Humanities & Social Sciences Communications

ARTICLE

https://doi.org/10.1057/s41599-022-01322-1 OPEN

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Profiles of learners based on their cognitive and metacognitive learning strategy use: occurrence and relations with gender, intrinsic motivation, and perceived autonomy support

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For life-long learning, an effective learning strategy repertoire is particularly important during acquisition of knowledge in lower secondary school—an educational level characterized with transition into more autonomous learning environments with increased complex academic demands. Using latent profile analysis, we explored the occurrence of different secondary school learner profiles depending on their various combinations of cognitive and metacognitive learning strategy use, as well as their differences in perceived autonomy support, intrinsic motivation, and gender. Data were collected from 576 ninth grade students in Uganda using self-report questionnaires. Four learner profiles were identified: *competent strategy user, struggling user, surface-level learner*, and *deep-level learner* profiles. Gender differences were noted in students' use of elaboration and organization strategies to learn Physics, in favor of girls. In terms of profile memberships, significant differences in gender, intrinsic motivation and perceived autonomy support were also noted. Girls were 2.4–2.7 times more likely than boys to be members of the *competent strategy user* and *surface-level learner* profiles. Additionally, higher levels of intrinsic motivation predicted an increased likelihood membership into the *deep-level learner* profile, while higher levels of perceived teacher autonomy predicted an increased likelihood membership into the *competent strategy user* profile as compared to other profiles. Further, implications of the findings were discussed.

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Introduction

One of the main objectives of science education is to produce students who are independent, autonomous, think like scientists, and are efficient life-long learners (Tanner & Jones, 2003). Despite the vast number of resources many countries have devoted to STEM education (Keller et al., 2017), there has been an outcry over the poor achievement of students in science subjects (Christidou, 2011; Eccles & Wigfield, 2002; Keller et al., 2017; Potvin & Hasni, 2014) especially Physics (Kwarikunda et al., 2020) at secondary school level in both developed and developing countries. Uganda has had its own share of this experience (see Kwarikunda, et al., 2020). Additionally, gender differences in Physics achievement have been reported in favor of boys (Organisation for Economic Cooperation and Development, 2010), consequently affecting the number of girls that opt for Physics-oriented careers. Whereas many countries strive to narrow the gender gap in Physics careers—careers that have been labeled masculine, minimum progress is registered (Organisation for Economic Cooperation and Development, 2010) especially in developing countries.

Evidence indicates that students' performance in science is influenced by several affective factors such as their motivation (e.g., Organisation for Economic Cooperation and Development, 2010; Ratelle et al., 2007), interest, attitudes, and use of learning strategies (Bouckenooghe et al., 2016; Schunk et al., 2008; Sjoberg & Schreiner, 2006). Initiative-taking students are usually interested in classroom activities, are enthusiastic, and engage more in the learning process than their counterparts. Further, autonomous motivation has been reported to be advantageous to achievement (Vansteenkiste et al., 2009) and other learner outcomes. To foster the development of autonomous motivation, some teachers integrate aspects to support the development of autonomy during instruction. However, the perception of these instructions by the learners to feel supported for autonomy development during science learning are important, since perceived teacher autonomy support has direct and indirect effects on learners' motivational beliefs, attitudes, achievement emotions, choice of learning skills (Ekatushabe et al., 2021; Zhao & Qin, 2021), and their achievement. In the present study, we focus on the predictive effects of autonomy support on the membership likelihood of different latent profiles of learners based on their cognitive and metacognitive learning strategy use.

Previous research highlights that learners differ in their ability to use learning strategies (Schunk et al., 2008): autonomously motivated students using more adaptive learning strategies such as critical thinking than their counterparts who adopt maladaptive learning strategies such as rote learning and rehearsal (Manganelli et al., 2019). Rogiers et al. (2019) suggested that lack of a well-adapted cognitive learning strategy repertoire could negatively affect the students' academic progress. Whereas much research has been done in science in general and Mathematics, little is known about students' repertoire of cognitive learning strategy use during Physics learning especially in lower secondary school, an educational level that is characterized of (i) transition into more independent learning and autonomous classroom situations and (ii) decline in levels of motivation to learn (Barmby, Kind, & Jones, 2008). Additionally, for effective gender-based pedagogical innovations to counter the gender gap in Physics achievement and consequently in Physics career choice, it is vital to examine gender differences in cognitive learning strategies in Physics. To this end, we used a person-centered approach to explore the various profiles of students based on their cognitive strategy use during Physics learning. Further, we investigated differences in gender, intrinsic motivation, and autonomy support within the various profiles of students' cognitive strategy use.

Theoretical framework

Since the late 1970's, fostering life-long learning became an important educational goal in many countries worldwide (Rogiers et al., 2019). With the growing need to train self-reliant, independent, and critically thinking citizens that meet the constantly evolving demands of the job and market world (Muwonge, et al., 2020), many countries consequently shifted their pedagogical practices from teacher-centered approaches to learner-centered approaches. Consequently, control of the learning process in the learner-centered classrooms shifted from the teachers to the learners. Thus, in such classrooms, the role of teachers shifts from classroom lecturer who presents information to students to "facilitators" of the learning process, learners solely taking up the responsibility to understand their learning environment and control over "how" and "when" they should learn a given academic task. To do so, learners must set learning goals, select strategies that help them achieve their learning goals, implement these strategies, and monitor their own progress towards achieving their learning goals (Schunk, 1991). Such learners are said to self-regulated (Pintrich, 2000).

The self-regulated learning theory contends that learning is governed by a variety of interactions between the cognitive, metacognitive, and motivational components of an individual (Pintrich, 2000, Zimmerman, 2000). Cognition includes different skills learners use to encode, memorize, and recall information (Schraw et al., 2006). Metacognition involves skills learners use to understand, monitor, and regulate their cognition process (Pintrich, 2000; Zimmerman, 2000). Motivation includes the various beliefs that drive the use and development of cognitive and metacognitive skills during learning (Pintrich, 2000).

Motivation as a component of self-regulation. Within the self-regulation framework, motivation plays a significant role in explaining the value and belief system that students have when it comes to goal setting and choice of the learning strategies to use (Pintrich, 1999; Zimmerman, 2000). Although different models of self-regulation highlight different components of motivation, Pintrich and colleagues' (1993) model encompass self-efficacy, intrinsic motivation, and extrinsic motivation. Self-efficacy is important for self-regulated learning because it affects the extent to which learners engage and persist at challenging tasks (Schraw et al., 2006; Zimmerman, 2002). Extrinsic motivation allows learners to participate in a learning activity for the sake of external rewards such as grades. Intrinsic motivation is the drive students feel when they do an academic task because it is inherently interesting and enjoyable (Ryan & Deci, 2000). Intrinsically motivated students pursue learning activities because of personal choice absence of external contingency regardless of the task difficulty and are more likely to engage in effective cognitive learning strategies (Deci & Ryan, 2000; Vanteenkiste et al., 2009).

