EXECUTIVE FUNCTIONS AND SELF-REGULATED LEARNING PROFILES IN HIGHER EDUCATION STUDENTS AND THEIR RELATIONSHIP WITH STUDY SUCCESS

D.M. Manuhuwa[1], M. Snel-de Boer[1], J. Fleer[2], J.W. De Graaf[1]

[1]Saxion University of Applied Sciences, School of Applied Psychology and (International) Human Resource Management (NETHERLANDS)
[2]University of Groningen, University Medical Center Groningen, Department of Health Sciences, Section Health Psychology (NETHERLANDS)

Abstract

Introduction: Both executive functions (EF) and self-regulated learning (SRL) are associated with successful studying ([1]; [2]). However, educational research barely focuses on their combination, whereas there is a clear link between the concepts. EF refer to higher-order cognitive functions that enable adaptive and goal-directed behaviour (e.g. [3]), especially working memory, inhibition, cognitive flexibility, and metacognitions such as planning and organising (e.g., [4]). SRL refers to the metacognitive, motivational, and behavioural processes to attain learning goals systematically ([5]). EF play an essential role in addition to SRL (e.g., [6]; [7]). EF can be seen as the brain's supervisory system that adapts to new, complex, and challenging learning situations; SRL is about the concrete strategies a student deploys to learn knowledge and skills.

To express SRL in teaching, students' SRL styles are regularly classified into group profiles (e.g., [8]; [9]), but there is little research on clustering students based on both EF and SRL. One advantage of clustering is its practical value, namely that it allows education to address these groups, with room for individual differences within them.

This study aims to (a) identify clusters of students with different EF and SRL and (b) examine how these clusters predict study success.

Methods: In November 2020, 327 and a year later, 269 first-year Applied Psychology students completed questionnaires about their perceived EF problems (Behavioral Rating Inventory Executive Function-BRIEF, [10]; [11]) and perceived self-regulated learning (Motivated Strategies Learning Questionnaire-MSLQ, [12]). After exploratory factor analysis, we analysed the results through hierarchical cluster analysis. Next, we compared the clusters via one-way ANOVA tests with study success operationalised in obtained credits, grade average, and the number of resits after one year of study.

Results: As a result of the analyses, we identified three clusters:

1. Highest EF problems, moderate SRL-learning strategies, less SRL-motivated strategies (n = 162);
2. Moderate EF problems, moderate SRL (n = 225);
3. Higher EF *metacognition* problems, average EF *behavioural* problems, less SRL-learning strategies, moderate SRL-motivated strategies (n = 209).

Three conclusions emerge from the correlation analyses of study success with the three clusters. First, the groups differed in credits earned after one year of study with a small effect size (F = 16.72; df = 2, 595; p < .001; $\eta 2$ = 0.05), with cluster 1 having significantly fewer obtained credits than clusters 2 and 3, and cluster 3 less than cluster 2. Second, the clusters also differed in mean grade, again with a similar small effect size (F = 16.27; df = 2,595; p < .001; $\eta 2$ = 0.05). Here too, students in cluster 1 have a significantly lower grade average than clusters 2 and 3 (p < .001), but cluster 3 has lower grades than cluster 2. Finally, cluster 1 had significantly more resits than clusters 2 and 3, but there were no significant differences between clusters 2 and 3 (F = 8.33; df = 2,595; p < .001; $\eta 2$ = 0.03).

Conclusion: These results show that different groups of students can be identified based on EF and SRL. The students who report the highest EF problems combined with average use of SRL strategies demonstrate worse study results.

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Future directions: In a follow-up study, we will explore how to tailor to these different groups of students when designing blended learning environments. We will then formulate design principles that consider EF-fit learning environments.

Keywords: Executive functions, self-regulated learning, study success, higher education.

1 INTRODUCTION

Both executive functions (EF) and self-regulated learning (SRL) have been associated with successful studying (e.g. [1]; [2]). EF refer to higher-order cognitive functions that enable adaptive and goal-directed behaviour (e.g., [13]; [4]; [3]), including working memory, inhibition, cognitive flexibility, and metacognitions such as planning and organising (e.g., [4]). SRL refers to the metacognitive, motivational, and behavioural processes to attain learning goals systematically, such as elaboration or self-efficacy ([5]). Put differently, SRL concerns the concrete strategies a student uses to acquire knowledge and skills, and EF is the brain's supervisory system that adapts to new and complex (learning) situations. Even though a clear connection between the concepts is assumed, educational research has hardly focused on combining EF and SRL. Such insights can also be used to design learning environments that support EF and SRL, to help students get the best out of their education.

