebra course within a foundation programme. Three iterative cycles commenced their study at the start of a year, and the third one commenced their studies mid-year. Students were invited to participate in a broader study from which this article emanates. The four cohorts were selectively chosen for this iterative study. In addition to semester enrolment, there were three participation prerequisites: students (1) agreed to participate voluntarily, (2) completed the questionnaire, and (3) earned a final course result. The cumulative sample comprised 796 participants. All participants signed informed consent and submitted complete questionnaires; no participants withdrew from the study. Enrolment numbers in the foundation programme declined across the semesters studied and mid-year enrolments were historically lower, as evidenced by the third iterative cycle. Table 3 summarises the population and samples, including biographical data by cohort.

The biographical details of cohorts enrolling at the start of a year are relatively similar: nearly half the students are men, about half the students previously completed the National Senior Certificate Mathematics syllabus and about 23% of the students completed the National Senior Certificate Mathematical Literacy syllabus. Between 60% and 70% of students wish to progress into Business Science, which may include majoring in Law. Approximately half the students identify as South African black students and very few students from continents other than Africa enrol in the foundation programme algebra course. The cohort commencing mid-year has more students enrolling from other African countries and completing curricula different from the National Senior Certificate offered in South Africa. The reason for this may be delays due to gaining study permit documentation or the timing of completion of secondary schooling. The variables presented in Table 3, along with MSLQ responses and academic performance, reported in the final course results, were investigated to address the research sub-questions.

3. Pass rate is the number of students who passed the course divided by the number of students enrolled in the course.

TABLE 3: Participant and biographical data by cohort.

Variable	Iterative cycle	1	2	3	4	Total
Population	-	456	376	51	253	1136
Sample	-	402	184	44	166	796
Sample as a % of population	-	88.16	48.94	86.27	65.61	70.07
Gender (%)	Male participants	54.5	43.5	52.3	44.0	49.6
	Female participants	45.5	56.5	47.7	56.0	50.4
Prior mathematics syllabus (%)	NSC Mathematics	45.3	57.1	18.2	49.4	47.4
	NSC ML	23.9	23.4	11.4	22.9	22.9
	O level	14.9	8.15	31.8	10.2	13.3
	A/AS level	7.46	6.52	18.2	6.63	7.66
	Other	8.46	4.89	20.45	10.8	8.80
Prospective degree (%)	BSci	66.7	55.3	43.2	43.4	57.4
	CIS	18.4	15.8	25.0	20.5	18.6
	HSci	14.9	15.2	13.6	16.3	15.2
	Law	None†	15.8	18.2	19.9	8.80
Ethnicity (%)	SA black students	47.8	55.4	20.5	52.4	49.0
	SA non-black students	18.7	24.5	9.1	17.5	19.2
	African (not SA)	31.1	18.5	68.2	28.9	29.8
	Non-African	2.49	1.63	2.27	1.2	2.01

Note: Iterative cycle 3 students were enrolled mid-year, the other three iterative cycles were enrolled at the start of the year. Other prior mathematics syllabi often studied by non-South African students include the West African Senior School Certificate Examination or the International Baccalaureate.

†, Law was not offered during the first iterative cycle, only becoming available to later cohorts, which explains the lower percentage of total Law enrolments.

NSC, National Senior Certificate; ML, Mathematical Literacy; O level, ordinary level or general certificate of secondary education (GCSE) of the Cambridge curriculum; A/AS, advanced/advanced subsidiary levels of the Cambridge curriculum; BSci, Business Science; CIS, Computer and Information Science; HSci, Health Science; SA, South African.

The data collection instruments

During the students' third week of attendance of the 12-week algebra course, a data collection instrument comprising 85 items was administered. Four items addressed biographic data, while 81 items were the MSLQ. The MSLQ items were rephrased to be mathematics specific. Item 17, for example, initially read: 'I am very interested in the content area of this course' (Pintrich et al., 1991, p. 11) and was adapted to read: *I am very interested in the content area of mathematics*. The most accurate response to each item was self-reported on a seven-point Likert scale from 1: *not at all true of me*, to 7: *very true of me*. To provide validity evidence, the data collection instrument was piloted with 10 students, characteristic of, but not included in, the first iterative cycle sample. Additionally, participants' final course results were obtained from the institution.

Data capturing and processing

Data were captured onto a Microsoft Excel spreadsheet and exported to the Statistical Package for Social Sciences (SPSS) version 26. The reliability of the 15 subscales of the MSLQ was interrogated for the entire sample and individual cohorts through Cronbach's alpha coefficients (Pintrich et al., 1991). The inter-item correlations were investigated where alphas were lower than 0.70 (Pallant, 2007). Four subscales, namely

TABLE 4: Motivated strategies for learning questionnaire subscales and final course average: Sample statistics and reliability measures.