Of the numerous ways of regulating academic motivation, intrinsic motivation has been highlighted as most advantageous to academic achievement (Corpus & Wormington, 2014; Deci & Ryan, 2000; Hayenga & Corpus, 2010; Ryan & Deci, 2000; Schiefele, 1991). However, if intrinsic motivation is to be improved, learners need to be autonomous -a perception of being the source of one's own learning behaviors (Manganelli et al., 2019; Deci & Ryan, 2000). To achieve their own learning goals with psychological freedom and satisfaction, students require autonomy support. Kusurkar and Croiset (2015) define autonomy support as the perception of choice and control over one's learning. Autonomy support can be from teachers, peers, parents, and role models. In our study we focused on perceived teacher autonomy support. Self-regulated students are autonomously motivated, study out of curiosity for inherent enjoyment, satisfaction, and personal interest with a sense of psychological freedom and perceived internal locus of causality (Manganelli et al., 2019; Vanteenkiste et al., 2009).

Cognitive and metacognitive learning strategy use. In the cognitive and metacognitive components of the self-regulation theory, Zimmerman (2000) stresses that for improved learning, learners must use a variety of individual tactics and skills. These skills were also identified as learning strategies by Pintrich and colleagues (1993). Depending on the demands and complexity of the given academic task, learners differ in their self-regulation and thus, use a variety of learning strategies (Duncan, & McKeachie, 2005). Learning strategies are a set of skills that students choose and effectively use to acquire knowledge and accomplish different learning tasks and goals (Pintrich et al., 1993). Learning strategies can be categorized according to their nature (i.e., cognitive, metacognitive, and motivational) and level of depth of information processing and internalization (Rogiers et al., 2019). Deep-level strategies are aimed at deep understanding and active transformation or application of information while surface-level strategies aim at memorization and basic comprehension without any information integration (Rogiers et al., 2019; Schiefele, 1991; Pintrich & Zusho (2002)).

Cognitive and metacognitive learning strategies involve basic and complex ways in which knowledge is chosen, retained, and processed in relation to previously acquired knowledge (Pintrich et al., 1993). Such ways include use of rehearsal, elaboration, organisation, planning, and monitoring. Rehearsal involves repeated recitation, writing, and naming of the items such as physics formulae and definitions to be learned. Rehearsal is a basic learning strategy through which information in working memory is activated (Pintrich, 2000). Organization is a more active process during which learners select appropriate information through clustering, outlining, and selecting the main idea in reading passage. However, both learning strategies do not allow construction of connectivity among information with prior knowledge but emphasize memorization (Pintrich et al., 1993). Consequently, constant use of rehearsal and organisation promotes surface-level learning (Schiefele, 1991; Pintrich, Zusho, 2002).

On the other hand, for deep learning to occur, learners need to use high-order strategies like elaboration and critical thinking (Schiefele, 1991). By building internal connections between items to be learned, students use elaboration strategies such as generative notetaking, making analogies, and effective notetaking to store information into long-term memory (Pintrich et al., 1993). At the same time, elaboration strategies help students integrate new learning with existing knowledge (Pintrich et al., 1991). Critical thinking involves a variety of skills such as the learners' ability to identify the source of information, analyze its credibility, reflect on whether that information is consistent with their previously acquired knowledge, apply previously acquired knowledge to new learning situations, make evaluations with respect to the standards of excellence, draw conclusions based on their critical thinking (Linn, 2000; Pintrich et al., 1993), and elaborate their personal opinion about the topics being studied (Crede & Phillips, 2011).

Metacognition involves students' knowledge of their cognition and their ability to control their cognition. In the self-regulation framework, learners have the responsibility to set learning goals, plan, monitor and evaluate their learning at various points during the learning process (Zimmerman, 1990). Planning involves the selection of appropriate strategies depending on the task at hand, allocating resources, and setting the learning goal (Pintrich et al., 1993; Schraw et al., 2006). Planning activities help to activate, or prime, relevant aspects of prior knowledge that make organizing and comprehending the material easier (Pintrich et al., 1993). Through monitoring strategies, learners can track their attention, make judgements of their motivation levels and effectiveness of the learning strategies. Evaluation usually involves accessing their learning goals and effectiveness of their learning strategies. Through evaluation, learners can continue to use a given set of learning strategies deemed effective and or replace those strategies that they find ineffective for a given learning task. Also, through evaluation, learners self-test their learning achievement.

Given that self-regulation is context dependent (Zimmerman, 2000), the way students engage with learning is rarely restricted to use of one single cognitive learning strategy (Bouckenooghe et al., 2016). Pintrich and Zusho (2002) also affirmed that no strategy is dominant or works equally for all individual learners for a given task. This implies that while some cognitive and metacognitive learning strategies are useful for some students, the same or similar learning strategies may not be equally useful to other students (Dowson & MCInerney, 1998). For example, Japanese students have been reported to use mostly memorization, summarization, and rehearsal while learning less enjoyable and abstract academic tasks (Purdie et al., 1996). Elsewhere, in Turkey, 7th grade Science students reported use of metacognition, rehearsal, and elaboration (Akyol et al., 2010). Additionally, studies have indicated existence of positive relationships between the nature and level of deep of the learning strategies used with achievement. For example, in Japan rehearsal (memorization) was highly associated with achievement (Purdie et al., 1996). In line with Pintrich et al. (1993), metacognition predicted Turkish students' achievement in science (see Akyol et al., 2010).

From literature, cognitive strategy use varies according to culture, subject, and grade level. Whereas secondary education is a challenging educational level, the first two years are characterized with transition into more complex and autonomous academic tasks and learning environments. Also, the first two years of secondary school are crucial years in which students develop an effective learning strategy repertoire (Rogiers et al., 2019) if properly guided and supported during instruction. Additionally, during this time, students in Uganda are introduced to new subjects such as Physics, a subject that most lower secondary school Ugandan students have connoted as less interesting, complex, and abstract (Kwarikunda et al., 2020). This connotation could affect the students' cognitive learning strategy use. However, little is known about the cognitive and metacognitive learning strategy usage during Physics learning among lower secondary school students' especially in developing countries.

