

Exploring how executive function and motivation shape deep and surface learning

Lorette Pretorius and Marita Heyns

Optentia Research Unit, North-West University, Vanderbijlpark, South Africa

Quarterly Review
of Distance
Education

207

Received 10 February 2026
Revised 31 March 2026
Accepted 31 March 2026

Abstract

Purpose – The purpose of this study was to examine how executive function (EF) skills and academic motivation shape the adoption of deep and surface learning approaches among South African distance learning student teachers. By examining the relationships between EF, intrinsic motivation, extrinsic motivation and amotivation, the study aimed to determine how these cognitive and motivational factors interact to influence learning behaviours in a higher education (HE) environment.

Design/methodology/approach – An empirical investigation was conducted to survey undergraduate teaching students using a cross-sectional design. The following quantitative scales: Executive Skills Questionnaire (ESQ-R), Academic Motivation Scale (AMS-C) and Study Process Questionnaire (R-SPQ-2F) we used to collect data from participants.

Findings – The findings revealed that EF has no noticeable impact on surface learning but is a strong predictor of deep learning. Intrinsic motivation emerged as the greatest positive predictor of deep learning. In contrast, amotivation was the most powerful predictor of surface learning. Intrinsic motivation demonstrated a negative, non-statistically significant relationship with surface learning. Overall, the findings show that students' learning styles in distance learning are greatly influenced by their level of motivation, particularly intrinsic motivation combined with EF skills.

Research limitations/implications – One of the study's limitations is its primarily female sample, which restricts its applicability to other student populations and genders. Age, gender and culture were not examined separately, which emphasises the need for more varied samples in future. Reliance on self-report questionnaires may have caused bias, despite mitigation efforts, indicating the importance of mixed-methods designs for more in-depth understanding. Furthermore, the cross-sectional research design prevents inferences about changes over time; therefore, longitudinal research is suggested to better comprehend evolving associations between executive function, motivation and learning approaches.

Practical implications – This study suggests that distance learning institutions improve EF support, identify students with lower EF early, and provide continuous guidance to build intrinsic motivation and confidence. Efficient techniques include problem-based learning, clear study guidelines, formative feedback, visual aids, AI chatbots, electronic portfolios and communities of practice. High-quality learning management system (LMS) platforms and integrated teaching approaches that boost both intrinsic and extrinsic motivation are essential. Strong EF support is essential to prevent students from dropping out and promoting deep learning in South Africa's distance learning environment. These results can guide focused instruction and interventions to improve students' academic performance and self-control.

Social implications – In the South African distance learning setting, effective EF support is critical to avoid dropout and enhance deep learning. The results can inform specific interventions and training to promote students' self-regulation and academic success. It is evident that without strong executive function and motivation support, distance learning may expand current educational inequalities, especially for students with weaker EF skills or restricted self-directed learning experience. Enhancing EF, motivation and support can lower the likelihood of dropout; encourage equal participation; and improve students' self-esteem, independence and future academic performance.

Originality/value – This study is unique and valuable since it investigates how various forms of motivation and executive function interact to influence both surface and deep learning among South African distance learning student teachers, a population that has not received sufficient attention. Recognising the relationship between EF, a deep learning approach and academic motivation are essential to helping students succeed in a demanding context like HE. Finally, this study contributes to current theoretical perspectives like self-regulating approaches and SDT by showing that motivation and cognitive processes are inter-related as opposed to acting separately.

Keywords Academic motivation, Deep and surface learning, Distance education, Executive functions, Higher education

Paper type Research article



Quarterly Review of Distance Education
Vol. 27 No. 2, 2026
pp. 207-226

© Emerald Publishing Limited
e-ISSN: 2169-1266
p-ISSN: 1528-3518

DOI 10.1108/QRDE-02-2026-0006

Funding: The research and writing of this paper were not funded by any stakeholders.

Conflict of interest: No possible conflicts of interest need to be disclosed.

1. Introduction

Higher education (HE) institutions consistently face challenges in preparing students for the workforce and developing their expertise. In the digital era, adopting executive function (EF) skills, such as self-regulation, strategic thinking and motivation, is essential for success, as students engage in complex cognitive and behavioural processes. In online distance education (DE), higher EF capability is linked to a greater use of learning techniques and self-regulation that highlight the increased demands placed on these mental functions in digital and AI-assisted educational settings (Fajardo-Ramos, Chiappe, & Mella-Norambuena, 2025). Students might adopt surface learning strategies to deal with inadequate course material and lack of supporting strategies for EF development and self-regulated learning (Meijs, Gijssels, Xu, Kirschner, & De Groot, 2021). While improving these skills is critical for enhancing academic performance, progress is often hindered by factors like ability and effort, both linked to students' cognitive skills, motivational capacities and their approach to learning in their studies (Hidi & Harackiewicz, 2000; Zimmerman, 2002). This is especially pertinent in South Africa, where HE institutions are still struggling to deal with a diverse range of student abilities and environmental constraints according to the annual report of the Council on Higher Education (CHE; 2024/2025).

Despite prior research examining influences of motivation and EF on students' learning, little is known about the association on the adoption of a deep or surface learning approach, especially in distance teacher education. Many studies have looked at different facets of HE students in a broad sense. However, research on the association between various forms of motivation and students' EF skills remains limited. Furthermore, there are very few studies on the relation between learning approaches and EFs in South Africa. Therefore, the main research question of this study is: How do EF and motivation shape deep and surface learning among South African student teachers in a DL context? This research is relevant since surface learning approaches are frequently encouraged by the growth of DL- and AI-assisted assessments (Pergantis, Bamicha, Skianis, & Drigas, 2025). This study contributes to existing research by exploring deep and surface learning within a digital learning setting. Moreover, this study incorporates various assessment scales: Executive Skills Questionnaire (ESQ-R), Academic Motivation Scale (AMS-C) and the Study Process Questionnaire (R-SPQ-2F) to understand the learning process in an online, digital context. The results of this study could benefit HE institutions by guiding the development and inclusion of EF and motivation into curricula, which will eventually improve institutional efficiency, success and performance.

2. Executive function

Controlling one's thoughts and behaviours to achieve a goal is referred to as executive function (EF), a broad and complex construct (Bunge, 2024). EF serves as the primary control system of the brain, organising and managing the activities vital for performance and learning (Manuhuwa, Snel-de-Boer, de-Graaf, & Fleer, 2024). In addition, EF operations occur in the pre-frontal cortex, a vulnerable part of the human brain and these networks communicate with other brain regions to produce new connections, improving EF (Spreij, Van Tuijl, & Leseman, 2023).

EFs comprise three main competencies, namely cognitive flexibility (CF), a component of thinking that enables a person to solve everyday challenges, adjust to changes in the environment and come up with innovative ideas that spur creativity (Algharaibeh, 2020). When an approach to problem-solving fails, CF is needed to think of or to come up with alternative approaches (Diamond & Ling, 2016) to deal with the particular situation. The second competency refers to working memory (WM), the capacity to execute complex cognitive operations such as reasoning, solving problems and comprehending language (Amzil, 2022). These cognitive processes are evident in activities like listening to lectures, connecting current information with previously learned concepts or establishing causal links between outcomes and events (Diamond & Ling, 2016). Finally, inhibitory control (IC) enables

one to control attention, thoughts and emotions (Bai, Liu, & Su, 2023; Ramos-Galarza, Acosta-Rodas, Bolaños-Pasquel, & Lepe-Martínez, 2019). The presence of IC empowers individuals to modify and determine their responses and actions instead of adhering to traditional habits (Diamond, 2013).

Higher-order EFs develop on the mentioned core functions that includes a) planning: creating, assessing and choosing actions to reach a goal (Bai *et al.*, 2023), b) organisation: being accountable for accessing and arranging essential task components, c) task and self-monitoring: adapting to different approaches and keep track of studies, d) initiation: work independently, e) self-motivation: stay motivated during challenges, f) emotional regulation: regulate reactions (Ramos-Galarza *et al.*, 2019), g) decision-making: enables reasoning and emotions, and h) problem-solving: advanced mental processes such as memory, perception and attention (Pinochet-Quiroz *et al.*, 2022). All related to self-regulated learning, academic achievement and motivation.

Efficient teachers need strong EFs to monitor, assess and reflect on their teaching and make changes as needed. This involves organising, observing, planning and managing their behaviour to accomplish certain goals (Correia & Navarrete, 2017). The good news is, with effort and repetition, EFs can be learned and enhanced (Pergantis *et al.*, 2025).

3. Deep- and surface learning approaches

How students approach learning in HE has been researched for decades. Initially, learning was defined as the total number of test-correct responses. However, in 1976 HE students' reading and processing of academic texts were examined by Marton and Säljö. The authors found two distinct methods for accomplishing this: surface- and deep processing. The two methods more suited to students' learning and studying were modified to deep and surface approaches to learning (Entwistle, McCune, & Scheja, 2006).