Up to now, research on SRL has mainly been conducted in educational research. Much research has focused on the relationship between SRL and study success (e.g., [14]). Some research focused on identifying SRL clusters that were more or less adaptive in the context of study success (e.g., [8]; [15]; [9]).

On the other hand, EF research has been conducted primarily in the context of neuro- and clinical psychological research, emphasising its relationship to mental health (e.g., [16]).

EF has been studied in education, but mainly in primary and secondary education, to get a better understanding of specific psychiatric disorders such as ADHD (e.g., [17]), ASD ([18]) or learning problems such as dyslexia (e.g. [19]). EF has also been found to predict study success within US first-grade multilingual children (e.g., [20]). One of the few examples of research into EF profiles in higher education is a study by Fennesy and Lee [21], which focused on configurations of EF and the personality trait neuroticism. They found four profiles differently associated with internalising and externalising problems and mental health. They concluded that it makes sense to consider such profiles to tailor prevention and intervention to ensure students' mental health.

Based on previous research, we think that it is relevant for educational practice to investigate whether it is possible to identify groups (or clusters) of students based on their EF and SRL profiles and whether these clusters predict study success longitudinally. This will contribute to our understanding of how these concepts work together in relation to study success. Additionally, by identifying groups of students based on their EF and SRL profiles, we may get a better handle on the group most at risk for reduced study success.

This study aims to answer the following research questions:

1. What kind of student clusters can be identified by combining executive functions and self-regulated learning?
2. Are these clusters predictive of study success one year later?

2 METHODOLOGY

2.1 The sample and data collection

The participants in this study are first-year Applied Psychology students at Saxion University of Applied Sciences in the Netherlands (18-25 years, M=19.72, SD=1.72) who took part in the module Diagnostic Research. The group consisted of 192 boys, 399 girls and 5 students identified as other. This study was implemented as an educational part of the module. We offered the students to fill out self-reports and learn more about themselves. The students received their results afterwards, regardless of whether their results could be used for the study. No credits were involved with their participation. The students who allowed their data to be used anonymously signed informed consent.

During one of the module lessons, students were instructed and filled out the self-reports. In November 2020, 327 students, and again in November 2021, 269 students completed questionnaires about their perceived EF problems and self-regulated learning. In addition, one year after taking the questionnaires, we retrieved the students' data about their obtained credits from BISON, a database of Saxion University of Applied Sciences

2.2 Materials and measurements

Two self-report questionnaires were administered: EF, the BRIEF-A (Behavioral Rating Inventory Executive Function for Adults BRIEF, [10]; [11]) and SRL, the MSLQ (Motivated Strategies Learning Questionnaire-MSLQ, [12]). The BRIEF-A consists of two main scales: behavioural regulation and metacognitive regulation. The MSLQ also has two main scales: motivated strategies and learning strategies. Brief-A consists of nine non-overlapping subscales, of which four (Inhibit, Shift, Emotional Control, Self-Monitor) yield the Behavioral Regulation Index (BRI), and the remaining five yield the Metacognitive Index (MI), which consists of Initiate, Working Memory, Plan/Organize, Task Monitor, Organization of Materials with a total of 75 items on a 3-point Likert scale. The MSLQ was developed to measure motivated strategies (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Self-Efficacy, Control of Learning Beliefs and Test Anxiety) and learning strategies (Rehearsal, Elaboration, Metacognition, Organization, Critical Thinking, Effort Regulation, Help Seeking, Peer Learning and Time and Learning Environment), in higher education students through an 81-item questionnaire based on a 7-point Likert scale. The assessment of *study success* in this study was based on three variables: obtained credits in one-year, average grade and the number of resits.

2.3 Factor analyses and reliabilities

A confirmatory factor analysis (CFA) was conducted to examine the construct validity and reliability of the measurement instruments. The CFA resulted in an unacceptable model fit. Therefore, an exploratory factor analysis was performed.

Both analyses can be executed with an Unweighted Least Squares-exploratory factor analysis which accounted for the non-normal distribution of the data and the small number of response categories (three in the BRIEF-A) (e.g. [22]). Model fit indices were assessed with a minimum GFI of .90 and a maximum SRMR of .08 for an acceptable fit ([23]). For convergent validity, an Average Variance Extracted (AVE) of .5 and higher was considered acceptable, although a lower AVE is allowed with a Construct Reliability (CR) of at least .6 ([24]). Discriminant validity was achieved when the shared variance was smaller than the AVE and the AVE greater than the correlation with other factors. Items with a communality smaller than .2 and cross-loadings were removed (e.g. [25]). Factors with a CR smaller than .6 were removed.