Iterative cycle: Subscale	1 (n = 402)		2 (n = 184)		3 (n = 44)		4 (n = 166)		Total (N = 796)		Cronbach's α	IIC†	ANOVA F	p-value
	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD				
Intrinsic goal orientation (IGO)	4.73	± 1.09	4.76	± 0.93	5.05	± 1.00	4.76	± 1.10	4.76	± 1.05	0.62	0.29	1.14	0.332
Task value (TV)	5.30	± 1.05	5.38	± 0.92	5.73	± 0.85	5.35	± 0.88	5.36	± 0.98	0.78	-	2.88	0.036‡
Self-efficacy for learning and performance (SE)	5.25	± 1.07	5.16	± 1.02	5.57	± 1.08	5.15	± 1.08	5.22	± 1.06	0.89	-	2.13	0.095
Test anxiety (TA)	4.53	± 1.36	4.69	± 1.23	4.80	± 1.44	4.95	± 1.44	4.67	± 1.36	0.76	-	3.92	0.009
Rehearsal (Reh)	4.75	± 1.17	4.88	± 1.11	4.88	± 1.43	4.75	± 1.23	4.79	± 1.18	0.65	0.32	0.61	0.611
Elaboration (Elab)	4.82	± 1.07	4.86	± 0.93	5.06	± 0.96	4.83	± 1.06	4.84	± 1.03	0.73	-	0.79	0.500
Organisation (Org)	4.70	± 1.11	4.89	± 1.01	4.75	± 1.38	4.77	± 1.20	4.76	± 1.13	0.65	0.33	1.15	0.329‡
Critical thinking (CT)	4.28	± 1.13	4.10	± 1.07	4.43	± 1.21	3.83	± 1.28	4.15	± 1.16	0.73	-	6.52	0.000‡
Metacognitive self-regulation (MSR)	4.71	± 0.82	4.62	± 0.84	4.77	± 0.87	4.55	± 0.88	4.66	± 0.84	0.74	-	1.72	0.161
Peer learning (PL)	3.81	± 1.42	3.86	± 1.36	4.16	± 1.61	3.89	± 1.57	3.86	± 1.45	0.65	0.39	0.76	0.518‡
Help seeking (HS)	4.61	± 1.36	4.66	± 1.33	5.03	± 1.37	4.69	± 1.54	4.66	± 1.39	0.64	0.23	1.23	0.299
Final course average	62.7	± 22.3	59.6	± 24.5	66.3	± 21.4	66.6	± 23.5	63.0	± 23.1	-	-	3.31	0.029

Note: Data for number of participants in subsamples (n) and the full sample (N) are reported as mean scores (± standard deviation [*SD*]).
†, These are provided where Cronbach's alpha coefficients are < 0.70; ‡, Variances not equal; results of the Brown-Forsythe test are reported.
ANOVA, analysis of variance; IIC, inter-item correlations; SD, standard deviation.

time and study environment, effort regulation, extrinsic goal orientation, and control of learning beliefs, delivered unsatisfactory alphas and poor inter-item correlations and were excluded from further investigation. Sample statistics and reliability measures for the 11 subscales investigated further, along with final course averages, are presented in Table 4 for distinct cohorts and the cumulative sample. The inter-item correlations are reported for subscales where alphas were lower than 0.70. One-way independent-samples analysis of variance (ANOVA), F values and significance levels (p-values) are also provided.

The intrinsic goal orientation, rehearsal, organisation, peer learning, and help seeking subscales were included for further investigation because they reported reliability in this study, even though they were not identified as regularly reporting reliability in the literature. As the inter-item correlation for organisation was reported as borderline, this subscale was cautiously included in further analyses. After removing Item 40 (reversed), the help seeking alpha improved from 0.55 to 0.64 and the inter-item correlation was acceptable, so a three-item help seeking subscale was cautiously included for further analysis.

Limitations

This study was subject to the limitations imposed by self-report Likert scale data. Poor reliability or validity relating to the MSLQ learning strategies subscales may be the reason why few statistically significant differences occurred. Biographical data collected were limited; age or first-generation status could be considered in the future. Although multiple cohorts were investigated to ensure the robustness of concluding recommendations, a single algebra course was investigated in a foundation programme at one private HEI in South Africa, and differences may be detected when exploring other courses or algebra courses in other access programmes at other HEIs. Qualitative data collection may advance broader or more profound insights into the relationships established in this study and could be a topic for future research. Relationships, rather than causations, were established, and causation could be interrogated in future investigations.

Results and discussion

Research sub-question 1: Which of the subscales indicated data reliability and validity for further interrogation?

As with other studies (Hamid & Singaram, 2016; Kumar & Bhalla, 2020), self-efficacy returned the highest Cronbach's alpha. Construct validity was investigated through exploratory factor analysis. The Kaiser-Meyer-Olkin measure of sampling adequacy for motivation was 0.91, while Bartlett's test of sphericity was significant ($\chi^2(465) = 9091$, $p < 0.001$). Eigenvalues greater than 1 were extracted for six factors, with a cumulative variance of 54.5%. The self-efficacy and test anxiety subscales demonstrated construct validity while, as in Chen and Smith (2017), intrinsic goal orientation and task value clustered together.

The learning strategies category returned a Kaiser-Meyer-Olkin measure of sampling adequacy of 0.92, and Bartlett's test of sphericity was significant ($\chi^2(1225) = 12364$, $p < 0.001$). Eigenvalues greater than 1 were extracted for nine factors, with a cumulative variance of 49.2%. As in the study of Chen and Smith (2017), cognitive and metacognitive subscales were not distinguishable, although elaboration and critical thinking demonstrated better construct validity than other subscales. The peer learning and help seeking subscales loaded onto the same factor, corroborating Ramírez-Echeverry et al. (2016), and reverse items loaded onto a single factor, concurring with Chen and Smith (2017). While intrinsic goal orientation, task value, metacognitive self-regulation, rehearsal, organisation, peer learning, and help seeking exhibited poor construct validity, they displayed internal consistency. These subscales were thus cautiously included alongside self-efficacy, test anxiety, elaboration, and critical thinking in further analyses.