Deep learning approaches are associated with high-quality learning outcomes. These approaches emphasise students' active participation in their education and promote a deeper understanding of the content (Masuku, Jili, & Sabela, 2020). Adopting a deep approach to learning indicates an effort to comprehend concepts on a person's own. Every student has a different approach to learning, consisting of motivation and strategy used to complete an activity or find solutions to problems (Biggs, 1991). The main idea of deep motive (intention of learning) is to understand the content (Aderibigbe, 2021), to seek for purpose (Biggs, 1991) and automatically trying to acquire specific information and ensure one gets the overall picture (Biggs & Tang, 2007). Within the deep strategy (process of learning), the aim is to address interest, maximise understanding, actively engage with the content and concentrate on details of the content (Biggs, 1991).

In contrast, a surface approach to learning aims to replicate the subject matter through memorisation (Dolmans, Loyens, Marcq, & Gijbels, 2016). Within this approach, students aim to complete higher-order thinking activities as quickly as possible resulting in substandard work. Students using this strategy rely on memorisation as the best approach for achieving their goal and must balance studying too hard and preventing failure (Biggs, 1991). However, a memorising fact do not only lend itself to a surface approach. When the student memorised the content to provide the impression of understanding, it turns into a surface approach (Biggs & Tang, 2007). In the surface motive approach, the goal is to minimise work and only replicate content to reach goals (Fu & Liu, 2024a). On the other hand, the surface strategy approach uses basic cognitive thinking to complete tasks not worrying about meaning (Biggs & Tang, 2007).

In education, a deep learning approach is preferred to enhance twenty-first century skills in HE students. It is crucial to help students grow their knowledge and skills through a deep learning approach to prepare them for future employment, lifelong learning and social issues (Mthethwa-Kunene, Rugube, & Maphosa, 2021) also reflected in the UN's Sustainable Development Goal 4 (SDG 4). Furthermore, employing a deep approach allows students to grasp the learning content easier, solve problems, think critically, establish how to learn,

contextualise learning, use digital tools, gain skills and knowledge and become lifelong learners (Mthethwa-Kunene *et al.*, 2021), all linked to the required twenty-first century skills. Although several factors play a role in student's approach to learning, this study focus mainly on the role of motivation and EF skills in a DL context (Diamond & Ling, 2016; Ryan & Deci, 2020).

4. Academic motivation

People's ability to control their behaviour is heavily impacted by the multifaceted and complicated concept of motivation (Kirkpatrick, Kirkpatrick, & Derakhshan, 2024). Self-determination theory (SDT) is one of the most influential frameworks for understanding human motivation and thriving (Ryan & Deci, 2017). Importantly, and unlike alternative theories that conceptualise motivation as a unitary construct, SDT differentiates various types of motivation along a continuum ranging from amotivation (signifying the lack of intentionality) to extrinsic motivation (associated with a feeling of being coerced or compelled to act) and ultimately to intrinsic motivation as the most autonomous form of motivation. When an individual is intrinsically motivated, behaviours are performed purely out of interest and for the sake of the associated feelings of spontaneous pleasure and enjoyment that results from those behaviours (Ryan & Deci, 2017).

Intrinsic motivation has been described by Deci (1992) as having both dispositional and experiential elements: dispositional elements refer to the intention to keep doing things and experiential elements refer to focused activity involvement, participation and feelings of pleasure, interest and enthusiasm. According to Fairchild, Horst, Finney, and Barron (2005) and Utvær and Haugan (2016), intrinsic motivation comprises three categories: intrinsic motivation to know (find learning something new enjoyable and fulfilling), intrinsic motivation to accomplish (outperforming oneself in studies provides joy) and intrinsic motivation to experience stimulation (finding enjoyment in studying fascinating people). In contrast, extrinsic motivation involves behaviour enacted for reasons that do not stem from inherent pleasure and satisfaction (Ryan & Deci, 2020). Fairchild *et al.* (2005) identify three sub-components of extrinsic motivation: external regulation (controlled behaviour due to outside rewards and punishments), introjected regulation (preventing guilty feelings or pursuing fulfilment in life) and identified regulation (a person intentionally valuing the purpose of the task).

Finally, amotivation refers to a lack of motivation, which is neither intrinsic nor extrinsic (Can, 2015; Fairchild *et al.*, 2005; Vallerand *et al.*, 1992). In this situation, people either believe that they cannot effectively perform the actions that are needed to attain outcomes, or it may also stem from a lack of interest simply because they attach no value to it. In some cases, amotivation may also be a case of resistance to influence, which can result either in nonaction or in oppositional behaviour to defy demands (Ryan & Deci, 2017). Those who lack motivation believe that circumstances beyond their control are to blame for their actions (Vallerand *et al.*, 1992). Essentially, in DE, students who feel that they do not comprise the necessary skills, do not have a frame of reference to understand the relevance of the study material, or simply have behavioural challenges may be prone to amotivation. It is therefore vital that online learning environments are intentionally designed to emphasise the relevance and real-world applicability of the study material.

According to a SDT framework (Ryan & Deci, 2017), motivation stems from the satisfaction of three fundamental psychological needs – relatedness, competence and autonomy – as essential drivers towards more autonomously motivated behaviour. Moreover, the degree to which a student's fundamental psychological needs are met or not is determined by both psychological and contextual factors. Vansteenkiste, Ryan and Soenens (2020) describe the three psychological needs in which the feeling of satisfaction, desire and eagerness is referred to as autonomy. When students are satisfied, they will be motivated and feel that they are in control of their studies and learning choices. Relatedness is fulfilled when

one connects with and feels important to others, signifying the feeling of comfort, connection and compassion. The sensation of efficacy and mastery is what competence is all about. When one successfully participates in activities and has the chance to apply and expand their knowledge and abilities, it is satisfied.

In addition to the psychological needs, self-efficacy, resilience and attitudes impact students' confidence in their capacity to cope and thrive. Students who have less self-efficacy regulation would be more stressed and, as a result, less motivated (Abdolrezapour, Jahanbakhsh Ganjeh, & Ghanbari, 2023). Because students are unfamiliar with the online setting, self-efficacy is a key influence in online learning (Shen, Cho, Tsai, & Marra, 2013; Zimmerman & Kulikowich, 2016). Resilience addresses students' capacity to overcome challenges and achieve success in their studies (Vance, Pendergast, & Garvis, 2015). According to SDT, the satisfaction of the three basic psychological needs, i.e. relatedness, autonomy and competence, improves well-being and strengthens inner resources related to resilience. Motivation and learning are also significantly impacted by students' attitudes (Kirkpatrick *et al.*, 2024), interests (Hidi & Harackiewicz, 2000) and accomplishment goals (Fairchild *et al.*, 2005). Though the motive behind these goals is crucial for success, positive attitudes increase participation, ongoing interest generates intrinsic motivation and students' goals encourage deeper learning.

One important contextual aspect involves lecturer support, which has been reported as a significant impact of student motivation. According to Ryan and Deci, 2020, lecturers supporting student autonomy provide them with valuable options and opportunities to control their studies and consider their viewpoints, and they encourage participation by providing justifications for assignments. In contrast, authoritarian lecturers force the students to think or behave a certain way without considering their opinions. Furthermore, the environment (encouraging, well-prepared, pleasant) to which students are exposed to is vital for student motivation (Cayubit, 2022). When a quality learning management system (LMS) is made available to students in which they receive instant feedback and personalised interaction with peers and lecturers, it improves motivation (Ferrer, Ringer, Saville, A Parris, & Kashi, 2022; Zhang, 2025).

Some other prevalent teaching methods have the potential to diminish students' self-motivation. These aspects include the emotions students encounter like anxiety and stress (Liu, Shi, & Wang, 2022) and pressure to perform (Ryan & Deci, 2020). Lecturers are especially crucial in encouraging perseverance in learning environments by helping students feel that their studies have purpose (Bureau, Howard, Chong, & Guay, 2022). While peer interactions and support are a crucial contextual component to meet the fundamental psychological needs of students. Peer support, such as boosting one another and promoting a supportive learning environment, is highly linked to increased motivation and engagement (Wang, Sun, Wang, & Li, 2022).

5. The relationship between executive function, deep- and surface learning approaches, and academic motivation

It is essential to gain insight into how students' cognitive functions and motivation relate to their academic learning activities. Research emphasises the highly complex twenty-first-century abilities, such as problem-solving, logical reasoning, interpersonal skills, collaboration, innovation, creativity and self-directed learning, that must be developed to fully participate in deep learning (Mthethwa-Kunene *et al.*, 2021; Reimers, 2021; Sølvik & Glenna, 2022). Moreover, these authors assert that EF offers the essential internal cognitive abilities required for students to effectively develop these skills. The main motivator to a deep learning approach requires higher-order mental skills like self-regulation, logical and analytical thinking and metacognition. Deep learning does not occur in isolation; rather, it happens when students employ their EFs and metacognitive skills to link difficult concepts, find deeper meaning and apply what they've learned to different situations (Reimers, 2021). Although a deep approach is essential, the ability to control oneself is ultimately what enables

or prevents the use of these advanced cognitive abilities such as EF (Häsä, Rämö, & Yan, 2024).