In a confirmatory factor analysis, the model fit indices of the original scales of the BRIEF-A and the MSLQ were inadequate (GFI = 0.89, SRMR = 0.07), the convergent validity was poor, all but three scales had an AVE below .5 (between .21 for Peer learning and .58 for Self-efficacy), and only Extrinsic goal orientation and Test anxiety had good discriminant validity. The CR varied between .44 (Peer learning) and .93 (Self-efficacy). As a result, the scale Peer learning was removed.

Subsequently, we conducted exploratory factor analyses, resulting in an acceptable model fit (GFI = 0.94, SRMR = 0.05). After removing poorly performing items and dividing the scale Emotion regulation from the BRIEF-A into two factors, the convergent validity was acceptable (between .38 for Working memory and .65 for Planning and Organization). The discriminant validity was good for all factors after combining the subsequent scales from the MSLQ: Intrinsic goal orientation and Task value; Self-efficacy and Control beliefs; Rehearsal and Organization. Effort regulation and Time and learning management were removed due to multicollinearity problems with the scale Initiate. The CR varied between .65 (Metacognition) and .93 (Self-efficacy with Control beliefs). Of the 151 in total, 69 items were removed.

2.4 Hierarchical cluster analysis

The clusters were calculated through hierarchical cluster analysis. This analysis predicted groups of students based on their BRIEF-A and MSLQ factor scores.

First, the squared Euclidian distance was calculated using Ward's clustering method. With this method, the total variance within the clusters is most minor, and the cluster sizes are more equal than in other ways ([26]).

Secondly, we aggregated the factors found in the factor analyses into four new variables: behavioural regulation and metacognitive regulation (from the BRIEF-A) and motivated strategies and learning strategies (from the MSLQ). These variables were used as outcome variables in a series of ANOVA tests, and the clusters found in the hierarchical cluster analysis as group variables. Standardised scores were also calculated to differentiate between average and non-average scores. More than a 1.5 standard deviation of the mean was considered outside the 95th percentile.

Finally, we compared the clusters via a series of ANOVA tests with study success operationalised in obtained credits, grade average, and the number of resits after one year of study as the outcome variables and the cluster as the grouping variable. The effect size was calculated using eta squared, where a value of .01 is a small effect, .06 a medium effect and .14 a large effect ([27]).

3 RESULTS

3.1 Three clusters of EF and SRL

To address the first research question, we conducted a hierarchical cluster analysis that differentiated groups of students based on their EF problems and the extent to which they employ SRL strategies. A three-cluster solution was obtained, and the following groups were found:

1. Highest EF problems, moderate SRL-learning strategies, less SRL-motivated strategies (n=162);
2. Moderate EF problems, moderate SRL (n=225);
3. Higher EF *metacognition* problems, average EF *behavioural* problems, less SRL-learning strategies, moderate SRL-motivated strategies (n=209).

The following procedures were executed to make the differences between the groups more explicit:

First, percentages of non-average scores greater than 1.5 standardised scores were calculated to further differentiate between the groups. In this way, we could distinguish, within the clusters, students who report substantially more or less EF problems compared to their peers. The same applies to SRL, but the other way around, meaning that a score above average implies that the student employs more SRL strategies.

Subsequently, a series of ANOVA were performed to establish significant differences between the clusters in EF behavioural regulation, EF metacognitive regulation, SRL-motivated strategies and SRL-learning strategies. Table 1 shows that cluster 1 (27.18% of all students) experienced the most EF problems and adopted the least SRL-motivated strategies. Cluster 2 (37.75%) reported the least EF problems and employed the most SRL-learning strategies. Cluster 3 (35.07%) reported relatively high metacognitive regulation problems and the least SRL-learning strategies. The effect size was large for EF behavioural and metacognitive regulation and medium for SRL-motivated and learning strategies.