Kolmogorov-Smirnov and Shapiro-Wilk tests elucidated that data were not normally distributed except for metacognitive self-regulation, although skewness and kurtosis measures for all subscales were well within the acceptable range (± 2). A careful examination of the stem-and-leaf plots, box-and-whisker plots and normal Q-Q plots, along with a large sample size, endorsed parametric methods as in prior studies (Al Khatib, 2010; Lee et al., 2020).

Correlations between the MSLQ subscales for the combined samples ($N = 796$) were investigated using the Pearson correlation coefficient. In Table 5, large correlations ($0.5 \le r \le 1$) are shaded in green, medium correlations ($0.3 \le r < 0.5$) in blue, and small correlations ($0.1 \le r < 0.3$) in yellow (Pallant, 2007). Non-significant and non-correlating relationships are omitted.

As in Baumgartner (2016), strong correlations were detected between motivation subscales and between learning strategy subscales; no strong correlations linked motivation subscales with learning strategies subscales in this study. Strong correlations observed between some subscales may be correlations or the result of poor factor loadings as previously reported. If strong correlations were consequential of poor factor loadings, the only strong correlation would be that linking self-efficacy with the intrinsic goal orientation-task value factor.

Research sub-question 2: How do the four cohorts' subscale responses and final course results compare?

Table 4 provides the sample statistics of the four distinct cohorts and the cumulative sample. The *F*-test and results of one-way ANOVA or Brown-Forsythe are reported in the last column of Table 4. The Scheffe post hoc test was applied, and homogeneous subsets were interrogated. Statistically significant differences were detected within 3 of the 11 MSLQ subscales across the four distinct cohorts.

The first statistically significant difference was in the *task value* subscale as demonstrated by Brown-Forsythe: $F(3, 384) = 2.88$, $p = 0.036$. While every cohort reported the task value subscale as the highest mean result, the mid-year cohort displayed significantly higher levels of task value than other cohorts and was placed in a separate subset to the first and fourth iterative cycles of cohorts. Smaller student cohorts may report higher task value related to learning algebra, or the mid-year cohort may be an anomaly. Further studies could consider whether the higher levels of task value reported in the mid-year cohort are also found in other mid-year cohort enrolments and whether these findings result from a smaller or biographically different cohort. When student cohorts are expected to report lower levels of task value, interventions that aim to equip students to improve the algebraic learning could help students understand the value of the algebra they are currently learning for their undergraduate studies and their future work as higher levels of task value may indicate higher levels of persistence in learning (You, 2018).

The second statistically significant difference reported between the cohorts was in the *test anxiety* subscale, as demonstrated by one-way ANOVA: $F(3, 792) = 3.92$, $p = 0.009$. Students in the fourth iterative cycle displayed significantly higher levels of test anxiety than those in the first iterative cycle. However, the homogeneous subsets resulting from scrutinising the Scheffe post hoc test elucidated only one subset. Higher levels of test anxiety may result from the fourth iterative cycle comprising a higher percentage of female participants than the first iterative cycle cohort, as female students have been found to report higher levels of test anxiety (Harris et al., 2019). If interventions can equip students to feel prepared for mathematics assessments, resulting reduced levels of anxiety may enable students to achieve better test results (Mirzaei-Alavijeh et al., 2020).

The third statistically significant difference was detected in the *critical thinking* subscale as determined by Brown-Forsythe: $F(3, 294) = 6.52$, $p < 0.001$. Students in the fourth iterative cycle displayed significantly lower levels of critical thinking than the cohorts of the first and third iterative cycles. Additionally, the homogeneous subsets from the Scheffe post hoc test placed the fourth iterative cycle in a separate subset from the first and third iterative cycle cohorts, with the second iterative cycle cohort intersecting the subsets. If critical thinking significantly affects student perceptions of content understanding (Lin et al., 2016), further research should be undertaken to understand why a cohort may

TABLE 5: Motivated strategies for learning questionnaire subscale correlations ($N = 796$).

Variable	TV	SE	TA	Reh	Elab	Org	CT	MSR	PL	HS
IGO	0.651*	0.573*	-0.155*	0.232*	0.444*	0.337*	0.476*	0.474*	0.318*	0.286*
TV	-	0.583*	-	0.276*	0.474*	0.346*	0.391*	0.478*	0.262*	0.298*
SE	-	-	-0.356*	0.152*	0.328*	0.213*	0.403*	0.400*	0.194*	0.218*
TA	-	-	-	-	-	-	-	-0.130*	-	-
Reh	-	-	-	-	0.545*	0.579*	0.369*	0.541*	0.291*	0.355*
Elab	-	-	-	-	-	0.591*	0.559*	0.658*	0.312*	0.407*
Org	-	-	-	-	-	-	0.361*	0.599*	0.338*	0.385*
CT	-	-	-	-	-	-	-	0.541*	0.381*	0.347*
MSR	-	-	-	-	-	-	-	-	0.400*	0.465*
PL	-	-	-	-	-	-	-	-	-	0.593*

Note: Data are provided for the full sample ($N = 796$).