In contrast to the deep approach, participating in simple, lower-order mental tasks that exclude extensive thinking is referred to as surface learning (Biggs & Tang, 2007). This strategy is motivated by the desire to do tasks as quickly as possible while still seeming to meet the task objectives. As a result, even when deeper, more complicated thinking is required to do the work successfully, students rely on easy solutions (Biggs & Tang, 2007). Students who lack self-regulatory skills; the capacity to organise, oversee, and assess their own learning, are inclined to stay at the surface level and depend on lecturers to provide them with precise instructions and guidance (De La Fuente, Sander, Kauffman, & Yilmaz Soylu, 2020). In addition, unstructured knowledge is usually the outcome of surface learning. This indicates that although students can recognise, label, or record isolated facts, they are unable to apply this knowledge to other situations (Biggs & Tang, 2007). As a result, students struggle to control their learning, track their development and perform cognitive tasks (EFs), like planning, managing time and decision making (De La Fuente *et al.*, 2020; Reimers, 2021). This implies that students who successfully adopt a deep learning approach will be less likely to employ surface learning strategies.

The core components of EF – CF, WM and IC – predict deep learning and promotes self-regulated and goal-directed learning (Pinochet-Quiroz *et al.*, 2022). Improved EF enables students to better organise, regulate and assess their learning, which helps them to cognitively grasp unfamiliar concepts as opposed to mindless memorisation (Dörrenbächer-Ulrich, Dilhuit, & Perels, 2024).

Nevertheless, students' adoption of a deep or surface learning approach is not entirely determined by EF. Rather, motivation, in particular intrinsic motivation as described by SDT (Ryan & Deci, 2020), guides students to use the required cognitive skills when engaging in learning (Stasolla *et al.*, 2025). Harel-Gadassi (2022) states that using EFs, like creating objectives, self-regulation, self-assessment and planning, helps students feel more confident in their learning skills and boosts their level of autonomy. Excessive autonomy has an impact on intrinsic motivation because students who excel in their studies are more likely to be mentally invested in the learning activities, which in turn motivates them to be more committed (Harel-Gadassi, 2022).

Intrinsic motivation is thought of as the learning ideal that promotes real understanding, whereas extrinsic motivation is frequently seen as a temptation to embrace surface study techniques (Biggs & Tang, 2007). Extrinsic motivation and learning strategies have a complicated relationship. When it comes to surface learning, the impact is clear: students who are motivated by outside incentives typically put in less effort, rely on memorisation and concentrate solely on finishing the assignment (Acosta-Gonzaga & Ramirez-Arellano, 2021; Biggs, 1991; Biggs & Tang, 2007; Häsä *et al.*, 2024). On the other hand, when students redirect that same external motivation into deliberate, advanced thinking to achieve a desirable goal, extrinsic motivation can also assist deep learning. Intrinsic and extrinsic motivational factors can also concurrently influence deep learning processes, each contributing uniquely to the student's engagement and comprehension in a complementary fashion (Ryan & Deci, 2017).

In contrast, amotivation is linked to negative emotions including disinterest, worry and scepticism, resulting in surface learning (Biggs & Tang, 2007). Amotivated students are more inclined to reduce their work if they do not believe the content to be inherently fascinating (Biggs, Kember, & Leung, 2001; Gozalo, León-del-Barco, & Mendo-Lázaro, 2020). A student who lacks the inherent motivation to interact with the material is said to be amotivated (also known as "unmotivated"), which usually leads to a surface rather than a deep approach to learning. When a student is unmotivated, it usually indicates that they lack belief that their work is worthwhile or they have no expectation to succeed (Biggs & Tang, 2007). Therefore, no motivated effort takes place if the likelihood of success is zero.

Students' cognitive abilities are influenced by their level of academic motivation (Berestova, Kolosov, Tsvetkova, & Grib, 2022), which implies that EF affords students the

mental abilities they need to regulate their behaviour, but motivation acts as the driving force guiding students to use those abilities in their learning. Hence, this study aims to explore how academic motivation, as well as a deep and surface learning approach of DL student in HE within the South African setting associate with their EF skills. The following hypotheses are stated to explore this goal further.

- H1. EF has a statistically significant, positive effect on a) deep learning but not on b) surface learning.
- H2. a) Intrinsic motivation has a statistically significant negative effect on surface learning, whereas b) extrinsic motivation and c) amotivation have a positive effect on surface learning.
- H3. a) Intrinsic motivation and b) extrinsic motivation have a statistically significant positive effect on deep learning while c) amotivation has a negative effect on deep learning.

6. Method

An empirical investigation was conducted to survey undergraduate teaching students using a cross-sectional design. Given that the goal was to conduct a preliminary investigation of relationships between a set of variables that had not been previously reported, this approach was considered appropriate (Spector, 2019; Wang & Cheng, 2020).

7. Instruments

7.1 Executive Skills Questionnaire (ESQ-R)

The 25-item ESQ-R were used to assess students' EF skills related to the academic context (Strait *et al.*, 2020). Five subscales, each representing a different EF skill, namely plan management, time management, organisation, emotional regulation and behavioural regulation, were assessed and recorded on a four-point Likert scale varying from 0 – never or rarely, 1 – sometimes, 2 – often and 4 – very often. Students responded based on how frequently they participate in behaviours related to each skill.

7.2 Academic Motivation Scale (AMS-C)

The 28-item college version of the Academic Motivation Scale (Vallerand *et al.*, 1992) measured students' 1. Intrinsic motivation, 2. Extrinsic motivation and 3. Amotivation based on why they participate in certain behaviours. Responses were presented on a 7-point Likert scale ranging from one (does not correspond at all), 2–3 (corresponds a little), 4 (corresponds moderately), 5–6 (corresponds a lot) and seven (corresponds exactly). Students responded to the questions based on why they participate in certain behaviours.

7.3 Study Process Questionnaire (R-SPQ-2F)

The R-SPQ-2F (Biggs *et al.*, 2001) was used to assess students' approach to learning. The scale consists of 20 items, which measure deep and surface learning. Deep- and surface learning were measured on a 5-point Likert scale varying from one “never or only rarely true of me”, two “sometimes true of me”, three “true of me about half the time”, four “frequently true of me” and five “always or almost always true of me”. Students responded to the questions based on their study experiences.

Several procedural practices were in place to avoid common method variance and bias: enhancing participant anonymity, increasing item reliability, isolating predictor and criterion variables, using different Likert scales and balancing question sequence (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

8. Statistical analysis

The applications, Mplus 9.0 (Muthén & Muthén, 2025) and SPSS v30 (IBM SPSS, 2025), were used for statistical analysis and factorial management in this study. Additionally, the maximum likelihood (MLM) estimator was employed with the covariance matrix as input (Muthén & Muthén, 2025). To assess the fit of the measurement and structural models, the root mean square error of approximation (RMSEA), the standardised root mean square residual (SRMR), the chi-square (χ^2) indicator, the Tucker–Lewis Index (TLI) and the comparative fit index (CFI) were used. The SRMR values below 0.08 and CFI and TLI values higher than 0.9 (Byrne, 2010) were considered a suitable fit. Additionally, RMSEA values of 0.05 or less suggest a close or good fit, while values between 0.05 and 0.08 indicate an adequate fit (Byrne, 2010). The measurement models were compared using the Bayes Information Criterion (BIC) and the Akaike Information Criterion (AIC), which penalise for model complexities, with a greater match shown by lower values (Wang & Wang, 2020).

McDonald’s omega coefficient (ω) was used to examine scale reliability. A cutoff value of 0.7 or greater was deemed ideal for interpreting composite reliability, although it is reasonable to anticipate results below 0.7 when working with psychological concepts (Field, 2018), and when only a few items measured the construct (Pallant, 2020). The Pearson product–moment correlations were incorporated to determine the associations among the variables, and a 95% level of statistical significance was chosen ($p < 0.05$). A correlation of 0.30 or higher indicates a moderate effect, but a correlation of more than 0.50 indicates a major impact (Field, 2018).

9. Participants and procedure

Teacher students associated with a private HE institution in South Africa were chosen to take part in an online survey. Data were collected from students between February and March 2024, before the integration of generative AI tools in HE. Every student was allowed to participate, and those who accepted the invitation were added to the research. Participants in the survey completed online questionnaires that were sent to them via a link. There were 917 respondents between the ages of 18–60. 32 males and 882 females participated in the study, and three participants preferred not to disclose their gender. Most participants reside in Gauteng (26.1%), and isiZulu (29%) and Setswana (25.1%) are the languages mostly spoken. Only 2.9% of participants indicated that their English language proficiency is below average. Participants (74.8%) have no teaching experience and only (26.8%) are in practice while studying. The participant characteristics are summarised in Table 1. Ethical approval to conduct the study from a recognised South African university was granted.

10. Results

10.1 Testing the measurement model

The initial measurement model was configured similarly to what theory proposes. However, in an initial run of the model, confirmatory factor analysis (CFA) indicated that the results were not ideal. To determine whether items of the different instruments (ESQ-R, AMS-C and R-SPQ-2F) loaded onto the factors that were intended according to theory, exploratory factor analysis (EFA) was utilised. The instrument items served as observed variables. Results indicated that the time dimension of EF, as well as two components of the motivation scale (introjected- and identified regulation) loaded across other constructs with no justification for retaining these items; consequently, they were omitted from the subsequent model. Items that loaded poorly <0.3 : Wang & Wang (2020) onto their respective constructs were also removed before testing the final model.