A person-oriented approach to explore learning strategies

Researchers have used theory-driven variable-centered methods to generate much information on effects and associations between several variables such as academic motivation, cognitive strategy use among others in the self-determination framework. However, variable-centered approaches have ignored the complex interaction of these variables at the level of the individual (Wang & Wang, 2012). To complement variable-centered studies, researchers have been advised to use data-driven approaches such as person-centered analyses. In person-centered approaches, the underlying latent groups that would have been otherwise been left masked in variable-centered approaches are revealed within the heterogeneous sample (Muthen & Muthen, 2000). These groups (profiles) represent people clustered together with similar levels on several variables. Unmasking such profiles is necessary for designing educational interventions that target a specific group's needs.

Since students tend to develop a flexible repertoire of different combinations of cognitive learning strategies during different learning contexts (Rogiers et al., 2019), several studies have explored the various combinations of students' strategy use using a person-centered approach; this helps to unveil the number and characteristics of learner profiles. In elementary school learners, Merchie and colleagues (2014) identified four profiles of learners: memorizers, mental learners, information organizers and integrated strategy users. Most students were categorized as integrated strategy users. Later, Karlen (2016) also identified four profiles of upper secondary students regarding their reported motivation and cognitive strategy use. It was observed that highly self-regulated students reported highest grades in German.

Among university students, Zhen et al. (2020) identified four profiles of self-regulated learners. The profiles were identified as competent learners, reflective-oriented learners, minimally regulated learners, and cognitive-oriented learners. Although competent learners reported highest scores on motivational process, cognitive strategy use, and behavioral regulation, reflective-oriented learners demonstrated the best academic performance. Similar number of profiles was also previously identified by Ning, Downing (2015) accepted that unlike Zhen et al. (2020), their competent profile was associated with the highest academic achievement.

Also, while using the motivated strategies l for learning questionnaire to examine individual differences in 238 junior college students' motivation and learning strategy use, Liu et al. (2014) uncovered four groups of students. The students in the two adaptive clusters showed better academic achievement. Alternatively, while using a sample of Ugandan teacher trainees in six universities, Muwonge et al. (2020) identified three quantitative profiles of science teacher trainees regarding their learning strategy use. Most first year teacher trainees were categorized as either low or average strategy users. High strategy users reported highest levels of extrinsic goal orientation and test anxiety. Elsewhere, Heikkilä et al. (2012) also identified three profiles of learners based on their learning strategy use. They identified their profiles as non-regulating students, non-reflective students, and self-directed students. The self-directed students reported deeper understanding of concepts and higher critical thinking. Additionally, while using 1326 biology students, Hong et al. (2020) identified three profiles of students according to their metacognitive self-regulated learning usage. They identified their profiles as infrequent metacognitive processing profile, planning and self-evaluation profile, and monitoring via self-assessment target profile.

It should be noted that most of the above studies have been conducted in developed countries whose curricula, academic demands, Physics teacher training programs and classroom settings are different from those of the present study. Additionally, these studies have been done in different subject contexts (e.g., German, STEM, learning in general, and text learning) and education levels. Furthermore, different sets of variables (in addition to cognitive learning strategies) have been used in most studies. Nevertheless, reviewing these studies provides insightful information and comparisons of the person-centered analyses within the self-regulation framework.

Gender differences in cognitive learning strategy use. Prior research has suggested that there are stable gender differences in learning strategy use (Meece & Jones, 1996; Rogiers et al., 2019; Wolters & Pintrich, 1998). Several studies have indicated reasonable gender differences. For instance, it has been revealed that girls show higher levels of cognitive strategy use (Wolters & Pintrich, 1998), are more knowledgeable about the various effective strategies (Organisation for Economic Cooperation and Development, 2010), and tend to utilize more learning strategies (Rogiers et al., 2019) than boys. Additionally, some studies have reported that girls prefer to use memorization strategies (e.g., rehearsal) while boys prefer to use elaboration strategies (Meece & Jones, 1996; Organisation for Economic Cooperation and Development, 2010). On the contrary, in other studies (e.g., Niemivirta, 1997) boys were found to use more memorization strategies than girls. Specifically, Niemivirta (1997) concluded that boys are rote learners since they outperformed girls when using rote learning strategies.

Studies in Mathematics classes indicate that unlike girls, boys are more likely to develop autonomous learning strategies and assume control of their learning (Meece & Jones, 1996). In other studies, Akyol et al. (2010) recorded no significant gender differences in cognitive strategy use during science learning among seventh grade students in Turkey. Similarly, in 5th and 6th grade Mathematics and Greek language students, Metallidou and Vlachou (2007) reported no significant gender differences in cognitive strategy use. Finally, Bidjerano (2005) reported significant gender differences in only the use of critical thinking in favor of boys.

Owing to the various contradictions in reports of gender differences in learning strategy use, it is possible that these differences reflect cultural contexts and nature of the academic tasks (Duncan, McKeachie, 2005). Also, it is unclear of the gender differences in cognitive strategy use among ninth grade students during Physics learning especially in developing countries. Thus, there is a need for further exploration of gender differences in cognitive strategy use during Physics learning especially in developing countries. Results from such an exploration may also inform teacher instructions.

Present study

Previous research (e.g., Muwonge et al., 2020) has already identified different learner profiles regarding their learning strategy use at different educational levels. However, little attention has been given to learner profiles especially in the context of Physics learning in secondary school—a critical educational level in which learners are expected to become more independent and autonomous during learning situation, as they develop an effective learning strategy repertoire for life-long learning (Rogiers et al., 2019). Moreover, depending on the nature of the subject and the learners' previous experiences, learners tend to use different combinations of learning strategies. It is unclear which combinations of cognitive learning strategies students use during Physics learning and how many profiles of these combinations exist in secondary schools especially in developing countries such as Uganda. Thus, to fill this research gap, we sought to identify the distinct learner profiles based on their various combinations of cognitive learning strategy use. We hypothesized that more than two latent profiles of learners based on their cognitive learning strategy usage exist; with one profile containing students who are less self-regulatory metacognitively.

Additionally, the male connotation of Physics instruction (Jurik et al., 2014) and Physics careers in society could affect use of cognitive learning strategies and consequently, result into differences in gender distribution within the profiles. Thus, we also explored the likelihood of membership because of gender. We hypothesized that the profile that contained students who reported to use more organisation strategies contained more female than male students.