*, $p < 0.001$ (two-tailed).

IGO, intrinsic goal orientation; TV, task value; SE, self-efficacy for learning and performance; TA, test anxiety; Reh, rehearsal; Elab, elaboration; Org, organisation; CT, critical thinking; MSR, metacognitive self-regulation; PL, peer learning; HS, help seeking.

report lower levels in the critical thinking subscale, and what strategies should be included in interventions to develop critical thinking.

Although no significant differences were detected in the *self-efficacy* subscale, examining the Scheffe post hoc homogeneous subsets elucidated that the second and fourth iterative cycle cohorts formed a separate subset from the third iterative cycle cohort, with the first iterative cycle cohort intersecting the subsets. The third cohort's self-efficacy mean was reported as higher than that of the other cohorts. Knowing at the outset of a course that a particular student cohort reports lower levels of self-efficacy provides an opportunity to introduce intervention strategies that develop rather than enhance the self-efficacy of that cohort through the duration of the algebra course.

In summary, the motivation and critical thinking of the fourth iterative cycle cohort were significantly different from other cohorts, as reported in the third week of the algebra course. The fourth iterative cycle cohort self-reported significantly lower levels of task value and critical thinking and significantly higher levels of test anxiety than one or more of the other cohorts. Additionally, the fourth iterative cycle cohorts' self-efficacy reporting was lower than other cohorts, resulting in placement within a different homogeneous subset. The remaining MSLQ relationships did not reveal statistically significant differences. As such, while task value, test anxiety, critical thinking, and self-efficacy may be similar between some cohorts, intrinsic goal orientation, rehearsal, elaboration, organisation, metacognitive self-regulation, peer learning, and help seeking appear to be similar across all cohorts. These findings provide evidence that while distinct cohorts enrolling in an algebra course within a foundation programme display similarities, they may exhibit significant differences in motivation or learning strategies from other cohorts. Applying questionnaires such as the MSLQ in the early stages of the course may allow course developers and teachers to include and apply intervention strategies to address aspects identified for particular cohorts.

Final course results were compared across the four distinct cohorts. Except for the second iterative cycle cohort, the mean averages were above 60% and one standard deviation from the mean included results between 40% and 90%. By contrast, one standard deviation for the second iterative cycle cohort included values of less than 40%. A statistically significant difference in the final course results, as demonstrated by one-way ANOVA, $F(3,792) = 3.04$, $p = 0.020$, was elucidated between the second and fourth iterative cycle cohorts, with the mean of the fourth iterative cycle cohort significantly higher than that of the second iterative cycle cohort. The fourth iterative cycle cohort achieved the highest mean algebra course average (as shown in Table 4) despite reporting statistically significantly lower levels of task value, self-efficacy, and critical thinking, and significantly higher levels of test anxiety. These findings do not correspond with prior studies that associate motivation and critical thinking with academic performance (e.g., Hamid & Singaram, 2016). A qualitative study, interviewing students and teachers of the algebra course, could provide insights to understand which factors influence academic performance in an algebra course within a foundation programme if motivation and learning strategies do not.

Research sub-question 3: How do the subscale responses and final course results compare based on biographic data?

The independent samples *t*-test was used to investigate differences in the MSLQ subscales as reported by *gender* for the combined sample ($N = 796$). One-way ANOVA and Scheffe post hoc tests were utilised to examine differences in the MSLQ subscales based on prior mathematics syllabus, prospective undergraduate degree, and ethnicity. The results and conclusions are reported in this section.

Table 6 reports the statistically significant differences in MSLQ subscales based on gender. No significant differences were found in the intrinsic goal orientation, task value, or peer learning subscales, and those subscales are not shown in the table.

Male participants self-reported significantly higher levels of self-efficacy and critical thinking. In comparison, female participants self-reported significantly higher levels of test anxiety, rehearsal, elaboration, organisation, metacognitive self-regulation, and help seeking, although the magnitude of the differences in the means, as reported by Cohen's d for all subscales, was small. Al Khatib (2010) and Lin et al. (2016) also found that female participants reported significantly higher levels of test anxiety, unlike Balam (2015) who concluded no significant differences in learning strategies or motivation based on gender. Significant gender differences were reported across the learning strategies subscales, although these subscales' construct validity should be verified prior to offering inferences. An examination of the final course results revealed that female students ($M = 65.8\%$, standard deviation [SD] = 22.5%) achieved statistically significantly higher final course results than male students ($M = 60.1\%$, SD = 23.4%; $t(794) = –3.51$, $p < 0.001$ [two-tailed]), despite significantly higher levels of test anxiety. The magnitude of the differences in the means (mean difference = 5.71; 95% confidence interval [CI]: –8.91 to –2.52) was relatively small (Cohen's d = 0.25). This may support the conjecture of Opateye (2014) that high levels of test anxiety push students to achieve academically, or the hypothesis of Bertrams et al. (2013) that students use self-control resources to ensure that test anxiety does not negatively impact academic performance.

The statistically significant gender differences within self-efficacy and academic performance are interesting, as although the male participants reported higher levels of self-efficacy, female participants scored a higher final course result mean. Self-efficacy may thus not correlate with academic performance as reliably for this algebra course within this foundation programme as has been found in prior

TABLE 6: Motivated strategies for learning questionnaire subscales: Significant differences by gender.