The final measurement model was constructed as follows: (1) EF, a second-order construct with four first-order variables (planning, organisation, emotional regulation and behavioural regulation); (2) intrinsic motivation, a first-order construct measured by nine observed variables; (3) extrinsic motivation, a first-order construct measured by two observed variables;

Table 1. Participant characteristics (*n* = 917)

Item	Category	Frequency	Percentage
Gender	Male	32	3.5
	Female	882	96.2
Age	18–30	356	38.8
	31–40	384	41.9
	41–50	148	16.1
	51–60	29	3.2
Province	Eastern Cape	33	3.6
	Free state	92	10
	Gauteng	239	26.1
	KZN	177	19.3
	Limpopo	69	7.5
	Mpumalanga	41	4.5
	Northern Cape	76	8.3
	Northwest	160	17.4
	Western Cape	29	3.2
	Not sure	1	0.1
Language	Afrikaans	83	9.1
	English	33	3.6
	Ndebele	7	0.8
	Sepedi	104	11.3
	Sesotho	99	10.8
	Setswana	230	25.1
	Siswati	5	0.5
	Venda	10	1.1
	isiZulu	266	29
	Xitsonga	20	2.2
	isiXhosa	52	5.7
	Other	8	0.9
English proficiency	Below average	27	2.9
	Average	394	43.0
	Above average	266	29
	Excellent	230	25.1
Year in study	1 st year	425	46.3
	2 nd year	481	52.5
	3 rd year	11	1.2
Currently teaching	Yes	246	26.8
	No	671	73.2
Teaching experience	Null	686	74.8
	Less than 1 year	91	9.9
	1–2 years	79	8.6
	2–3 years	61	6.7

Source(s): Authors' own work

(4) amotivation, a first-order construct measured by four observed variables; (5) deep learning, a first-order construct by 10 observed variables; and (6) surface learning, a first-order construct with eight observed variables. All indicators considered in combination, the model demonstrated a suitable fit to the data ($\chi^2 = 2033.541^*$, $df = 1056$, $p = 0.000$, $CFI = 0.91$, $TLI = 0.91$, $RMSEA = 0.03$, $SRMR = 0.05$). The standardised regression coefficients all loaded positively and statistically significantly onto their respective constructs ($p < 0.01$). Table 2 presents the descriptive statistics, coefficient reliabilities and correlations of the instruments employed in this study.

The composite reliability of all the scales exceeded the threshold of 0.7, thereby indicating that the scales reliably captured the respective constructs.

Table 2. Descriptive statistics, coefficient reliabilities and correlations of the instruments

Variable	Mean	SD	<i>p</i>	1	2	3	4	5	6
1. Intrinsic motivation	5.38	1.01	0.81	1					
2. Extrinsic motivation	6.03	1.29	0.70	0.502**	1				
3. Amotivation	2.11	1.35	0.72	0.070	0.117**	1			
4. Surface learning	2.46	0.82	0.82	0.101**	0.268**	0.782**	1		
5. Deep learning	3.69	0.72	0.86	0.602**	0.414**	−0.047	0.124**	1	
6. Executive Function	2.67	0.43	0.89	0.115**	−0.063	−0.474**	−0.426**	0.321**	1

Note(s): $p \leq 0.01$ ** $p \leq 0.05$ * The motivation-related variables (Items 1–3) in the first column were measured on 7-point scales, the scale for EF (item 6) = 4 and learning (items 4–5) = 5. The correlation coefficients were deemed a small effect when $r < 0.3$, a medium effect when $r \geq 0.3$ and a large effect when $r \geq 0.5$

Source(s): Authors' own work

Considering the maximum values that could be obtained for each of the various scales, above average mean values were recorded for EF, intrinsic- and extrinsic motivation as well as deep learning. The mean for surface learning was about average and the amotivation factor shows a desirable low mean.

The standard deviation for EF was relatively closer to 0 (0.43) indicating that participants' opinions on this construct were essentially more similar. However, larger variation in the participants' responses on the motivation and deep- and surface learning scales were detected. This suggests that individual responses varied greatly, representing a range of experiences and opinions, even while the mean values offer an insightful overall picture.

There is a statistically significant positive relationship between EF and intrinsic motivation (small effect); the association between EF and extrinsic motivation was negative (−0.063), but this result is not statistically significant. EF further showed a statistically significant positive relationship with deep learning (medium effect) and negative correlations approaching a large effect with both amotivation and surface learning.

The most robust positive correlations are observed between amotivation and surface learning (0.782, $p = 0.00$) and between deep learning and intrinsic motivation (0.602, $p = 0.001$) These associations suggest that students who are more intrinsically motivated are significantly more likely to use deep learning strategies while those who are amotivated are more inclined to use surface learning strategies.

Results furthermore revealed a statistically significant positive relationship between extrinsic and intrinsic motivation showing a large effect (0.502, $p = 0.00$). While both motivation types are evidently influential when it comes to learning, it is also interesting to note that while both intrinsic and extrinsic motivation are positively associated with both deep- and surface learning strategies, intrinsic motivation is more strongly correlated with deep learning while extrinsic motivation is more strongly correlated with surface learning. Finally, there is a statistically significant positive relationship between deep and surface learning showing a small effect. As expected, the relationship between amotivation and intrinsic motivation was not significant.

10.2 Testing the structural model

The measurement model served as the basis for testing the structural model. The results revealed an acceptable fit of the data ($\chi^2 = 2033.541^*$, $df = 1056$, $p = 0.000$, CFI = 0.91, TLI = 0.91, RMSEA = 0.03, SRMR = 0.05).

EF reflected a negative association with surface learning in the structural model, but the path coefficient of EF (-0.06) is not statistically significant ($p > 0.05$). Therefore, [H1b](#) is accepted.

Amotivation (coefficient = 0.733) has the strongest and most significant positive ($p < 0.001$) effect on surface learning. This finding implies that those who are more amotivated are more likely to employ surface learning techniques. In addition, extrinsic motivation also has a significant positive effect (0.2 , $p = 0.00$) on surface learning, resulting in extrinsic motivation to encourage one to engage in surface learning. [H2b](#) and [c](#) is confirmed. Although the direction of the relationship between intrinsic motivation and surface learning was negative, the result was not statistically significant (-0.043 , $p > 0.05$). [H2a](#) is not accepted. These findings suggest that individuals with higher levels of intrinsic motivation will be less likely to employ surface learning motives and strategies.

Three factors, namely, EF, extrinsic- and intrinsic motivation, are statistically significant predictors of deep learning strategies. Intrinsic motivation shows the strongest effect (coefficient = 0.468 , $p = 0.00$) followed by EF (0.298 , $p = 0.00$) with the second largest effect. Extrinsic motivation also played a role, but this effect was rather small (0.194 , $p = 0.00$). The fourth factor, amotivation, played no role in deep learning ($p > 0.05$). These findings suggest that increases in EF as well as two types of motivation (intrinsic and extrinsic) can be beneficial to support a deep learning approach. [H1a](#) and [H3a](#) and [b](#) is accepted; [H3c](#) cannot be accepted.

11. Discussion

The current study advances our knowledge of the connections between teacher students' academic motivation, EF and deep and surface learning approaches. The aim was to investigate how these aspects associate with students' EF skills of DL students in HE within the South African setting. The results offer important insights into how cognition and motivation simultaneously impact learning processes in a DL environment.

In this study, EFA and CFA confirmed that only four out of the proposed five-factors of the ESQ-R subscales were reliably measured. The factors include planning, organisation, emotional regulation and behavioural regulation. Due to cross-loading, the three items measuring time could not be reproduced as a separate sub-component of EF and was therefore excluded from the analysis. This finding contrasts with the initial development of the ESQ-R scale by [Strait et al. \(2020\)](#), which proposed time as a separate sub-dimension. However, the exclusion of the time factor in the current study corroborates with a recent Mexican study conducted with students from 12 universities, which developed and validated a self-report EF scale suitable for HE students ([Zamora-Lugo et al., 2025](#)). Their study analysis revealed that the time dimension could also not be measured separately but instead formed part of a larger latent variable and was therefore integrated with the planning dimension ([Zamora-Lugo et al., 2025](#)). The close association between time management and planning is also in line with research by [Knouse, Feldman and Blevins \(2014\)](#).

Additionally, in the current research, the sample was drawn from a non-Western cultural context. The participants represented a range of rural, semi-urban and urban settings across South Africa, which may have influenced the findings. As highlighted by [Dörrenbächer-Ulrich et al. \(2024\)](#) and [Ramos-Galarza et al. \(2023\)](#), it is possible that time is experienced and perceived differently across cultures and contexts. This validates the idea that EFs are rooted in culture and that societal norms regarding time and accountability influence students' perspectives of time ([Zamora-Lugo et al., 2025](#)). The findings indicate that further research is required to better understand the time variable within the SA HE context.