The extent to which students make use of the cognitive learning strategies depends on their motivation (Stolk & Harari, 2014; Schiefele, 1991). In their study using university students, Vanteenkiste et al. (2009) reported that autonomously motivated students (with prominent levels of intrinsic than extrinsic motivation) exhibited use of a variety of adaptive learning strategies. However, Wormington et al. (2012) found that students with higher levels of both intrinsic and extrinsic motivation used adaptive learning strategies. Even though various forms of motivation have accounted for differences in academic achievement and learning strategy use (Ekatushabe et al., 2021; Manganelli et al., 2019), it is unclear how intrinsic motivation and perceived autonomy support differ in various groups of learners depending on their cognitive strategy use specifically in lower secondary school. Thus, while using a person-centered approach, we sought to explore further the interplay between autonomy support, intrinsic motivation and cognitive strategy use during Physics learning in lower secondary schools. We hypothesized that members in the distinct identified profiles differed in their perceived autonomy support and intrinsic motivation, with students in profiles indicating high-order strategies reporting highest levels of both intrinsic motivation and perceived teacher autonomy support.

Methods

Participants. Following recommendations by Krejcie and Morgan (1970), 579 ninth grade students were randomly selected from six schools Central Uganda. However, data from six female students was excluded from further analyses due to students' failure to provide written consent. Consequently, data from 573 students were used for analyses. Given that gender was a binary variable, most of the students were females ($n = 321$, 56%). Most of the students aged between 14 and 15 years (Mean = 14.3, SD = 1.51). Of all students, 50.9% resided home. Being a day scholar is characteristic typical of most secondary school going children in semi-urban areas of Uganda coming from low economic status families.

Procedure and ethics. Initially, ethical clearance was sought from XMbarara university research ethical committee and Universität Potsdam research ethics commision. Then, school head teachers at the selected schools were approached to obtain permission allowing us access to grade 9 students and Physics teachers. Upon in-depth discussions about the purpose, significance, and data collection and protection procedures of the study during the information-giving session, students provided written consent to voluntarily take part in the study. Subsequently, anonymised questionnaires were administered to the participants during a Physics class, in the presence of at least one of the researchers and a research assistant. Participants required ~30 min to complete the questionnaire.

Instrument. We used a self-reported questionnaire to collect data. This instrument consisted of four sections. In the first section, students' socio-demographic characteristics, e.g., gender, age, residence status, and highest education level of their parents were elicited. Below, we briefly discuss each of the remaining three sections.

Cognitive and metacognitive learning strategies. In the second section, three distinct aspects of cognitive learning strategies i.e., rehearsal, elaboration, critical thinking, and metacognitive self-regulation were assessed using the cognitive and metacognitive learning strategies section of the Motivated Strategies Learning Questionnaire (MSLQ; Pintrich et al., 1991). The cognitive and metacognitive learning strategies sections of the MSLQ were selected because they incorporate various categories of learning strategies ranging from surface-level learning strategies, e.g., memorization to deep-level learning strategies, e.g., self-testing, critical thinking, and task analysis. Items were modified to suite the study context by replacing "*class*" with "*Physics class.*" An example of a modified rehearsal strategy item includes "*I memorize key words to remind me of important concepts in the Physics class.*" All items were answered on a 7-point Likert scale ranging from 7 (*very true of me*) to 1 (*not at all true for me*). Results of the confirmatory factor analysis on the four-factor model used on the present student sample produced good model fit indices (see Table 1). Reliability coefficients and descriptive statistics of the used subscales are presented in Table 2.

Table 1 Fit indices from confirmatory factor analyses of each section the variables used.

	χ^2/df	CFI	TLI	RMSEA	SRMR
Teacher autonomy support	1.34	0.93	0.95	0.03	0.05
Intrinsic motivation	2.11	0.92	0.93	0.06	0.04
Cognitive learning strategy use	1.52	0.93	0.94	0.05	0.04

CFI, comparative fit index, *TLI*, Tucker-Lewis's index, *RMSEA*, root mean square error of approximation, *SRMR*, standardized root mean residual, *df* degrees of freedom.

Perceived autonomy support. The third section assessed students' perceived teacher's autonomy support using a 15-item section that we adapted from Williams and Deci's (1996) Learning Climate Questionnaire (α = 0.91). Sample items included "*I feel that my physics teacher provides me choices and options*" and "*my physics teacher shows confidence in my ability to do well in physics tests.*" Students scored the items on a 7-point Likert scale ranging from *strongly disagree* (1) to *strongly agree* (7). Following a confirmatory factor analysis, one item "I feel able to share my feelings with my physics teacher" had a factor loading less than 0.40. Consequently, this item was excluded. Fit indices, descriptive statistics and reliability coefficient are reported in Tables 1 and 2.

Intrinsic motivation. Lastly, the fourth section assessed Students' intrinsic motivation for Physics learning. We used a 5-item intrinsic motivation section from the adapted Physics version (Kwarikunda et al., 2020) of the Science Motivation Questionnaire II (Glynn et al., 2011). Items were answered on a 5-point Likert scale with anchors ranging from *never* (1) to *always* (5). Fit indices from a confirmatory factor analysis of the intrinsic motivation section, internal consistency as indexed by Cronbach's alpha, and descriptive statistics are indicated in Tables 1 and 2.

Data analyses

Preliminary analyses. Data were initially screened for missing values, outliers, normality, sampling adequacy, and sphericity. Owing to its efficiency compared to other methods such as listwise deletion (Wang & Wang, 2012), Full-Information-Maximum likelihood estimator was used to manage the 0.5% missing values. Using the Shapiro-Wilk test, normality distribution of the data was checked. Data passed the normality test since a non-significant value ($p = 0.78$) was obtained. Then, Kaiser-Meyer-Olkin measure of sampling adequacy was conducted, which Data passed (KMO = 0.93). To evaluate for sphericity, Bartlett's test was done. A significant Chi square value ($\chi^2 = 2789.65$, $p < 0.05$) was obtained indicating adequate quality of the correlation matrix

Table 2 Tests of measurement invariance of the cognitive and metacognitive learning strategy use scale across gender.

Level of measurement invariance	Model fit				Compared model	Results of model comparison	
	χ^2/df	CFI	TLI	RMSEA		ΔCFI	ΔRMSEA
Female	1.942	0.963	0.957	0.053	-	-	-
Male	1.933	0.962	0.950	0.057	-	-	-
Configural invariance	2.046	0.981	0.961	0.055	-	-	-
Metric invariance	2.061	0.986	0.969	0.052	Configural	0.00	0.003
Scalar Invariance	2.069	0.986	0.971	0.050	Metric	−0.002	0.002
Strict invariance	2.072	0.991	0.978	0.049	Scalar	−0.001	0.001

Table 3 Means and standard deviations, correlations between measured variables, and reliability coefficients for each subscale.