Table 1. Means and standard deviations for the clusters

	Cluster 1 (n = 162)	***Cluster 2 (n = 225)***	***Cluster 3 (n = 209)***	***Sig. differences between the clusters***
EF Behavorial regulation	1.95 (0.32)	1.57 (0.30)	1.55 (0.22)	1 > 2; 1 >3
EF Metacognitive regulation	2.22 (0.27)	1.56 (0.22)	1.90 (0.25)	1 > 3; 1 > 2; 3 > 2
SRL Motivated strategies	4.62 (0.57)	5.06 (0.59)	4.95 (0.56)	1 < 2; 3 > 1
SRL Learning strategies	4.26 (0.75)	4.66 (0.61)	4.15 (0.80)	1 < 2 > 3

Note. EF-behavioural and metacognitive regulation items have a range of 1 – 3 (a higher score indicates more problems), and SRL-motivated and learning strategies items have a range of 1 – 7 (a higher score indicates more use of strategies).

Table 2 shows the differences between average and non-average scores on EF-behavioural and metacognitive regulation. The differences were significant between all clusters (F = 17.82; df = 2, 595; p < .001 and F = 18.29; df = 2, 595; p < .001; range 1 – 3). Nearly a quarter of the students in cluster 1 had above-average scores in EF problems. In contrast to cluster 1, in cluster 2, a significantly higher percentage of students had below-average scores on EF-metacognitive regulation. There were no significant differences in SRL-motivated strategies. However, on SRL-learning strategies, we found significant differences on a 90%-confidence interval (F = 2.87; df = 2, 595; p = .057; range 1 – 7), with a higher percentage of students in cluster 3 demonstrating below-average scores than in cluster 1 (p = .078). Finally, the effect size was small for EF-behavioural and metacognitive regulation and SRL-learning strategies and zero for SRL-motivated strategies.

Table 2. Percentages above and below average scores.

	All students	*Cluster 1 (n = 162)*	*Cluster 2 (n = 225)*	*Cluster 3 (n = 209)*
EF *Behavorial regulation*	+ 8.2% - 4.7%	+ 24.1% - 0.6%	+ 3.6% - 8.9%	+ 1.0% - 3.3%
EF *Metacognitive regulation*	+ 7.0% - 6.2%	+ 24.7% - 0.0%	+ 0.0% - 13.8%	+ 1.0% - 2.9%
SRL *Motivated strategies*	+ 6.9% - 6.5 %	+ 2.5% - 12.3%	+ 9.3% - 4.4%	+ 6.7% - 5.3%
SRL *Learning strategies*	+ 6.2% - 6.2%	+ 4.3% - 4.9%	+ 8.9% - 1.8%	+ 4.8% - 12.0%

Note. EF-behavioural and metacognitive regulation: % above average score indicates more problems; SRL-motivated and learning strategies: % above average score indicates more use of strategies.

3.2 Clusters of EF and SRL as predictors for study success

To assess if the identified clusters predict study success, a second series of ANOVA was performed to prove significant differences between the clusters in *obtained credits* after one year of study, *grade averages* and the *number of resits*.

Students in cluster 1 obtained significantly fewer credits with a small effect size (M = 40.46, SD = 19.68, range 0 – 60) than students in cluster 2 (M = 50.59, SD = 14.11) and cluster 3 (M = 45.76, SD = 17.72) (F = 16.72; df = 2, 595; p < .001; $\eta 2$ = 0.05), and cluster 3 less than cluster 2.

The clusters significantly differed in *mean grade,* with a small effect size (F = 16.27; df = 2, 595; p < .001; η2 = 0.05). Again, students in cluster 1 have a lower grade average (M = 6.33, SD = 1.01, range 1 - 10) than in clusters 2 (M = 6.88, SD = 0.87) and 3 (M = 6.64, SD = 0.91), and students in cluster 3 had lower grade averages than students in cluster 2.

Finally, there were significant differences between the clusters in the *number of resits* with a small effect size (F = 8.33; df = 2, 595; p < .001; η2 = 0.03. Cluster 1 had more resits (M = 6.20, SD = 3.90, range 0 – 17) than cluster 2 (M = 4.73, SD = 3.36) and cluster 3 (M = 5.15, SD = 3.58). The difference between clusters 2 and 3 was not significant.

4 CONCLUSIONS

4.1 Different clusters of EF, SRL and study success

The results of our study underline the necessity of considering both EF and SRL in light of study success. We identified three distinct clusters of students based on their EF and SRL scores. In addition, there were significant differences between these clusters concerning the study success achieved one year after the SRL and EF tests were administered.

The first cluster consisted of students who reported the highest EF problems, and adopted moderate SRL-learning strategies, but used the least SRL-motivated strategies compared to their peers in the other clusters. One year later, students within this cluster obtained significantly fewer credits and a lower grade average than their peers. Moreover, they have significantly more resits than their peers. This *'high EF problems and minor use of motivated strategies'* group could qualify as the 'at risk' group.