In relation to the hypotheses presented, the findings offered supportive empirical proof. The findings confirmed that EF had a statistically significant positive effect on deep learning ([H1a](#)). This implies that students who possess greater EF abilities like WM, CF and IC are better equipped to adopt a deeper approach to learning. This finding provides further support

for previous research suggesting that goal-directed behaviour and cognitive control may promote meaningful interaction with the subject matter (Pinochet-Quiroz *et al.*, 2022). This is also consistent with research that associates EF with self-directed learning serving as the foundation for academic success (Dörrenbächer-Ulrich *et al.*, 2024; Harel-Gadassi, 2022).

In contrast, a negative association between EF and surface learning was detected; however, the directional effect (H1b) of EF was not statistically significant. The negative correlational result suggests that EFs may inhibit inappropriate learning strategies and promote more self-regulated and focused learning. Broadly speaking, this result resonates with research by La Lopa and Hollich (2014), which claimed that higher level of EF is likely to a decrease dependence on surface learning techniques, which are usually linked to rote memorisation and low cognitive effort. In addition, students not remembering information over time results from lecturers and students failing to consider the rigorous capacity limits of WM, which leads to a dependence on rote memorisation and simple surface learning techniques (La Lopa & Hollich, 2014). Therefore, one can note that higher levels of EFs equip students with the skills to organise, transform and integrate knowledge instead of merely storing it.

The correlational relation result furthermore corroborates with the results of a study which concludes that students who apply deep learning techniques exhibit greater knowledge of difficult topics, while those who use surface learning techniques lack analytical abilities and only depend on memorising the content (Paleenud *et al.*, 2024). It should however be kept in mind that although the structural model result also indicated a negative association between EF and surface learning, the directional effect was not statistically significant and should therefore be further examined in future studies.

The second main hypothesis examined how different types of motivation affected surface learning strategies. Both extrinsic and amotivation showed statistically significant positive influences on surface learning, which is consistent with Hypotheses 2b and 2c. When students are extrinsically motivated, they are more likely to rely on surface learning. This finding recalls on research conducted by (Biggs, 1991) emphasising that extrinsic motivation and surface learning are directly related to each other. According to an existing study, it is possible that surface learning can be a result of factors such as anxiety, low task interest and extrinsic motivation (Biggs & Tang, 2007). In addition, students may not have the socioeconomic motivation necessary to participate in deep learning, especially in rural communities that lack academic expectations. This could lead to reduced motivation and a greater tendency towards surface techniques (Fu & Liu, 2024a, b).

Moreover, in this study, the largest predictor of surface learning is amotivation, suggesting that students who feel unmotivated or believe that learning tasks are not worthwhile are more likely to use surface learning methods. This finding corroborates with existing studies which suggest that the degree to which students may choose low-effort learning techniques may be due to discouragement, an absence of value, or doubt about their competence and a fear of failure, and these indicators of amotivation may inevitably result in surface – rather than deep learning (Biggs & Tang, 2007; De La Fuente *et al.*, 2020; Hulreski, Syatriana, & Ardiana, 2020). Furthermore, literature notes a crucial connection between amotivation and surface learning with the topic of self-regulation. With a lack of self-regulation, students will adopt a surface approach to learning since they find it difficult to control their learning (De La Fuente *et al.*, 2020).

As anticipated in Hypothesis 2a, intrinsic motivation had a negative impact on surface learning; however, this effect was not statistically significant. The lack of statistical significance demonstrates that intrinsic motivation alone may not consistently prevent surface learning behaviours. Subsequently, Hypothesis 2a was not accepted. This result emphasises how complex motivation is as it comprises multiple interrelated components like values, beliefs, views, opinions and behaviour amongst others (Abdolrezapour *et al.*, 2023).

According to findings of the third main hypothesis, deep learning would benefit from intrinsic and extrinsic motivation, but amotivation would have the opposite effect. H3 emphasises the significant role of motivation in enhancing deep learning, which is mostly aligned with the

findings of this study. One of the strongest effects found in the study was the strong and statistically significant positive relationship between intrinsic motivation and deep learning (H3a). When students are driven by curiosity and personal meaning, they are more likely to invest in cognitive effort necessary for understanding concepts and critical thinking, resulting in deep learning. This result is in line with previous research by [Pinochet-Quiroz et al. \(2022\)](#) which showed that DL inherently requires higher levels of self-regulation and autonomous functioning.

Additionally, there was a statistically significant, but weaker, positive effect of extrinsic motivation on deep learning (H3b). Together, the findings of H3a and b are in line with the SDT framework which considers extrinsic and intrinsic motivation as two aspects on a continuum of self-regulation, rather than as two independent categories ([Gareau, Gaudreau, & Boileau, 2019](#); [Ryan & Deci, 2017](#)). According to [Harel-Gadassi \(2022\)](#), extrinsic factors, such as rewards, may be the initial stimulus to perform a certain activity but as learning advances, the extrinsic factors can increasingly be internalised and converted into intrinsic motivation. Moving along this continuum may lead students to become increasingly autonomously motivated to participate in learning tasks for their own intrinsic fulfilment and worth, which is ultimately linked to better academic results, increased well-being and lower levels of stress.

While the study hypothesised that amotivation would have a negative effect on deep learning, this relation was not supported, indicating no significant effect (H3c). Consequently, amotivated students will likely adopt surface learning strategies, while intrinsically motivated students are inclined to engage in deep learning techniques. Prior research relates amotivation with deep learning, mainly because it keeps students from developing the self-control and cognitive skills required for meaningful learning ([Berestova et al., 2022](#)). The result of the current study does not support this finding.

The findings imply that an improvement in EF, as well as intrinsic- and extrinsic motivation may benefit students and encourage them to adopt a deep learning approach. Collectively, these results highlight the intricate interplay between cognitive and motivational processes in influencing students' learning approaches. Although EF constitutes the cognitive underpinnings for deep learning, motivation, especially intrinsic motivation and some forms of extrinsic motivation are substantial factors influencing how well these cognitive abilities are used in students' learning. This result corroborates with previous research which found that intrinsic and identified extrinsic motivation relate to deep learning, whereas external regulation and amotivation are associated with surface learning ([De La Fuente et al., 2020](#)). In conclusion, the findings confirmed the hypothesis that intrinsic and extrinsic motivation, as well as EF, have a statistically significant positive effect on deep learning, and no noticeable correlations exist between EF and surface learning and EF and amotivation.

12. Practical implications and recommendations

The results of this study have many significant implications for research, methodology and teaching in distance HE. Early identification and support could be beneficial for both students and the institution ([Harel-Gadassi, 2022](#); [Trolan & Jach, 2020](#)) in achieving academic success. It is therefore recommended for institutions to implement online learning environments that offer strong support for strengthening EF skills and cultivating more autonomous learning strategies. It is essential to identify students with lower EFs when admitting them to the institution, especially first-year students. This is crucial since these students are at high risk of failure in the self-regulated DL environment ([Harel-Gadassi, 2022](#)). After identification, adequate guidance should be provided, which involves teaching them certain skills and enhancing their feelings of intrinsic motivation and self-confidence ([Harel-Gadassi, 2022](#)). In addition, continuing evaluation of students' self-report EF progress longitudinally may offer vital insight to institutions which can be used to support students at risk continuously.

Furthermore, effective student support involves various cognitive and meta-cognitive strategies to enhance EF and self-regulated learning. Activities comprising problem-based

learning (PBL), in which students are expected to solve real-world problems and apply it, is an effective way to build twenty-first century skills and enhance students' understanding of a particular concept (Biggs & Tang, 2007; Martinez, 2022). Clear study guidelines, reasonable goal setting, regular formative evaluation and concrete resources such as diagrams, concept maps and digital instruction during problem-solving (Ertmer, Schlosser, Clase, & Adedokun, 2014) are all effective ways to enhance autonomy in DL (De La Fuente *et al.*, 2020). It is crucial to equip students with the cognitive tools such as creating questions while studying, summarising information using visual aids and actively engaging with the material to help them recall difficult content (Corcoran and O'Flaherty, 2017).

In this advanced digital world, the provision of innovative technological tools could ensure structure and within the DL context. Mobile AI chatbots act as a supportive digital assistant that enhance students' EFs: CF, WM, problem-solving skills, metacognitive skills, planning, creativity and self-regulation by providing timely feedback in a supportive and organised environment (Dias, Avila, da Costa, Cardoso, & Fonseca, 2022; Pergantis *et al.*, 2025; Zhang, 2025). Moreover, implementing e-portfolios might guide students to engage in continuous self-monitoring and critical reflection on their learning and development (Reimers, 2021). According to Aderibigbe (2021), Community of Practice (COP) groups and processes can be established to regulate and motivate students to participate in planned and organised online discussions. This method enables lecturers to supervise and direct conversations, identify learning gaps and provide students with focused support. Mentoring students in this way may improve their academic self-efficacy, address EF impairments and increase self-confidence. Hence, having access to a high-quality LMS that allows students to connect with peers and lecturers, increases motivation (Ferrer *et al.*, 2022). Implementing the latter will ensure that institutions focus on the process of learning, rather than the product, resulting in enhanced academic motivation.