Motivated strategies for learning questionnaire subscale	Female participants (n = 401)		Male participants (n = 395)		Significance (two-tailed)	p	Cohen's d
	Mean	SD	Mean	SD			
Self-efficacy for learning and performance	5.14	1.11	5.31	1.01	t(794) = 2.29	0.022	0.16
Test anxiety	4.81	1.39	4.52	1.32	t(794) = -2.97	0.003	0.21
Rehearsal	4.98	1.21	4.59	1.12	t(791) = -4.79	0.001*	0.34
Elaboration	4.94	1.12	4.75	0.92	t(768) = -2.57	0.010*	0.18
Organisation	5.02	1.17	4.49	1.02	t(782) = -6.83	< 0.001*	0.48
Critical thinking	3.99	1.21	4.31	1.09	t(787) = 3.90	< 0.001*	0.28
Metacognitive self-regulation	4.72	0.90	4.59	0.77	t(779) = -2.18	0.030*	0.15
Help seeking	4.76	1.42	4.56	1.36	t(794) = -1.97	0.049	0.14

*, Equal variances not assumed.
N, number of participants; *SD*, standard deviation.

studies (Bruso & Stefaniak, 2016). When designing intervention strategies to support students learning algebra, teachers could consider having male students describe how they manage their test anxiety and think critically in order to solve problems. By contrast, female students could share how they organise and self-regulate themselves and their studies in relation to learning algebra.

Prior mathematics syllabus was considered, and statistically significant differences were found in the MSLQ subscales intrinsic goal orientation (F(5,790) = 3.42, p = 0.005), task value (F(5,790) = 5.71, p < 0.001), self-efficacy (F(5,790) = 16.87, p < 0.001), and test anxiety (F(5,790) = 6.29, p < 0.001). The statistically significant differences were elucidated between students with Mathematical Literacy and one or more other prior mathematics syllabus grouping. Students with Mathematical Literacy displayed significantly lower levels of intrinsic goal orientation and higher levels of test anxiety than the National Senior Certificate Mathematics group. Students with Mathematical Literacy self-reported significantly lower levels of task value than students from general certificate of secondary education (GCSE) O-level, National Senior Certificate Mathematics, and those grouped as *Other,* and significantly lower levels of self-efficacy than all prior mathematics syllabus groupings. These findings augment those of Baumgartner et al. (2018), who noted statistically significant differences in their examination of students with Mathematical Literacy or National Senior Certificate Mathematics. Students with Mathematical Literacy do not display the same motivation in the learning of an algebra course within a foundation programme, and intervention strategies that can target the development of motivation aspects in prior Mathematical Literacy students may be effective in improving the motivation of these students to learn algebra. The final course results of students with Mathematical Literacy were significantly lower than those of students from other mathematics backgrounds, as the Brown-Forsythe test revealed (F(5,306.4) = 76.9, p < 0.001). Three homogeneous subsets were generated.

The significant difference between the academic performance of the students with Mathematical Literacy and the rest of the participants is a matter that requires serious consideration. Students with Mathematical Literacy appear to be the most underprepared to perform in algebra at a level that is academically commensurate with their peers. The researchers agree with the suggestion of Baumgartner (2016) that the disparity in the mathematical content learned at the secondary level might be a leading factor in this discrepancy, but if students with Mathematical Literacy are to be enrolled in foundation programme algebra courses, then further studies to determine appropriate support strategies are required.

When considering differences in the subscales based on a *prospective undergraduate degree*, one-way ANOVA recorded statistically significant differences for task value (F(3,792) = 2.71, p = 0.044), self-efficacy (F(3,792) = 4.73, p = 0.003), test anxiety (F(3,792) = 3.64, p = 0.013), and organisation (F(3,792) = 7.15, p < 0.001). Law students self-reported significantly lower levels of task value than Health Science students and significantly lower levels of self-efficacy than Health Science and Computer Information Science students. Additionally, Law students self-reported significantly higher levels of test anxiety than Computer Information Science or Business Science students. Finally, Computer Information Science students self-reported significantly higher levels of organisation than all other students. Significant differences noted between the prospective Law students and other groups relating to task value and test anxiety may be due to the recent inclusion of this degree offering, resulting in few undergraduate Law cohorts sharing or distilling information about their degree studies. Alternatively, it may be that students enrolling in Law offerings presumed that they would not be required to enrol in an algebra course[4], while other students knew they were required to complete an algebra course to progress.

Self-report responses to the MSLQ subscales were investigated according to *ethnic groupings*, and only one statistically significant difference was revealed. The non-South African African group reported a significantly higher task value mean than the non-African group (F(5,790) = 2.94, p = 0.012), although only one homogeneous subset was generated. Moreover, there was no statistically significant difference in final course results based on ethnicity. Ethnic groupings appear to be more alike in their self-reporting of motivation

4. In South Africa, Law students often study a Social Sciences degree, where mathematics courses are not obligatory.

and learning strategies than groupings based on gender, prior mathematics syllabus, or prospective undergraduate studies. Based on ethnicity, standardised intervention strategies could similarly benefit and equip students in algebra courses.

