Medical Teacher

ISSN: 0142-159X (Print) 1466-187X (Online) Journal homepage: www.tandfonline.com/journals/imte20

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To cite this article: Susanna M. Lucieer, Laura Jonker, Chris Visscher, Remy M. J. P. Rikers & Axel P. N. Themmen (2016) Self-regulated learning and academic performance in medical education, Medical Teacher, 38:6, 585-593, DOI: 10.3109/0142159X.2015.1073240

To link to this article: https://doi.org/10.3109/0142159X.2015.1073240

Published online: 24 Aug 2015.

2016, 38: 585–593 MEDICAL TEACHER

Self-regulated learning and academic performance in medical education

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Abstract

Content: Medical schools aim to graduate medical doctors who are able to self-regulate their learning. It is therefore important to investigate whether medical students' self-regulated learning skills change during medical school. In addition, since these skills are expected to be helpful to learn more effectively, it is of interest to investigate whether these skills are related to academic performance.

Methods: In a cross-sectional design, the Self-Regulation of Learning Self-Report Scale (SRL-SRS) was used to investigate the change in students' self-regulated learning skills. First and third-year students ($N = 949$, 81.7%) SRL-SRS scores were compared with ANOVA. The relation with academic performance was investigated with multinomial regression analysis.

Results: Only one of the six skills, reflection, significantly, but positively, changed during medical school. In addition, a small, but positive relation of monitoring, reflection, and effort with first-year GPA was found, while only effort was related to third-year GPA.

Conclusions: The change in self-regulated learning skills is minor as only the level of reflection differs between the first and third year. In addition, the relation between self-regulated learning skills and academic performance is limited. Medical schools are therefore encouraged to re-examine the curriculum and methods they use to enhance their students' self-regulated learning skills. Future research is required to understand the limited impact on performance.

Introduction

The medical profession has to ensure that high standards in providing patient care are repeatedly being met in the context of a rapidly and constantly changing medical world (Brydges & Butler 2012; Bjork et al. 2013). This means that medical doctors have to stay updated with the developments in their field of expertise and have to maintain their competencies (Greveson & Spencer 2005; Artino et al. 2012; Brydges & Butler 2012; Premkumar et al. 2013). To be able to benefit and choose from the many opportunities of continuous medical education, medical doctors have to define their own learning needs, set personal goals and engage in the most appropriate learning activities (Lycke et al. 2006; Brydges et al. 2012; Premkumar et al. 2013). In short, medical doctors have to be self-regulated learners, which means that they have to be behaviorally, metacognitively and motivationally proactive in their learning process (Zimmerman 1986; Wolters 1998; Jonker et al. 2010).

According to Ertmer and Newby (1996), self-regulated learners are individuals who are able to plan their study behavior, monitor their progress, reflect upon, and evaluate the entire learning process. Other researchers also highlighted the importance of motivational components in self-regulated learning (Hong & O'Neil 2001; Sitzmann & Ely 2011). They argued that one may be able to plan, monitor, reflect upon, and evaluate his or her learning behavior, but that these competencies are of little value when one is not motivated to employ them. Therefore, they added two subcomponents of motivation to the concept of self-regulated learning, i.e., effort and self-efficacy. Effort is crucial to reach the goals self-regulated learners have set, and self-efficacy is important since one needs to have trust in his or her own potential in order to complete a task (Hong & O'Neil 2001; Sitzmann & Ely 2011).

Since medical doctors should be self-regulated learners, medical schools aim to graduate medical doctors who have acquired these competencies (Greveson & Spencer 2005; Premkumar et al. 2013). Students can be helped to become

Practice points

- Medical schools aim to graduate medical doctors who are able to self-regulate their learning.
- Except for reflection, students' self-regulated learning skills do not change between the first and third year of medical school.
- Effort remains related to academic performance throughout medical school.
- In the first-year, students with higher levels of reflection and monitoring also obtain slightly higher grades.

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ISSN 0142-159X print/ISSN 1466-187X online/15/060585–9 © 2015 Taylor & Francis
DOI: 10.3109/0142159X.2015.1073240

self-regulated learners by providing them effective learning skills and appropriate and timely feedback (Zimmerman 1989; Hong & O'Neil 2001). When a task is correctly illustrated, a student can observe and imitate the performance afterwards. After first heavily relying on the observations, the process can become more and more internalized until it eventually becomes "self-regulated" (Brydges et al. 2015). Unfortunately, self-regulated learning skills are not always emphasized during medical school (Artino et al. 2012). While studies showed that students do develop self-regulated learning skills during medical school (Loyens et al. 2008), some graduates feel uncertain and unprepared to do so (Artino et al. 2012). Therefore, it is important to investigate to what extent medical students' self-regulated learning skills change during their education.