It is recommended that institutions implement an integrated learning and teaching strategy that increases both intrinsic and extrinsic motivation while also enhancing students' EFs. Although intrinsic motivation is the primary aim, using both intrinsic and extrinsic rewards could be useful to encourage unmotivated students (Hidi & Harackiewicz, 2000). When intrinsic motivation is low, lecturers can use properly designed extrinsic incentives together with meaningful tasks to encourage greater interest (Hidi & Harackiewicz, 2000). Additional studies should explore the long-term effects of focused interventions that incorporate motivation and EF training on students' learning strategies. Increased understanding of the causal relationships between EF, motivation, deep learning and academic achievement may be possible through longitudinal and experimental research in various contexts. Additionally, employing qualitative research to collect detailed insights from students' perspectives could produce insightful data.

In the South African DL environment, where students study without face-to-face contact, strong EF skills seem crucial for managing learning independently and applying knowledge rather than engaging in rote learning. Since many students enter HE with diverse educational backgrounds and little exposure to self-directed learning, this study raises the possibility that DL may unknowingly increase existing gaps between students with higher and lower EF skills (Dörrenbächer-Ulrich *et al.*, 2024; Harel-Gadassi, 2022). Expectedly, DL increases HE access but also places pressure on students' EFs and motivation. Hence, without lecturer and institutional support, it risks study dropout among students with lower EFs or higher motivation (De La Fuente *et al.*, 2020). In summary, in the South African HE context, DL should involve quality EF and motivation support for students, focused support systems and curricula must be implemented, and finally it is essential to encourage deep learning across support, assessment and learning programs.

This study's findings could assist HE institutions to create interventions and develop frameworks that support cognitive and motivational aspects of learning. The findings can be used as the foundation for initiatives intended for short courses on EF enhancement, self-regulated learning (e.g. planning, goal setting) and motivation-intensive training to encourage

students to become self-sufficient, confident, autonomous and competent in their learning. By applying these strategies in practice, HEI may guarantee that DL is inclusive and successful for students who face cognitive and motivational difficulties, as well as for students with strong self-regulation abilities.

13. Limitations

The limitations of this research is acknowledged. Initially, participating students in the study was predominantly female (96.2%), restricting the findings applicable to varying gender populations. Therefore, the findings should not be generalised to other undergraduate teacher–student groups in South Africa. Similarly, no separate analysis pertaining to factors like age, gender and culture was performed; therefore, more research is recommended. Future studies should aim to incorporate equitable gender balanced samples from several HE institutions to increase cultural significance.

Another limitation pertains to the use of self-report questionnaires to collect data, which may have resulted in inaccurate results in some instances, even after every effort was made to minimise response bias. It's possible that inflated responses resulted from students' differing perceptions of the constructs. Nonetheless, as self-report instruments continue to be the most successful way to evaluate students' views, thoughts and experiences, applying them was inevitable. It is suggested that future studies include mixed-methods research designs, integrating qualitative strategies to allow for a more in-depth understanding of students' reflections and perspectives on EF, motivation and learning.

It is vital to note that data were collected before the extensive incorporation of generative AI tools. Therefore, the current study did not account for the potential impact of AI-supported methods of learning on student participation, motivation and learning approaches. Future studies should specifically look at how deep- and surface learning processes in digital learning settings might be affected by AI-driven assistance.

Employing a cross-sectional study methodology, which precludes measuring factors that change with time, is the third limitation. As a result, the relationships between the different factors were interpreted and not verified. To evaluate long-term outcomes and the relationships between EF, deep and surface learning and various forms of motivation: intrinsic, extrinsic and amotivation, longitudinal studies are therefore recommended for further research. Considering the study's cross-sectional design, these relationships can only be conclusively demonstrated through recurring research.

14. Conclusion

This study explored the associations between EF, academic motivation and learning approaches among student teachers in a DL setting. Recognising the relationship between EF, a deep learning approach and academic motivation are essential to helping students succeed in a demanding context like HE. The findings reveal that EF and intrinsic motivation are significantly linked to deep learning, while amotivation mainly predicts surface learning approaches. This study contributes to current theoretical perspectives claiming that motivational quality and cognitive control play a significant role in how students deal with learning in HE. The results offer empirical data regarding the function of EF and motivation in students' learning approaches within a digitally facilitated learning context. Subsequent studies can expand on such results by employing longitudinal or mixed-methods methodologies to further investigate how these associations evolve over time and in various learning environments.

Author contributions

The study was conceptualised, reviewed and amended with input from LP and MH. MH carried out the statistical analysis, and both authors accepted the submitted version of the article and contributed to it.

Ethics statement

Ethical clearance was obtained from the Basic and Social Sciences Research Committee (BaSSREC) of the Northwest University in Potchefstroom, South Africa (number: NWU-01046–23-A7).

Data availability statement

Without hesitation, the authors will make the raw data corroborating with the results of this research available.

Publisher's note

This manuscript's expressions are entirely the authors' own and do not necessarily reflect those of the publisher, editors, reviewers or related institutions.

References

- Abdolrezapour, P., Jahanbakhsh Ganjeh, S., & Ghanbari, N. (2023). Self-efficacy and resilience as predictors of students' academic motivation in online education. *PLoS One*, 18(5), e0285984. doi: [10.1371/journal.pone.0285984](https://doi.org/10.1371/journal.pone.0285984).
- Acosta-Gonzaga, E., & Ramirez-Arellano, A. (2021). The influence of motivation, emotions, cognition, and metacognition on students' learning performance: A comparative study in higher education in blended and traditional contexts. *Sage Open*, 11(2). doi: [10.1177/21582440211027561](https://doi.org/10.1177/21582440211027561).
- Aderibigbe, S. A. (2021). Can online discussions facilitate deep learning for students in General Education?. *Heliyon*, 7(3), e06414. doi: [10.1016/j.heliyon.2021.e06414](https://doi.org/10.1016/j.heliyon.2021.e06414).
- Algharaibeh, S. A. S. (2020). Cognitive flexibility as a predictor of subjective vitality among university students. *Cypriot Journal of Educational Sciences*, 15(5), 923–936. doi: [10.18844/CJES.V15I5.5122](https://doi.org/10.18844/CJES.V15I5.5122).
- Amzil, A. (2022). Working memory capacity, cognitive regulation, and their relationship to academic achievement in university students. *Journal of Education and Learning*, 11(6), 133–139. doi: [10.5539/jel.v11n6p133](https://doi.org/10.5539/jel.v11n6p133).
- Bai, L., Liu, X., & Su, J. (2023). ChatGPT: The cognitive effects on learning and memory. *Brain-X*, 1(3), e30. doi: [10.1002/brx2.30](https://doi.org/10.1002/brx2.30).
- Berestova, A., Kolosov, S., Tsvetkova, M., & Grib, E. (2022). Academic motivation as a predictor of the development of critical thinking in students. *Journal of Applied Research in Higher Education*, 14(3), 1041–1054. doi: [10.1108/JARHE-02-2021-0081](https://doi.org/10.1108/JARHE-02-2021-0081).
- Biggs, J. B. (1991). Approaches to learning in secondary and tertiary students in Hong Kong: Some comparative studies.
- Biggs, J. B., & Tang, C. S. (2007). *Teaching for quality learning at university: What the student does*. reprinted (3.). McGraw-Hill. [u.a.].
- Biggs, J., Kember, D., & Leung, D. Y. P. (2001). The revised two-factor study process questionnaire: R-SPQ-2F. *British Journal of Educational Psychology*, 71(1), 133–149. doi: [10.1348/000709901158433](https://doi.org/10.1348/000709901158433).
- Bunge, S. A. (2024). How should we slice up the executive function pie? Striving toward an ontology of cognitive control processes. *Mind, Brain, and Education*, 18(1), 17–27. doi: [10.1111/mbe.12403](https://doi.org/10.1111/mbe.12403).
- Bureau, J. S., Howard, J. L., Chong, J. X. Y., & Guay, F. (2022). Pathways to student motivation: A meta-analysis of antecedents of autonomous and controlled motivations. *Review of Educational Research*, 92(1), 46–72. doi: [10.3102/00346543211042426](https://doi.org/10.3102/00346543211042426).
- Byrne, B. M. (2010). *Structural equation modeling with AMOS: Basic concepts, applications, and programming (multivariate applications series)*. New York: Taylor & Francis Group, 396 (1), 7384.
- Can, G. (2015). Turkish version of the academic motivation scale. *Psychological Reports*, 116(2), 388–408. doi: [10.2466/14.08.PR0.116k24w5](https://doi.org/10.2466/14.08.PR0.116k24w5).