Students in cluster 2, which contained the largest number of students, appeared to do well compared to their peers in the other clusters. They reported moderate EF problems and employed moderate SRL. After one year, they had achieved the most credits and highest-grade averages. This group holds *'moderate EF and SRL'* students.

Finally, cluster 3 included students with higher EF-metacognition problems, moderate EF-behavioural problems, fewer SRL-learning strategies, and moderate SRL-motivated strategies. This *'moderate EF problems and minor use of SRL learning strategies*' cluster is the in-between group when considering study success.

Based on the results, several things stand out. First, within the group of students with the least study success (i.e., cluster 1), EF problems are more prominent than SRL problems. Within this cluster, one in four students indicated that they "often" experience multiple EF problems (both behavioural and metacognitive problems), such as concerning inhibition, planning and initiating tasks.

They also deployed fewer SRL-motivated strategies but not SRL-learning strategies. However, they generally still indicate average or higher motivation on the various statements. This group is, therefore, not remarkably unmotivated, but indicates, for example, that their self-efficacy is lower than in the other groups.

One explanation could be that they have more negative experiences with studying because they achieve less satisfactory results, which is associated with reduced. Conversely, previous studies have shown that motivation is positively associated with executive functions (e.g., [28]) and study success (e.g., [29]; [30]).

EF problems are also negatively associated with study success (e.g., [31]). However, one explanation that EF problems are more determinant in this group may have to do with students' brain maturation, which is related to EF development. In young people, the prefrontal cortex, the part of the brain strongly associated with EF, is still developing and matures at about age 23 in women and 25 in men (e.g., [32]; [33]). Individual differences in the course of this development are substantial. When students need to catch up in their EF development and at the same time face the drastic transition to higher education, a complex and challenging context, they demand chronically (too much) of their executive functioning. This can be the case with students from cluster 1.

In addition, education needs to pay more attention to learning to cope with their EF. This is especially true in higher education. A missed opportunity because implementing interventions precisely in education can certainly be effective, as Diamond and Lee ([34]) described in elementary education. In higher education, interventions are scarce and mostly are not integrated into teaching. In contrast, SRL receives more attention; for example, in mentoring classes, teachers and students discuss how to learn or how to motivate themselves. Nevertheless, students can benefit more if we make training in SRL more explicit in education.

Secondly, SRL-learning strategies, which have also been associated with effective learning and study success (e.g., [15]; [35]), were moderately employed by students in both clusters 1 and 2, whereas students in cluster 3 did demonstrate relatively less use of learning strategies. Even if we look at the absolute data in the answers given to the statements, almost half in cluster 3 tend to score below average. In other words, students report that they use the strategies mentioned less regularly.

In addition, students in this cluster report relatively more EF metacognitive problems. Although they say fewer problems than students in cluster 1, the problems are still high. Combined with the reduced learning strategies, students in this cluster deploy fewer metacognitions, or in other words, they think less about their thinking and how they learn. There is no uniformity in the literature about the effect of metacognitions on study success. Either a small effect or weak correlations are found (e.g., [36]; [37]), or moderate positive effects ([38]) or no effect ([39]). Still, it is expected that these metacognitive problems and less use of learning strategies would result in less study success. However, this group of students achieve less study success than in cluster 2 but more than students in cluster 1. Possibly a contributing factor is that the students predominantly deploy motivational strategies regularly and achieve their grades despite perhaps poorer ways of learning.

The students in cluster 2 have found a balance in experiencing average EF problems while applying motivated and learning strategies and achieving the most study success. This group has probably developed their EF sufficiently or strategies to use their EF optimally. That they still regularly experience some EF problems is to be expected with this young target group, who still face significant challenges. The students in this cluster also regularly employ both SRL strategies. This group may be able to face additional learning challenges but is undoubtedly still in the woods. To continue to deal well with their EF in the future, it makes sense to increase their competencies in this area.

It should be noted that the differences in study success between the clusters were minor. However, we deem them relevant since we included first-year students only. If the trend of falling behind continues, a group of students is expected to graduate significantly later and with lower grades or drop out early.

4.2 Educational implications

The added value of clustering students based on EF and SRL emerges in a practical sense. By distinguishing groups, it is possible, on the one hand, to indicate a group that is at risk of falling behind as they study. On the other hand, it is possible to distinguish a group that is well on track and may even face more challenges. In designing and implementing the learning environments, we could offer these distinct groups, for example, additional support or challenges.