Variable	Mean (*SD*)	1	2	3	4	5	6	7
1. Perceived autonomy support	5.28 *(1.28)*	**0.90**						
2. Intrinsic motivation	2.73 *(0.92)*	0.52**	**0.73**					
Cognitive and metacognitive learning strategies								
3. Rehearsal	5.45 *(1.19)*	0.33**	0.25**	**0.87**				
4. Organisation	5.28 *(1.06)*	0.28**	0.23**	0.62**	**0.84**			
5. Elaboration	5.33 *(1.27)*	0.35**	0.47**	0.64**	0.54**	**0.88**		
6. Critical thinking	4.63 *(1.29)*	0.37**	0.46**	0.63**	0.61**	0.61**	**0.82**	
7. Metacognition	5.27 *(1.01)*	0.39**	0.47**	0.67**	0.63**	0.65**	0.65**	**0.90**

**$p < 0.05$. Bold-faced figures indicate the reliability coefficients (α) of each instrument subscale.

of the items. Following the above tests, Confirmatory Factor Analysis (CFA) was conducted on each of the instrument sections. One item "I feel able to share my feelings with my physics teacher" with a factor loading of less than 0.40 was deleted from the model. Following Hu and Bentler's (1999) model fit criteria (Comparative Fit Index and Tucker-Lewis Index ≥ 0.90, Standardized Root Mean Square Residual ≤0.08, and Root Mean Square Error of Approximation ≤ 0.06), data were of good fit (see Table 1).

Since we wanted to explore gender differences, as an important prerequisite for conducting meaningful cross-group comparisons (Vandenberg & Lance, 2000), we also assessed the measurement invariance of the learning strategy use section of the instrument across gender. Three levels of measurement invariance were assessed, i.e., configural invariance, metric invariance, scalar invariance, and strict invariance. A higher level of measurement invariance is confirmed when ΔCFI ≤ −0.01 and ΔRMSEA ≤ 0.015 values are obtained upon comparing a model specifying a higher level of measurement invariance to that of a model specifying lower levels of measurement invariance (Chen, 2007). In the present study, girls interpreted the items similarly as boys (see Table 2). Cronbach's alphas, as an index of internal reliability, were also examined for each section of the instrument. Pearson's correlation coefficients were also noted (see Table 3).

Prior to latent profile analyses, we also conducted paired *t*-tests using SPSS version 20 to test for gender variations in students' cognitive learning strategy use. We could not find any variable-centered research in gender differences across cognitive strategy use during Physics learning in Uganda. Thus, we conducted these tests to provide us with a variable-centered result that would be complemented by the person-centered approach. In addition, Cohen's *d* effect sizes (Cohen, 1988) were examined. Effect sizes were interpreted as; small if ≤ 0.20, medium if $0.21 \le d \le 0.50$ or high if $0.51 \le d \le 0.80$ (Cohen, 1988).

Latent profile analyses (LPA). As recommended by Hickendorff et al. (2018), we used the 3-step approach of LPA. In the first step, a series of LPA models with an increasing number of latent profiles while comparing *k* profile model with the *k-1* profile model were conducted to determine the number of profiles. The best profile model solution was reached using a combination of several model fit criteria.

Firstly, information-theoretic methods such as Akaike's Information Criterion (AIC; Akaike, 1974), Bayesian Information Criterion (BIC; Schwarz, 1978), and sample-size adjusted BIC (ABIC; Sclove, 1987) were used. A model that produces smaller values of AIC, BIC and ABIC has better fit (Wang & Wang, 2012).

Secondly, likelihood ratio statistic tests such as Lo-Mendell-Rubin likelihood ratio test (LMR), ad hoc adjusted LMR, and bootstrap likelihood ratio test (BLRT; McCutcheon, 1987) that assess improvement in neighboring class models by comparing normal mixture distribution of the *k* class against an alternative *k*-1 class were also used. A small probability value ($p < 0.05$) implies that there is statistically significant improvement in the k profile model than in the *k*-1 profile model. Thus, the *k* profile model, which is of better fit to the data is accepted, while the *k*-1 profile model is rejected (Wang & Wang, 2012). Basing on results from simulation studies, BLRT performs better in estimating the best model fits as compared to other likelihood tests (Berlin et al., 2014). Thus, we prioritized BLRT results before we could use other likelihood ratio statistics.

Thirdly, entropy-based criterions that assess the quality or adequacy of latent profile membership were used. A normalized entropy value greater than 0.8, indicates that the latent profiles are highly discriminating (Wang & Wang, 2012). We further examined closely the posterior classification probabilities and profile size distribution (as suggested by Wang & Wang, 2012). A model, whose profiles' posterior classification probability values are greater than 0.85, indicate adequate membership allocation. A profile with size of <5% is problematic, and it is recommended to reject the model with such a profile size. Vermunt (2010) recommends further examination of the profiles in respect to the theory underlying the study such that the profiles can be interpreted and explained by the study theory. This is important in identifying each of the processes in the second step.

Table 4 Model fit indices for the models with number of latent profiles ranging from 1 to 6.

Fit index	Model					
	1-profile	2-profile	3-profile	4-profile	5-profile	6-profile
nf	10	16	22	**28**	34	40
Log L	−3226.49	−2768.99	−2678.75	**−2590.87**	−2498.14	−2541.65
AIC	6172.98	5464.19	5238.11	**5254.64**	5090.67	5003.94
BIC	6216.02	5520.98	5287.64	**5319.62**	5212.37	5168.33
ABIC	6180.23	5481.23	5237.84	**5136.78**	5165.02	5073.97
Entropy	-	0.84	0.86	**0.80**	0.816	0.79
LMR LR	-	0.0004	<0.0001	**0.43**	0.015	0.41
aLMRT	-	0.0005	<0.0001	**0.44**	0.016	0.44
BLRT	-	<0.0001	<0.0001	**<0.0001**	<0.0001	0.46
<5% Class size	-	0	0	**0**	1	2

nf free parameters, *Log L* model loglikelihood, *AIC* Akaike's information criterion, *BIC* Bayesian information criterion, *ABIC* sample-size adjusted BIC, *LMR LR* Lo-Mendell-and Rubin likelihood ratio test, *aLMRT* adjusted Lo-Mendell-and Rubin likelihood ratio test, *BLRT* bootstrap likelihood ration Test. Bold indices are for the selected model.

Gender, perceived autonomy support, and intrinsic motivation as predictors of profile membership. After selecting the number of profiles, the third step was to examine the predictive relations of students' gender, perceived teacher autonomy support and intrinsic motivation and the likelihood of membership into the various profiles. We conducted multinomial logistic regression analyses. At this step, these variables were incorporated as covariates in model estimation using the auxiliary command and LPA were rerun. The inclusion of the covariates at this stage in the model does not affect profile allocation, and it helps to limit type 1 errors (Vermunt, 2010), which are common when using the 1-step LPA approach. Regression coefficients and odd ratios were reported. Latent profile analyses were conducted in Mplus 8 (Muthén & Muthén, 2017).