- Cayubit, R. F. O. (2022). Why learning environment matters? An analysis on how the learning environment influences the academic motivation, learning strategies and engagement of college students. *Learning Environments Research*, 25(2), 581–599. doi: [10.1007/s10984-021-09382-x](https://doi.org/10.1007/s10984-021-09382-x).
- Correia, R., & Navarrete, G. (2017). Social cognition and executive functions as key factors for effective pedagogy in higher education. *Frontiers in Psychology*, 8, November. doi: [10.3389/fpsyg.2017.02016](https://doi.org/10.3389/fpsyg.2017.02016).
- Corcoran, R., & O’Flaherty, J. (2017). Executive function during teacher preparation. *Teaching and Teacher Education*, 63, 168–175, (WOS:000397364900016). doi: [10.1016/j.tate.2016.12.023](https://doi.org/10.1016/j.tate.2016.12.023).
- Council on Higher Education (2025). Annual performance and financial report 2024/25. Available from: <https://www.che.ac.za/publications/reports/ches-annual-report-202425>
- De La Fuente, J., Sander, P., Kauffman, D. F., & Yilmaz Soylu, M. (2020). Differential effects of self- vs. External-regulation on learning approaches, academic achievement, and satisfaction in undergraduate students. *Frontiers in Psychology*, 11, 543884. doi: [10.3389/fpsyg.2020.543884](https://doi.org/10.3389/fpsyg.2020.543884).
- Deci, E. L. (1992). The relation of interest to the motivation of behavior: A selfdetermination of theory perspective. In K. A. Renninger, & K. Hidi, S. A. (Eds), *The Role of Interest in Learning and Development* (pp. 43–70).
- Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64(1), 135–168. doi: [10.1146/annurev-psych-113011-143750](https://doi.org/10.1146/annurev-psych-113011-143750).
- Diamond, A., & Ling, D. S. (2016). Conclusions about interventions, programs, and approaches for improving executive functions that appear justified and those that, despite much hype, do not. *Developmental Cognitive Neuroscience*, 18, 34–48. doi: [10.1016/j.dcn.2015.11.005](https://doi.org/10.1016/j.dcn.2015.11.005).
- Dias, N., Avila, B., da Costa, D., Cardoso, C., & Fonseca, R. (2022). Is it possible to promote executive functions in university students? Evidence of effectiveness of the π FEx-academics. *Applied Neuropsychology-Adult*, 31(6), 1116–1124, (WOS:000840381700001) doi: [10.1080/23279095.2022.2109971](https://doi.org/10.1080/23279095.2022.2109971).
- Dolmans, D. H. J. M., Loyens, S. M. M., Marcq, H., & Gijbels, D. (2016). Deep and surface learning in problem-based learning: A review of the literature. *Advances in Health Sciences Education*, 21 (5), 1087–1112. doi: [10.1007/s10459-015-9645-6](https://doi.org/10.1007/s10459-015-9645-6).
- Dörrenbächer-Ulrich, L., Dilhuit, S., & Perels, F. (2024). Investigating the relationship between self-regulated learning, metacognition, and executive functions by focusing on academic transition phases: A systematic review. *Current Psychology*, 43(18), 16045–16072. doi: [10.1007/s12144-023-05551-8](https://doi.org/10.1007/s12144-023-05551-8).
- Entwistle, N., McCune, V., & Scheja, M. (2006). Student learning in context: Understanding the phenomenon and the person.
- Ertmer, P. A., Schlosser, S., Clase, K., & Adedokun, O. (2014). The grand challenge: Helping teachers learn/teach cutting-edge science via a PBL approach. *Interdisciplinary Journal of Problem-Based Learning*, 8(1). doi: [10.7771/1541-5015.1407](https://doi.org/10.7771/1541-5015.1407).
- Fairchild, A. J., Horst, S. J., Finney, S. J., & Barron, K. E. (2005). Evaluating existing and new validity evidence for the Academic Motivation Scale. *Contemporary Educational Psychology*, 30(3), 331–358. doi: [10.1016/j.cedpsych.2004.11.001](https://doi.org/10.1016/j.cedpsych.2004.11.001).
- Fajardo-Ramos, D. C., Chiappe, A., & Mella-Norambuena, J. (2025). Human-in-the-loop assessment with AI: Implications for teacher education in Ibero-American universities. *Frontiers in Education*, 10, 1710992. doi: [10.3389/feduc.2025.1710992](https://doi.org/10.3389/feduc.2025.1710992).
- Ferrer, J., Ringer, A., Saville, K., A Parris, M., & Kashi, K. (2022). Students’ motivation and engagement in higher education: The importance of attitude to online learning. *Higher Education*, 83(2), 317–338. doi: [10.1007/s10734-020-00657-5](https://doi.org/10.1007/s10734-020-00657-5).
- Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th., repr.). Sage.
- Fu, H., & Liu, H. (2024a). A comparative study of learners’ conceptions of and approaches to learning English between high school students in urban and rural areas of China. *Frontiers in Psychology*, 15, 1324366. doi: [10.3389/fpsyg.2024.1324366](https://doi.org/10.3389/fpsyg.2024.1324366).

- Fu, H., & Liu, H. (2024b). A comparative study of learners' conceptions of and approaches to learning English between high school students in urban and rural areas of China. *Frontiers in Psychology*, 15, 1324366. doi: [10.3389/fpsyg.2024.1324366](https://doi.org/10.3389/fpsyg.2024.1324366).
- Gareau, A., Gaudreau, P., & Boileau, L. (2019). Past academic achievement contributes to university students' autonomous motivation (AM) which is later moderated by implicit motivation and working memory: A Bayesian replication of the explicit-implicit model of AM. *Learning and Individual Differences*, 73, 30–41. doi: [10.1016/j.lindif.2019.05.004](https://doi.org/10.1016/j.lindif.2019.05.004).
- Gozalo, M., León-del-Barco, B., & Mendo-Lázaro, S. (2020). Good practices and learning strategies of undergraduate university students. *International Journal of Environmental Research and Public Health*, 17(6), 1849. doi: [10.3390/ijerph17061849](https://doi.org/10.3390/ijerph17061849).
- Harel-Gadassi, A. (2022). For whom is distance learning suitable? The relationship between distance learning, executive functions, and academic achievements. *Universal Journal of Educational Research*, 10(2), 129–136. doi: [10.13189/ujer.2022.100202](https://doi.org/10.13189/ujer.2022.100202).
- Häsä, J., Rämö, J., & Yan, Z. (2024). Examining the reciprocal influence between undergraduate students' self-regulation and approaches to learning. *Scandinavian Journal of Educational Research*, 69(6), 1–15. doi: [10.1080/00313831.2024.2394404](https://doi.org/10.1080/00313831.2024.2394404).
- Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for the 21st century. *Review of Educational Research*, 70(2), 151–179. doi: [10.3102/00346543070002151](https://doi.org/10.3102/00346543070002151).
- Hulreski, M., Syatriana, E., & Ardiana, A. (2020). An investigation of deep and surface learning approach towards English vocabulary acquisition of EFL students. *Middle Eastern Journal of Research in Education and Social Sciences*, 1(1), 15–26. doi: [10.47631/mejress.v1i1.5](https://doi.org/10.47631/mejress.v1i1.5).
- Kirkpatrick, R., Kirkpatrick, J., & Derakhshan, A. (2024). An investigation into the motivation and attitudes of Japanese students toward learning English: A case of elementary and junior high school students. *Asian-Pacific Journal of Second and Foreign Language Education*, 9(1), 23. doi: [10.1186/s40862-023-00243-z](https://doi.org/10.1186/s40862-023-00243-z).
- Knouse, L. E., Feldman, G., & Blevins, E. J. (2014). Executive functioning difficulties as predictors of academic performance: Examining the role of grade goals. *Learning and Individual Differences*, 36, 19–26. doi: [10.1016/j.lindif.2014.07.001](https://doi.org/10.1016/j.lindif.2014.07.001).
- La Lopa, J. M., & Hollich, G. (2014). The critical role of working memory in academic achievement. *Journal of Culinary Science & Technology*, 12(3), 258–278, doi: [10.1080/15428052.2014.913952](https://doi.org/10.1080/15428052.2014.913952).
- Liu, C., Shi, Y., & Wang, Y. (2022). Self-Determination Theory in education: The Relationship between Motivation and academic Performance of primary school, high school, and college students. In *2022 3rd International Conference on Mental Health, Education and Human Development (MHEHD 2022)* (Vol. 670). doi: [10.2991/assehr.k.220704.167](https://doi.org/10.2991/assehr.k.220704.167).
- Manuhuwa, D. M., Snel-de-Boer, M., de-Graaf, J. W., & Fleer, J. (2024). Combining performance-based and self-reported measures of executive functions: Are both meaningful in predicting study success in higher education students?. *European Journal of Educational Research*, 13, October, 1647–1663. doi: [10.12973/eu-jer.13.4.1647](https://doi.org/10.12973/eu-jer.13.4.1647).
- Martinez, C. (2022). Developing 21st century teaching skills: A case study of teaching and learning through project-based curriculum. *Cogent Education*, 9(1), 2024936. doi: [10.1080/2331186X.2021.2024936](https://doi.org/10.1080/2331186X.2021.2024936).
- Masuku, M. M., Jili, N. N., & Sabela, P. T. (2020). Assessment as A Pedagogy and measuring tool in promoting deep learning in institutions of higher learning. *International Journal of Higher Education*, 10(2), 274. doi: [10.5430/ijhe.v10n2p274](https://doi.org/10.5430/ijhe.v10n2p274).
- Meijs, C., Gijsselaers, H. J. M., Xu, K. M., Kirschner, P. A., & De Groot, R. H. M. (2021). The relation between cognitively measured executive functions and reported self-regulated learning strategy use in adult online distance education. *Frontiers in Psychology*, 12, 641972. doi: [10.3389/fpsyg.2021.641972](https://doi.org/10.3389/fpsyg.2021.641972).
- Mthethwa-Kunene, K., Rugube, T., & Maphosa, C. (2021). Rethinking pedagogy: Interrogating ways of promoting deeper learning in higher education. *European Journal of Interactive Multimedia and Education*, 3(1), e02204. doi: [10.30935/ejimed/11439](https://doi.org/10.30935/ejimed/11439).