In summary, statistically significant differences according to biographic data were more pronounced in the motivation category, although gender differences were observed in some learning strategy subscales. Standardised interventions are more likely to improve students' learning strategies, while targeted tactics could be employed to develop or enhance motivation in biographically categorised student segments.

Research sub-question 4: Which subscales correlate with students' final course results?

A Pearson product-moment correlation coefficient was used to investigate the relationship between the MSLQ subscales and final algebra course results for the four distinct cohorts and the cumulative sample. Only subscales that produced significant correlations with final algebra course results are presented in Table 7.

Strong correlations were not detected between any of the MSLQ subscales and the final algebra course results. A significant medium correlation was revealed between self-efficacy and final course results for every cohort, and thus cumulative academic performance. This finding corroborates literature correlating higher self-efficacy with higher final course grades (e.g., Bruso & Stefaniak, 2016; Hamid & Singaram, 2016). All cohorts demonstrated significant negative correlations between test anxiety and academic performance, concurring with Al Khatib (2010). Only two significant correlations were identified in the mid-year cohort, while seven were detected in each of the first and fourth iterative cycle cohorts. Motivation subscales related better to academic performance than the learning strategies subscales, which may suggest that it is not how one learns, but one's determination to learn that influences performance. No significant correlations were observed between critical thinking, peer learning, or help seeking and academic performance. Further studies on understanding why some cohorts' motivation and learning subscales responses correlate more significantly with final course results than others may inform improved interventions.

TABLE 7: Correlations between the motivated strategies for learning questionnaire subscales and final course results.

Iterative cycle	Final course results				
	1 (n = 402)	2 (n = 184)	3 (n = 44)	4 (n = 166)	Cumulative (N = 796)
Intrinsic goal orientation	0.274*	0.171**	-	0.212**	0.231*
Task value	0.332*	-	-	0.162**	0.241*
Self-efficacy for learning and performance	0.454*	0.343*	0.424*	0.342*	0.399*
Test anxiety	-0.178*	-0.188**	-0.376**	-0.222**	-0.190*
Rehearsal	-	-	-	0.183**	-
Elaboration	0.119**	-	-	0.200**	0.114**
Organisation	0.144**	-	-	-	-
Metacognitive self-regulation	0.223*	-	-	0.222**	0.167*

*, $p < 0.001$ (two-tailed); **, $p < 0.05$ (two-tailed).
n, subsample number of participants; N, full sample number of participants

Aligning with Bruso and Stefaniak (2016), the self-efficacy subscale reported the highest reliability and validity in this study and was the most likely subscale to relate significantly with academic performance (Hamid & Singaram, 2016). A student's self-efficacy result and interpretation could thus be shared with the individual as a diagnostic tool to develop self-regulated learning skills (Lawson, 2019) and motivation to learn algebra. Additionally, a particular cohort's self-efficacy results may inform the design and implementation of efficacious algebra interventions that target the development of algebraic motivation and learning strategies for that cohort.

Students' learning strategies across the four cohorts may be similar. After all, they employ similar practices when rehearsing, elaborating, or organising their work, thinking critically about algebra, managing their studies, or regulating their efforts, or learning with others. These strategies may be a focus area for future studies, because if students and cohorts enrolled in a foundation programme algebra course apply similar learning strategies, generic interventions to harness and improve these strategies may improve overall learning.

Conclusion

The primary purpose of this study was to investigate relationships between motivation and learning strategies at course commencement and the final algebra course results of four distinct cohorts of students enrolled in an algebra course within a foundation programme to inform intervention strategies. The interrogation of 11 MSLQ subscales and four biographic items across four distinct cohorts of students and the cumulative sample of students enrolled in a foundation programme algebra course returned few statistically significant differences between the cohorts. Statistically significant differences mainly were detected in the motivation subscales and the academic performance largely related to gender and prior mathematics syllabus. Where cohorts are similar, generic interventions designed to equip one cohort may equip others. Specific intervention strategies that target the needs of students based on particular needs identified in this study may equip future students to improve their algebraic knowledge. For example, students with Mathematical Literacy will likely require extensive and intensive support interventions to develop the necessary skills and content knowledge to achieve results comparable with other students in the algebra course.

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Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

W.L.B. was the main author of this manuscript (conceptualisation, data gathering and analysis, and writing), E.D.S. was the main supervisor and contributed in conceptualisation and writing, and G.V.L. co-supervised and contributed with the methodology and writing.

Ethical considerations

Ethical clearance for the study was obtained from the Faculty of Education Research Ethics Committee (2013-066, 2018-004) at the University of Johannesburg. Participants signed and returned a consent form after understanding the purpose of the study, which was outlined in an explanatory statement handed to each prospective participant. Physical documents were stored in an environment with controlled access and electronic data that were not deidentified were password protected to ensure participant confidentiality.

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Data availability

Deidentified data are available from the first author upon written request.

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References

Abdel Meguid, E., Smith, C., & Meyer, A. (2019). Examining the motivation of health profession students to study human anatomy. *Anatomical Sciences Education*, *13*(3), 340–349. https://doi.org/10.1002/ase.1919

Adamma, O., Ekwutosim, O., & Unamba, E. (2018). Influence of extrinsic and intrinsic motivation on pupils academic performance in Mathematics. *Supremum Journal of Mathematics Education*, *2*(2), 52–59. https://doi.org/10.35706/sjme.v2i2.1322

Al Khatib, S. (2010). Meta-cognitive self-regulated learning and motivational beliefs as predictors of college students' performance. *International Journal for Research in Education*, *27*, 57–72.