For example, the students in cluster 1, who experience substantial EF difficulties, benefit from more structuring of modules, the scaffolding of complex assignments, and support in planning or reflecting on collaborating within a group. In addition, interventions can be used for this 'at risk' group. For example, an intervention aimed at reducing the fear of failure or training for students with cognitive problems, such as Move aHead! ([40]).

The students in cluster 3 would benefit from EF interventions like those mentioned above. Additionally, these students who use fewer learning strategies would develop themselves from training and support in deep learning strategies, such as critical thinking or elaboration.

The students in cluster 2 might even face more challenges to grow as learners. Education professionals can offer challenges by increasing the complexity of assignments. This can be done, for example, by giving more freedom of choice in assignment type, content or even test format. Here, it remains essential to provide students with a good education in EF and SRL so that they develop insights and skills in them.

Involving learning EF and SRL strategies in higher education offers opportunities for three stakeholders: the students themselves, the teachers and the management. Precisely because the 'hard' EF functions (inhibition, etc.) are strongly related to the parts of the prefrontal cortex that are still developing in students in higher education, including the knowledge that the tests yield per student when clustering of students and the types of education to be chosen, opportunities to increase study success. This has the potential to personify the curriculum. However, this will need to be further investigated. We suggest the following topic points for the three stakeholders:

1 *The student.* You can give students brain education in general and insight into their own EF profile and SRL profile, which is obtained through questionnaires such as the BRIEF or the MSLQ. However, more instruments are available and appropriate. In addition, you can talk to the student, as a mentor or study coach, to find out which EF and SRL strategies the student is currently using. You can also investigate what works and why (based on knowledge of the brain, learning and your own experience) and what can be done differently. New strategies can be trained if necessary, but it should be emphasised to the student that behavioural change takes time and effort.

2 *The professional.* It is also vital for the professional to take up brain education ([33]; [41]) to support the student in the process as formulated under 1 and in developing and implementing the education. Lack of brain knowledge or mishandling brain knowledge can lead to neuromyths that can harm the student's learning process ([42]). Furthermore, it is helpful to understand what different profiles (see 1) can mean in a student so that adequate coaching can be applied. In addition, an essential attitude of "curious, inquisitive, without judgment" contributes to the student's learning process. Incorrect labelling of the observed behaviour (e.g. 'lazy' or 'unmotivated') creates negative or wrong expectations of the student, which can lead to improper coaching in their learning process.

3 *The management*. It would help to formulate a clear vision and policy on how study success or student success is viewed. Student success is broader than study success and also includes the student's personal development. Providing explicit education and training during the program multiple times throughout the different years can be a component that contributes to the student's personal development. In addition, an organisation can ensure that professionals are adequately trained in EF and SRL to converse with students at different times about how they learn and solve problems. As a result, students also develop the language to describe what they are up against in their learning and how they want to address it. Creating this language is also an essential part of the student's development.

4.3 Limitations

This study has its limitations. First, the effect size in social science research is usually small. For example, there are so many "coincidental" (situational) aspects that can influence study success completely unrelated to SRL and EF – think, for example, caring responsibilities for a sick parent, poor student housing, or stress from a broken relationship - that in general no higher explained variance can be expected than .03.

Second, EF and SRL are measured by self-reports. These carry the risk of socially desirable answers or discrepancies in what students think of themselves and what they actually show. However, self-reporting provides an excellent representation of how students experience their performance, and this information forms a good starting point for interventions, such as coaching. Nevertheless, more objective measurements, such as through learning analytics, could also provide valuable insights into whether their perceptions match their observed behaviour and how the results relate to study success.

Finally, a pitfall of grouping may be that it does not do justice to the significant individual and intra-individual differences regarding the role that EF and SRL strategies play per individual student. We established the clusters from this study among a group of psychology students of a given year at a given time. The clusters are expected to be dynamic and to look slightly different at various times or with another group. Nevertheless, we do expect that there will always be a group that experiences relatively more EF problems combined with less SRL and less study success because of the correlational relationship that exists between the concepts of EF and SRL (e.g., [6]) and EF, SRL and study success (e.g., [43]). A pitfall could be that a classification such as this might even encourage labelling because a student is counted as belonging to a particular group.

4.4 Future directions

In a follow-up study, we will explore how to tailor to these different groups of students when designing blended learning environments. We will then formulate design principles that consider EF-fit learning environments.

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