Results

Preliminary results. Data passed tests of sampling adequacy (KMO = 0.93) and sphericity ($\chi^2 = 2789.65$, $p < 0.05$). Confirmatory factor analyses revealed acceptable fit indices, supporting the factor validity of each of the sections of the measures we used with our study sample (see Table 1). Factor loadings of the items were above 0.65. Results of the tests of measurement invariance of the learning strategy use section of the instrument used across gender indicate that learning strategy use section of the instrument showed strong measurement invariance (See Table 2). Thus, comparisons of means across gender could be conducted in the next steps. On assessing the internal reliabilities of the sections (subscales) of the questionnaire we used, Cronbach's coefficients were satisfactory (ranging from 0.70 to 0.90; see Table 3).

Descriptive statistics and correlations between the study variables. Means and standard deviations of the variables included in the model were examined and presented in Table 3. The mean scores for perceived teacher autonomy support and intrinsic motivation were mid-range. Of the cognitive learning strategies used, the mean score of critical thinking was the lowest in our sample while that of elaboration was the highest.

Table 3 Also includes the correlations between our study variables. As expected, all the study variables were significantly positively associated with each other, with strong associations between perceived teacher autonomy support and intrinsic motivation. Within the cognitive learning skills used, metacognition was strongly associated with rehearsal. On one hand, students reported to use mostly elaboration and metacognition. On the other hand, critical thinking was the least used cognitive learning strategy.

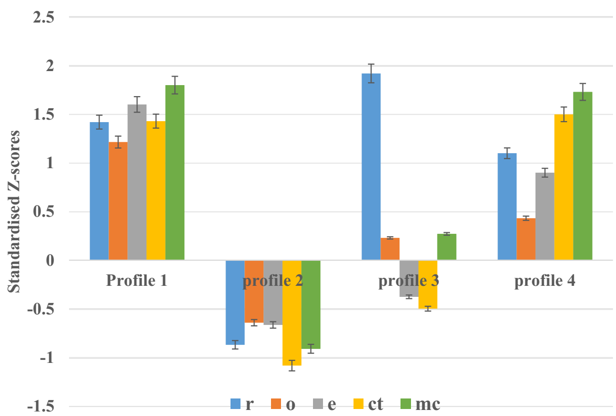

Fig. 1 *A graph showing z*-scores for the different cognitive and metacognitive learning skills used in the four profiles. r, rehearsal; o, organization; e, elaboration; ct, critical thinking; mc, metacognitive self-regulation.

Latent profile analysis. Results of the latent profile analyses were presented in Tables 4 and 5, and Fig. 1.

Model selection. AIC and BIC decreased with increasing number of profiles in the model. Apart from the 6-profile model, entropy values were higher than 0.80. Following recommendations by Asparouhov and Muthén (2007), we run latent profile analyses until we obtained a non-significant *p*-value for BLRT for $K = 6$. However, the 5-profile model was also rejected due to possession of a profile with profile size of <5% (see Table 4) leaving four models choose from. Although the LMR LR and $_{a}$LMRT-rejected the 4-profile model, we chose this model based on it is (a) significant BLRT (Asparouhov & Muthén, 2007), (b) classification probabilities (Nagin et al., 2005), and theoretical interpretation of the profiles (Wang & Wang, 2012).

Profile composition and identification. As presented in Table 4, the model that fit in our data indicates existence of four distinct learner profiles in our data sample. Each profile's standardized *z*-scores of rehearsal, organization, elaboration, critical thinking, and metacognitive self-regulation were graphically represented in Fig. 1, below.

The first profile ($n = 152$, 26.5%) consisted of students with the highest mean scores on elaboration, organization, and critical thinking. Also, these students reported elevated levels of metacognitive self-regulation skills. Thus, this students' learner profile was labeled as the *competent strategy users'* profile.

Table 5 Final cluster counts, profile size, and classification probabilities for most likely latent profile membership for the different models.

Model	Profile size	Classification probabilities				
		1	2	3	4	5
Two-profile						
1 $n = 222$	38.8%	0.98	0.02			
2 $n = 351$	61.2%	0.03	0.97			
Three-profile						
1 $n = 76$	13.4%	0.96	0.04	0.00		
2 $n = 233$	40.6%	0.05	0.91	0.04		
3 $n = 264$	46.0%	0.00	0.04	0.96		
Four-profile						
1 $n = 152$	**26.5%**	**0.94**	**0.06**	**0.00**	**0.00**	
2 $n = 62$	**10.9%**	**0.09**	**0.87**	**0.03**	**0.00**	
3 $n = 204$	**35.6%**	**0.00**	**0.01**	**0.89**	**0.09**	
4 $n = 155$	**27.0%**	**0.05**	**0.00**	**0.05**	**0.90**	
Five-profile						
1 $n = 9$	1.6%	0.94	0.06	0.00	0.00	0.00
2 $n = 68$	11.8%	0.03	0.93	0.00	0.04	0.00
3 $n = 191$	33.4%	0.00	0.00	0.83	0.09	0.08
4 $n = 171$	29.9%	0.00	0.02	0.09	0.89	0.00
5 $n = 134$	23.3%	0.00	0.00	0.13	0.00	0.87

Bold numbers indicate the profile sizes and classification probabilities of the model that we chose.

Table 6 Gender differences in cognitive learning strategies used.

	Mean (SD)		*t*	*p*
	Male	Female		
Rehearsal	5.08 (1.32)	5.05 (1.27)	0.26	0.47
Organisation	5.03 (1.30)	5.24 (1.29)	1.93	**0.03***
Elaboration	5.09 (1.34)	5.36 (1.16)	−2.21	**0.02***
Critical thinking	4.79 (1.30)	4.69 (1.28)	0.69	0.47
Metacognition	5.16 (1.06)	5.22 (0.93)	−0.61	0.54

*$p < 0.05$.
Bold values denote significant *p* values.

With the smallest student population ($n = 62$, 10.9%), the second profile comprised of students whose mean scores of usages of the cognitive and metacognitive strategies were the lowest (all *z* -scores were negative). We named this profile the struggling *strategy user* profile. The largest student population ($n = 204$, 35.6%) were categorized in the third profile. Students in this profile reported high mean scores on surface learning skills (rehearsal, =1.94), low *z-score* on oragnisation, elaboration and critical thinking strategies, *and* slightly above-the-mean score on metacognitive self-regulation skills. Thus, this profile was named *surface-level learners*. The last profile ($n = 155$, 27%) comprised of students that demonstrated use of complex high-order cognitive learning strategies compared to their counterparts. Consequently, this profile was identified as *deep-level leaners*' Profile.