Bai, B., Nie, Y., & Lee, A. (2020). Academic self-efficacy, task importance and interest: Relations with English language learning in an Asian context. *Journal of Multilingual and Multicultural Development*, *43*(5), 438–451. https://doi.org/10.1080/0143632.2020.176317

Balam, E. (2015). Learning strategies and motivation of graduate students: Is gender a factor? *Institute for Learning Styles Journal*, *1*, 1–9.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, *37*(2), 122–147. https://doi.org/10.1037/0003-066X.37.2.122

Baumgartner, W. (2016). *The development of a strategy for Mathematical Literacy learners for selected undergraduate studies.* Master's dissertation, University of Johannesburg. Retrieved from http://hdl.handle.net/10210/214488

Baumgartner, W. (2021). *Design principles for a pre-undergraduate foundation programme mathematics course promoting academic growth*. Doctoral thesis, University of Johannesburg.

Baumgartner, W., Spangenberg, E., & Jacobs, G. (2018). Contrasting motivation and learning strategies of ex-mathematics and ex-Mathematical Literacy students. *South African Journal of Higher Education*, *32*(2), 8–26. https://doi.org/10.20853/32-2-941

Bertrams, A., Englert, C., Dickhäuser, O., & Baumeister, R. (2013). Role of self-control strength in the relationship between anxiety and cognitive performance. *Emotion*, *13*(4), 688–680. https://doi.org/10.1037/a0031921

Bruso, J., & Stefaniak, J. (2016). The use of self-regulated learning measure questionnaires as a predictor of academic success. *Tech Trends*, *60*, 577–584. https://doi.org/10.1007/s11528-016-0096-6

Chen, C., & Smith, S. (2017). Multiple iterations of MSLQ validation: A contemporary assessment. *Issues in Information Systems*, *18*(3), 149–160. Retrieved from https://iacis.org/iis/2017/3_iis_2017_149-160.pdf

Credé, M., & Phillips, L. (2011). A meta-analytic review of the motivated strategies for learning questionnaire. *Learning and Individual Differences*, *21*(4), 337–346. https://doi.org/10.1016/j.lindif.2011.03.002

Deci, E., & Ryan, R. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behaviour. *Psychological Inquiry: An International Journal for the Advancement of Psychological Theory*, *11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01

Derr, K., Hübl, R., & Ahmed, M. (2019). Monitoring the use of learning strategies in a web-based pre-course in mathematics. In D. Ifenthaler, D. Mah, & J. Yau (Eds.), *Utilizing learning analytics to support study success* (pp. 119–141). Springer. https://doi.org/10.1007/978-3-319-64792-0_8

Donker, A., De Boer, H., Kostons, D., Dignath van Ewijk, C., & Van der Werf, M. (2013). Effectiveness of a learning strategy instruction on academic performance: A meta-analysis. *Educational Research Review*, *I*(2014), 1–26. https:/doi.org/10.1016/j.edurev.2013.11.002

Dunningan, J. (2018). *The relationship of self-regulated learning and academic risk factors to academic performance in community college online mathematics courses*. Unpublished doctoral dissertation, Seattle Pacific University, Seattle,WA.

Federici, R., Skaalvik, E., & Tangen, T. (2015). Students' perceptions of the goal structure in mathematics classrooms: Relations with goal orientations, mathematics anxiety and help-seeking behaviour. *International Education Studies*, *8*(3), 146–158. https://doi.org/10.5539/ies.v8n3p146

Gumede, D., Ross, A., Campbell, L., & MacGregor, R. (2017). Rural-origin health professional students' perceptions of a support programme offered by Umthombo Youth Development Foundation. *African Journal of Primary Health Care and Family Medicine*, *9*(1), a1212. https://doi.org/10.4102/phcfm.v9i1.1212

Hamid, S., & Singaram, V. (2016). Motivated strategies for learning and their association with academic performance of a diverse group of 1st-year medical students. *African Journal of Health Professions Education*, *8*(1), 104–107. https://doi.org/10.7196/AJHPE.2016.v8i1.757

Harris, R., Grunspan, D., Pelch, M., Fernandes, G., Ramirez, G., & Freeman, S. (2019). Can test anxiety interventions alleviate a gender gap in an undergraduate STEM course? *CBE-Life Sciences Education*, *18*(35), 1–9. https://doi.org/10.1187/cbe.10-05-0083

Hattie, J., & Donoghue, G. (2016). Learning strategies: A synthesis and conceptual model. *Science of Learning*, *1*, 1–13. https://doi.org/10.1038/npjscilearn.2016.13

Keskin, S., & Yurdugül, H. (2019). Factors affecting students' preferences for online and blended learning: Motivational vs. Cognitive. *European Journal of Open, Distance and e-Learning*, *22*(2), 72–86. https://doi.org/10.2478/eurodl-2019-0011

Khumalo, V., Van Staden, S., & Graham, M. (2022). Weathering the storm: Learning strategies that promote mathematical resilience. *Pythagoras*, *43*(1), a655. https://doi.org/10.4102/pythagoras.v43i1.655

Kirby, N., & Dempster, E. (2018). Alternative access to tertiary science study in South Africa: Dealing with 'disadvantage', student diversity, and discrepancies in graduate success. In C. Agosti & E. Bernat (Eds.), *University pathway programs: Local responses within a growing global trend* (pp. 85–106). Springer. https://doi.org/10.1007/978-3-319-72505-5_5

Kumar, V., & Bhalla, J. (2020). Validation of motivated strategies for learning questionnaire (MSLQ) in Indian context. *International Journal of Future Generation Communication and Networking*, *13*(2), 507–517.