- Muthén, L. K., & Muthén, B. O. (2025). Mplus user's guide. (Version 8) [Computer software].
- Paleenud, I., Tanprasert, K., & Waleeittipat, S. (2024). Lecture-based and project-based approaches to instruction, classroom learning environment, and deep learning. *European Journal of Educational Research*, 13, April, 531–539. doi: [10.12973/eu-jer.13.2.531](https://doi.org/10.12973/eu-jer.13.2.531).
- Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS*. London: Routledge.
- Pergantis, P., Bamicha, V., Skianis, C., & Drigas, A. (2025). AI chatbots and cognitive control: Enhancing executive functions through chatbot interactions: A systematic review. *Brain Sciences*, 15(1), 47. doi: [10.3390/brainsci15010047](https://doi.org/10.3390/brainsci15010047).
- Pinochet-Quiroz, P., Lepe-Martínez, N., Gálvez-Gamboa, F., Ramos-Galarza, C., Del-Valle-Tapia, M., & Acosta-Rodas, P. (2022). Relationship between cold executive functions and self-regulated learning management in college students. *Estudios Sobre Educacion*, 43, 93–113, (WOS: 000825169200001). doi: [10.15581/004.43.005](https://doi.org/10.15581/004.43.005).
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5), 879–903. doi: [10.1037/0021-9010.88.5.879](https://doi.org/10.1037/0021-9010.88.5.879).
- Ramos-Galarza, C., Acosta-Rodas, P., Bolaños-Pasquel, M., & Lepe-Martínez, N. (2019). The role of executive functions in academic performance and behaviour of university students. *Journal of Applied Research in Higher Education*, 12(3), 444–455. doi: [10.1108/JARHE-10-2018-0221](https://doi.org/10.1108/JARHE-10-2018-0221).
- Ramos-Galarza, C., Ramos, V., Del Valle, M., Lepe-Martínez, N., Cruz-Cárdenas, J., Acosta-Rodas, P., & Bolaños-Pasquel, M. (2023). Executive functions scale for university students: UEF-1. *Frontiers in Psychology*, 14, 1192555, (WOS:001033845600001). doi: [10.3389/fpsyg.2023.1192555](https://doi.org/10.3389/fpsyg.2023.1192555).
- Reimers, F. M. (2021). *Implementing deeper learning and 21st education reforms: Building an education renaissance after a global pandemic*. Springer International Publishing. doi: [10.1007/978-3-030-57039-2](https://doi.org/10.1007/978-3-030-57039-2).
- Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press. doi: [10.1521/978.14625/28806](https://doi.org/10.1521/978.14625/28806).
- Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology*, 61, 101860. doi: [10.1016/j.cedpsych.2020.101860](https://doi.org/10.1016/j.cedpsych.2020.101860).
- Shen, D., Cho, M.-H., Tsai, C.-L., & Marra, R. (2013). Unpacking online learning experiences: Online learning self-efficacy and learning satisfaction. *The Internet and Higher Education*, 19, 10–17. doi: [10.1016/j.iheduc.2013.04.001](https://doi.org/10.1016/j.iheduc.2013.04.001).
- Sølvik, R. M., & Glenna, A. E. H. (2022). Teachers' potential to promote students' deeper learning in whole-class teaching: An observation study in Norwegian classrooms. *Journal of Educational Change*, 23(3), 343–369. doi: [10.1007/s10833-021-09420-8](https://doi.org/10.1007/s10833-021-09420-8).
- Spector, P. E. (2019). Do not cross me: Optimizing the use of cross-sectional designs. *Journal of Business and Psychology*, 34(2), 125–137. doi: [10.1007/s10869-018-09613-8](https://doi.org/10.1007/s10869-018-09613-8).
- Spreij, L. C., Van Tuijl, C., & Leseman, P. P. M. (2023). Validating rating scales for executive functioning across education levels and informants. *Contemporary School Psychology*, 28(3), 296–315. doi: [10.1007/s40688-023-00462-8](https://doi.org/10.1007/s40688-023-00462-8).
- Stasolla, F., Zullo, A., Maniglio, R., Passaro, A., Di Gioia, M., Curcio, E., & Martini, E. (2025). Deep learning and reinforcement learning for assessing and enhancing academic performance in university students: A scoping review. *AI*, 6(2), 40. doi: [10.3390/ai6020040](https://doi.org/10.3390/ai6020040).
- Strait, J. E., Dawson, P., Walther, C. A. P., Strait, G. G., Barton, A. K., & Brunson McClain, M. (2020). Refinement and psychometric evaluation of the executive skills questionnaire-revised. *Contemporary School Psychology*, 24(4), 378–388. doi: [10.1007/s40688-018-00224-x](https://doi.org/10.1007/s40688-018-00224-x).
- Trolan, T. L., & Jach, E. A. (2020). Engagement in college and university applied learning experiences and students' academic motivation. *Journal of Experiential Education*, 43(3), 317–335. doi: [10.1177/1053825920925100](https://doi.org/10.1177/1053825920925100).

- Utvær, B. K. S., & Haugan, G. (2016). The academic motivation scale: Dimensionality, reliability, and construct validity among vocational students. *Nordic Journal of Vocational Education and Training*, 6(2), 17–45. doi:[10.3384/njvet.2242-458X.166217](https://doi.org/10.3384/njvet.2242-458X.166217).
- Vallerand, R. J., Pelletier, L. G., Blais, M. R., Brière, N. M., Senécal, C., & Vallières, É. F. (1992). The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement*, 52(4), 1003–1017. doi: [10.1177/0013164492052004025](https://doi.org/10.1177/0013164492052004025).
- Vance, A., Pendergast, D., & Garvis, S. (2015). Teaching resilience: A narrative inquiry into the importance of teacher resilience. *Pastoral Care in Education*, 33(4), 195–204. doi: [10.1080/02643944.2015.1074265](https://doi.org/10.1080/02643944.2015.1074265).
- Vansteenkiste, M., Ryan, R. M., & Soenens, B. (2020). Basic psychological need theory: Advancements, critical themes, and future directions. *Motivation and Emotion*, 44(1), 1–31. doi: [10.1007/s11031-019-09818-1](https://doi.org/10.1007/s11031-019-09818-1).
- Wang, X., & Cheng, Z. (2020). Cross-sectional studies. *Chest*, 158(1), S65–S71. doi: [10.1016/j.chest.2020.03.012](https://doi.org/10.1016/j.chest.2020.03.012).
- Wang, J., & Wang, X. (2020). *Structural equation modeling: Applications using Mplus*. John Wiley & Sons.
- Wang, X., Sun, F., Wang, Q., & Li, X. (2022). Motivation and affordance: A study of graduate students majoring in translation in China. *Frontiers in Education*, 7, 1010889. doi: [10.3389/feduc.2022.1010889](https://doi.org/10.3389/feduc.2022.1010889).
- Zamora-Lugo, S., Reynoso-Alcántara, V., Sanchez-Lopez, J., Vergara-Lope, S., Ocampo-Gómez, E., García-Gomar, M. L., . . . Cuevas-Ferrera, R. D. F. (2025). Assessing executive functioning in higher education: Development and structural validation of a new self-report scale. *Frontiers in Psychology*, 16, 1613290. doi: [10.3389/fpsyg.2025.1613290](https://doi.org/10.3389/fpsyg.2025.1613290).
- Zhang, Z. (2025). The role of robot-assisted learning in fostering learners’ motivation, self-efficacy, and autonomy: Self-determination theory framework. *Learning and Motivation*, 92, 102184. doi: [10.1016/j.lmot.2025.102184](https://doi.org/10.1016/j.lmot.2025.102184).
- Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice*, 41 (2), 64–70. doi: [10.1207/s15430421tip4102_2](https://doi.org/10.1207/s15430421tip4102_2).
- Zimmerman, W. A., & Kulikowich, J. M. (2016). Online learning self-efficacy in students with and without online learning experience. *American Journal of Distance Education*, 30(3), 180–191. doi: [10.1080/08923647.2016.1193801](https://doi.org/10.1080/08923647.2016.1193801).

Corresponding author

Lorette Pretorius can be contacted at: lorette.pretorius@outlook.com