Profile membership likelihood based on Gender, perceived autonomy support, and intrinsic motivation. Prior to latent profile analysis, we conducted paired *t*-tests to assess gender differences in the usage of the cognitive and metacognitive learning strategies in the whole sample. As presented in Table 6, female students used elaboration ($t = 2.21$, $p = 0.02$, $d = 0.47$) and organization ($t = 1.93$, $p = 0.03$, $d = 0.47$) strategies more likely than the male students.

In terms of profile membership, female students were 2.4–2.7 times more likely than the male students to be members of the competent user and surface-level learner profiles relative to the struggling user and deep-level learner profiles. Regarding perceived teacher autonomy support and intrinsic motivation, higher levels of perceived teacher autonomy support and intrinsic motivation increased the likelihood of membership into the competent user and deep-level learner profiles relative to the other profiles. One the other hand lower levels of intrinsic motivation and perceived autonomy support predicted an increased likelihood of membership into the struggling user profile (see Table 7).

Discussion

An effective education system aims at producing independent, autonomous, and efficient life-long leaners. For effective recommendations and interventions, tremendous amount of educational research is needed to understand the learning process of students, especially their repertoire of learning strategies. Several studies have been conducted to investigate learning strategy use at different educational levels. Nevertheless, research on cognitive strategy use and learner profiles in lower secondary school remains scarce. Moreover, the few studies that do exist have examined self-regulation in general Science, text-reading using cluster analysis. Little is known about the occurrence of learner profiles regarding their cognitive learning strategy use during Physics learning in lower secondary school. Thus, the present study investigated the existence of learner profiles using latent profile analysis. We included metacognition as one of our latent profile indicators due to its usefulness for academic achievement (Akyol et al., 2010; Pintrich et al., 2000). Further, differences in gender, intrinsic motivation, and perceived autonomy support within the identified profiles were investigated to deepen our understanding of individual differences in learners' cognitive strategy use.

Prior to the latent profile analyses, we closely examined the mean score for each cognitive learning strategy used in our sample. Findings revealed that lower secondary school students reported use of mostly rehearsal, elaboration, and metacognitive self-regulation learning strategies during Physics learning, while critical thinking strategies were least used. This could be due to

Table 7 Results from multinomial logistic regressions of predictors of profile memberships.

	Profile 1 vs. Profile 2		Profile 2 vs. Profile 3		Profile 3 vs. Profile 4	
	Coef (SE)	**OR**	**Coef (SE)**	**OR**	**Coef (SE)**	**OR**
Gender	0.83 (0.41)**	2.43	0.64 (0.39)	1.14	**1.03 (0.41)****	**2.53**
Perceived autonomy support	**1.27 (0.21)****	**2.87**	**−0.57 (0.17)****	**0.63**	**−0.96 (0.16)****	**2.11**
Intrinsic motivation	**1.07 (0.16)****	**2.42**	**−0.42 (0.39)****	**1.02**	**−0.63 (0.15)****	**2.01**
	Profile 1 vs. Profile 3		Profile 2 vs. Profile 4		Profile 1 vs. Profile 4	
	Coef (SE)	OR	Coef (SE)	OR	Coef (SE)	OR
Gender	−0.26 (0.36)	0.94	1.02 (0.33)	1.47	**0.91 (0.38)****	**2.74**
Perceived autonomy support	**1.01 (0.13)****	**1.24**	**−1.26 (0.41)****	**2.03**	**1.17 (0.18)****	**2.41**
Intrinsic motivation	**1.39 (0.21)****	**1.28**	**−0.63 (0.19)****	**2.13**	**1.48 (0.41)****	**2.95**

Profile1 Competent user learner profile, *Profile 2* Struggling User learner profile, *Profile 3* surface-level learner profile, *Profile 4* deep-level learner profile, *Coef* Coefficients, *SE* Standard error of the coefficient, *OR* odds ratio. The Coef and OR reflects the effects of the predictors on the membership likelihood into the first listed profile relative to the second listed profile.
** $p < 0.05$.
Bold values indicate significant coefficients and odd ratios.

limited knowledge acquired at this level. Perhaps students perceive Physics information at this level as still new and thus they cannot seem to find how it could be related to solving daily problems. Given that elaboration strategies assist learners in transferring acquired knowledge to working memory (Jurik et al., 2014), prominent levels of elaboration use help learners to manipulate knowledge and summarize material (Karlen, 2016). Since Physics is composed of numerous equations, graphs, and formulae, students tend to comprehend such tasks through elaboration. Through metacognition, learners plan, paraphrase and self-evaluate their learning. It is quite common in Uganda to find students using Uganda National Examinations Board (UNEB) question banks as reference questions during Physics revision. In fact, students begin using these booklets as early as their first term in secondary school so that they can evaluate how much they have learnt according to the previously set UNEB questions for the topics they have covered. Whereas such questions can be used for revision guidance, there have been reported tendencies of students relying only on such material during learning rather than textbooks that require a lot of critical analysis, summarization, paraphrasing, and problem solving, skills that could further promote critical thinking. Nevertheless, the use of mostly rehearsal and elaboration strategies during learning was also reported among high-school students in; Turkey during science learning (Akyol et al., 2010), Uganda during biology (Ekatushabe et al., 2021), Philippines (King & Areepattamannil, 2014). Based on our study findings and the fore mentioned studies, elaboration strategies could be the basic learning strategies used by most high-school science students in developing countries.

Using latent profile analysis, four distinct profiles of students regarding their cognitive learning strategy use during Physics learning were unveiled. In terms of the number of profiles, similar findings were found in previous studies (e.g., Karlen, 2016; Merchie et al., 2014; Zhen et al., 2020). Surface-level learners were the most preferable profile. These learners reported to use mostly rehearsal than critical thinking and metacognition. However, we could not identify these learners as memorizers (as in Merchie & Van Keer, 2014) or as rote learners (as in Niemivirta, 1997) because they had reported an average use of elaboration, which enhances minimal interconnection of newly learned information to preexisting knowledge (Pintrich et al., 1993). Identifying them as memorizers would imply that they used only rehearsal, which was not the case here. On the other end of the spectrum lie the struggling strategy users. This profile was the least preferred profile among all the four profiles. Although students in this profile used all the cognitive learning strategies, their frequency of use was below the sample average. Perhaps, these learners could be using other learning strategies such as highlighting important phrases and underlining or circling important formulae and points, strategies that were not included in the scope of the study instruments. Unlike the *competent strategy users*, who also scored quantitatively highly on all cognitive learning strategies, *deep-level* learners reported to use mostly critical thinking and metacognition than rehearsal and elaboration given that the mean score was also above average but not like in *surface-level* learners or *competent strategy users*. Several studies (e.g., Karlen, 2016) have highlighted the importance of critical thinking and metacognition for academic achievement. As to whether the frequency (competent strategy users) or quality (deep-level learners) cognitive strategy use is superior to performance (Karlen, 2016), we have no opinion since we were not able to assess such a relationship due to lack of achievement data in Physics. However, further study in this direction is recommended.