Lawson, D. (2019). Supporting students' development of self-regulated learning using a diagnostic questionnaire tool. *Practitioner Research in Higher Education Journal*, *12*(1), 15–23.

Lee, D., Watson, S., & Watson, W. (2020). The relationships between self-efficacy, task value and self-regulated learning strategies in massive open online courses. *International Review of Research in Open and Distributed Learning*, *21*(1), 23–39. https://doi.org/10.19173/irrodl.v20i5.4389

Lin, Y., Durbin, J., & Rancer, A. (2016). Math anxiety, need for cognition, and learning strategies in quantitative communication research methods courses. *Communication Quarterly*, *64*(4), 390–409. https://doi.org/10.1080/01463373.2015.1103294

Mirzaei-Alavijeh, M., Pasdar, Y., Hatamzadeh, N., Solaimanizadeh, L., Khashij, S., & Jalilian, F. (2020). The role of motivational strategies in prediction of grade point average among students of Kermanshah University of Medical Sciences. *Educational Research in Medical Sciences*, *8*(2), 1–6. https://doi.org/10.5812/erms.94234

National Youth Development Agency. (2015). *National youth policy 2015–2020*. South African Government. Retrieved from https://www.gov.za/documents/national-youth-policy-2015-2020-8-jun-2015-0000

Opateye, J. (2014). The relationship between emotional intelligence, test anxiety, stress, academic success and attitudes of high school students towards electrochemistry. *IFE PsychologIA*, *22*(1), 239–249.

Pallant, J. (2007). *SPSS survival manual: A step by step guide to data analysis SPSS for Windows*. 3rd ed. Allen & Unwin.

Payne, J., & Israel, N. (2010). Beyond teaching practice: Exploring individual determinants of student performance on a research skills module. *Learning and Individual Differences*, *I*, 260–264. https://doi.org/10.1016/j.lindif.2010.02.005

Pintrich, P., Smith, D., Garcia, T., & McKeachie, W. (1991). *A manual for the use of the motivated strategies for learning questionnaire (MSLQ)*. Ann Arbor.

Ramírez-Echeverry, J., García-Carillo, A., & Dussán, F. (2016). Adaptation and validation of the motivated strategies for learning questionnaire – MSLQ – In engineering students in Colombia. *International Journal of Engineering Education*, *32*(4), 1–14. Retrieved from https://dialnet.unirioja.es/servlet/articulo?codigo=6915619

Schunk, D. (2012). *Learning theories: An educational perspective*. 6th ed. Pearson Education.

Taylor, R. (2012). *Review of the motivated strategies for learning questionnaire (MSLQ) using reliability generalization techniques to assess scale reliability.* Doctoral thesis, Auburn University. Retrieved from https://etd.auburn.edu/handle/10415/3114

Tock, J., & Moxley, J. (2017). A comprehensive reanalysis of the metacognitive self-regulation scale from the MSLQ. *Metacognition Learning*, *12*, 79–111. https://doi.org/10.1007/s11409-016-9161-y

Vaculíková, J. (2016). The third round of the Czech validation of the motivated strategies for learning questionnaire (MSLQ). *International Education Studies*, *9*(7), 35–46. https://doi.org/10.5539/ies.v9n7p35

Van Zyl, A., Gravett, S., & De Bruin, G.P. (2012). To what extent do pre-entry attributes predict first year student academic performance in the South African context? *South African Journal of Higher Education*, *26*(5), 1095–1111. https://doi.org/10.20853/26-5-210

Wang, X., Sun, N., & Wickersham, K. (2017). Turning math remediation into “homeroom:” Contextualization as a motivational environment for community college students in remedial math. *The Review of Higher Education*, *40*(3), 427–464. https://doi.org/10.1353/rhe.2017.0014

Xolo, S. (2007). Developing the potential of the gifted disadvantaged in South Africa. *Gifted Education International*, *23*(2), 201–206. https://doi.org/10.1177/026142940702300211

You, J. (2018). Testing the three-way interaction effect of academic stress, academic self-efficacy, and task value of persistence in learning among Korean college students. *Higher Education*, *76*, 921–935. https://doi.org/10.1007/s10734-018-0255-0

Young, A., Wendel, P., Essen, J., & Plank, K. (2018). Motivation decline and recovery in higher education STEM courses. *International Journal of Science Education*, *40*(9), 1016–1033. https://doi.org/10.1080/09500693.2018.1460773

Zaharin, N.L., Sharif, S., Singh, S., Talin, R., Mariappan, M., Mohanaraj, N., Jusup, Y., & Suppiah, P. (2020). Promoting students’ interest, attitude and intrinsic motivation towards learning STEM through minimalist robot education programme. *International Journal of Science and Management Studies*, *4*(1), 41–65. https://doi.org/10.24191/ijsms.v4i1.8054