Similarly, our quantitative profiles were closely related to those in Ugandan teacher trainees while using the same questionnaire (see Muwonge et al., 2020). This could be indicative that probably specific cognitive learning strategies are emphasized by teachers during instruction. Perhaps when teacher trainees become teachers, they emphasize and encourage their students to use a certain set of cognitive learning strategies that the teacher trainees themselves found more useful while during their lower secondary school physics lessons.

To deepen our understanding of individual differences in the distinct profiles, we conducted tests for gender, intrinsic motivation, and perceived autonomy support across the profiles. As expected, significant gender differences were recorded in use of organization and elaboration strategies in favor of girls. Contrary to Organisation for Economic Cooperation and Development (2010) findings, girls preferred to use elaboration strategies. Although boys preferred use of rehearsal, we disagree that boys are necessarily rote learners Niemivirta (1997). This is because, in our sample, boys reported a higher mean score of critical thinking than girls. Perhaps, boys preferred to use rehearsal strategies while learning what they perceived as simple Physics tasks such as memorization of formulae and theorem, definition of key terms, and use critical thinking for what they perceive as mentally challenging Physics tasks such as manipulation of apparatus in laboratories during experiments that prove a theorem or given concept. Regarding profile membership, girls were preferably categorized as *competent strategy users* and *surface-level learners*. The high frequency of female *competent strategy users* conforms to previous study findings that girls are more knowledgeable of different learning strategies (Organisation for Economic Cooperation and Development, 2010) and utilize more strategies than their male counterparts (Rogiers et al., 2019) during science learning. Contrary to Niemivirta (1997) there were more female than male students in a profile with students who use more superficial learning strategies during physics learning. The presence of more girls than boys in the *surface-level learners'* profile could be perhaps that girls use more overt strategies to understand and remember information (Organisation for Economic Cooperation and Development, 2010); Slotte et al., 2001). Also, the fact that Physics contains a lot of mathematics applications, formulae, graph work, and theories, girls with mathematics anxiety, bias and boredom could transfer such affective factors and negative emotions towards physics learning (Hunt et al., 2021), which in turn could influence their choice for use of surface-level cognitive learning strategies.

It is worrisome that as early as lower secondary school, a large group of students found difficulty using cognitive strategies (*struggling strategy users*). Immediate attention should be given to such students before advancement and complexity of knowledge takes place. If the gender gap in Physics achievement and Physics career is to be bridged, teachers should give clear, explicit, and direct instructions about cognitive strategy use during instruction, with more emphasis on deep-level learning strategies especially to the girls.

As hypothesized, struggling strategy users reported least score of intrinsic motivation and perceived less autonomy support. Given that autonomy support is particularly important for the development of intrinsic motivation (Ratelle et al., 2007; Vanteenkiste et al., 2009), such a pattern in struggling strategy users is not surprising. Perhaps these students rely more on their Physics teachers or peers to plan, summarize, monitor, and supervise their learning activities. Such a pattern in struggling strategy users could be indicative of these students using extrinsic (controlled) motivation during Physics learning (Ratelle et al., 2007). What is intriguing is the difference in perceived autonomy support and intrinsic motivation between the competent strategy users and deep-level learners. We expected deep-level learners to have high scores of both perceived autonomy support and intrinsic motivation, which was not the case. Further study could be undertaken to understand such a pattern.

Limitations and recommendations for future studies. The findings of the present study should be interpreted considering the limitations discussed below. Recommendations for further studies have also been highlighted.

Firstly, data were collected using self-report questionnaires. To further complement the quantitative findings in students' cognitive learning strategy use, use of in-depth methods such as review of students' Physics learning diaries is recommended. From these diaries, perhaps other patterns of different cognitive learning repertoires and strategies can be unveiled.

Secondly, the cross-sectional nature of the present study precludes inferring causality. Moreover, stability of the profiles throughout the remaining years of High-School is not known. Thus, longitudinal explorations of the stability and evolution of learners' profiles over time is recommended.

Lastly, our study focused on Physics learning only. Future studies could explore cognitive learning strategy use in other Science domains such as Biology and Chemistry. Also, due to lack of data regarding participants' Physics performance, it was not possible to establish the relationship between the profiles and Physics performance. Thus, an investigation into the relationships between the profiles and students' Physics achievement is highly recommended.

Conclusions

Results from the present study have revealed that unlike critical thinking, students use mostly elaboration and metacognition during Physics learning. Person-centered analyses revealed four distinct learner profiles with respect to their cognitive learning strategy use among lower secondary school students. In addition, these profiles significantly differ in their intrinsic motivation and perceived autonomy support. Specifically, competent strategy users reported receiving more autonomy support from their Physics teachers than their counterparts, while the highest levels of intrinsic motivation were reported among deep-level learners. Additionally, significant gender differences were noted in two-profile memberships. Girls were more likely to be categorized as competent strategy users and surface-level learners. Thus, teachers should use instructions that emphasize deep-learning cognitive skills in girls in the first years of secondary school.

Data availability

Data can be provided on reasonable request for academic purposes only.

Received: 31 May 2021; Accepted: 30 August 2022;
Published online: 26 September 2022

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Acknowledgements
We would like to thank the participants, teachers, and research assistants. Special gratitude goes to the Catholic Academic foreigners' service (KAAD) and Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Projektnummer 491466077 for financing the study. Much appreciation to Mr. Amrit Sedain who helped typeset the Manuscript and Dr. Thomas Hunt for proofreading the manuscript.

Funding
Open Access funding enabled and organized by Projekt DEAL.

Competing interests
The authors declare no competing interests.

Ethical approval
We confirm that the present research was conducted in accordance with the relevant ethical guidelines and regulations for human participants. Ethical approval for the study was obtained from Mbarara University of Science and Technology Research Ethics Committee (no. 86/2019) and the Universität Potsdam Research Ethics Committee. Approval from the latter committee was necessary for legal reasons.

Informed consent
Participants provided written consent without coercion.

Additional information
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