It has also been shown that self-regulated learning is one of the best predictors of academic performance (Pintrich & Degroot 1990). Self-regulated learning is viewed as a proactive learning process that is used to set learning goals and develop effective strategies for learning (Zimmerman 2008). This process helps people to transform mental abilities in academic skills, such as setting goals, developing learning strategies, and monitoring the progress and effectiveness of their learning (Zimmerman 2002, 2008). Knowing how to monitor the progress of your learning and how to control and adapt your learning behavior, is seen as a requirement for being a truly effective learner (Ertmer & Newby 1996; Bjork et al. 2013). Although research suggests that it is not necessary to use self-regulated learning skills for high achievement (Ablard & Lipschultz 1998), it has been shown that self-regulated learners are more effective learners (Nota et al. 2004; Toering et al. 2009) who get more out of their potential (Zimmerman 1986) and attain higher grades during high school (Nota et al. 2004) and in college (Ablard & Lipschultz 1998).

In this study, the Self-Regulation of Learning Self-Report Scale (SRL-SRS) is used. This questionnaire contains six subscales: planning, monitoring, evaluation, reflection, effort, and self-efficacy, following the theories of Ertmer and Newby (1996) and Hong and O'Neill (2001). The questionnaire has been shown to be a valid and reliable measure of self-regulated learning (Toering et al. 2012; Lucieer et al. 2015) and addresses two important questions on self-regulated learning. First, do students' self-regulated learning skills change during medical school? We hypothesize that they do since medical education is based upon the premise that students should develop self-regulated learning skills (Greveson & Spencer 2005). Second, is there a positive relation between self-regulated learning skills and grade point average during medical school? We hypothesize that there is, since it is expected that self-regulated learners are more efficient learners (Bjork et al. 2013) and are academically more successful (Zimmerman 1986; Ablard & Lipschultz 1998; Nota et al. 2004; Toering et al. 2009; Turan & Konan 2012).

Methods

Setting

This study was performed at Erasmus MC Medical School, Rotterdam, the Netherlands. The integrated and theme-oriented curriculum at this school comprises a three-year Bachelor degree course followed by a three-year Master degree course. The Bachelor of Medicine is divided into thematic blocks of 4–16 weeks, which are organized around pathophysiological systems and each theme covers subjects ranging from the basic sciences up to and including clinical practice. The Bachelor includes both lectures and small-group learning. While the lectures are voluntary, participation in about a quarter of the small-group sessions is compulsory. Skills such as planning, monitoring, evaluation, and reflection are specifically addressed during education, but students are not assessed on these skills.

Participants

Two cohorts of first-year students and one cohort of third-year students from the Erasmus MC Medical School were included in this study. In total, 1161 students were approached to participate, of whom 949 completed the questionnaire, giving an overall response rate of 81.7%. The mean age of the 949 respondents was 20.2 years ($SD = 2.2$ years); 582 respondents were female (61.3%) and 367 were male, a division similar to the total medical school student population at Erasmus MC Medical School. Of the two cohorts of first-year students, 595 out of 803 responded (73.9%) and of the third-year students, 354 out of 358 responded (98.9%). The mean age of the first-year students was 19.1 years ($SD = 1.9$) and 360 of them were female (60.5%) and 235 were male. The mean age of the third-year students was 21.5 years ($SD = 2.0$), 222 of them were female (62.7%) and 132 were male.

Instruments

Questionnaire: Self-regulation of learning – Self-report scale

The Self-Regulation of Learning Self-Report Scale (SRL-SRS) was used to investigate the students' level of self-regulated learning. The SRL-SRS contains 50 items on a 4- or 5-point Likert scale, depending on the subsection of the questionnaire. Following the theory described by Ertmer and Newby (1996) and Hong and O'Neill (2001), the questionnaire comprises six subscales of original English-language questionnaires: planning, monitoring, evaluation, reflection, effort, and self-efficacy. An example of a question in the subscale monitoring is: "While making an assignment, I check my progress," and an example from the subscale effort is: "I keep trying to finish my assignment, even when I find the assignment extremely difficult". The questionnaire has been compiled and validated in a Dutch study (Toering et al. 2012). The questionnaire was originally created for high school students. Therefore, in this study, minor changes were made in a few questions, e.g., the term homework was replaced by study assignments.

Measurements of academic performance

First-year and third-year grade point average (GPA) were used to investigate the correlation between students' level of self-regulated learning skills and their academic performance. Grades were given on a 10-point scale (1 = poor, 10 = excellent) where 5.5 was the cut-off for passing the course.

First-year GPA was calculated from all first-year exams taken by the students. Scores obtained on resits were not taken into account, also not for those students whose resit was their first attempt. For this study, students were divided in quartiles based on their GPA; the 25% students with the lowest GPA, the 25% students with a slightly higher GPA and so on. The first-year quartiles were Q1: GPA < 5.4; Q2: GPA 5.4–5.9; Q3: GPA 6.0–6.5 and; Q4: GPA > 6.5.

Third-year GPA was calculated from all obligatory third-year exams taken, since here, 25% of the curriculum existed of chosen courses, i.e., the minors. The third-year GPAs were slightly higher and were therefore divided as following: Q1: < 5.8; Q2: 5.8–6.3; Q3: 6.4–6.9 and Q4: > 6.9.

Procedure

The questionnaire was integrated as an assignment in both a first-year and in a third-year course. Students were on forehand informed about the use of their data for this study.

All students received an e-mail and at most two reminders with a personal link plus a deadline to complete the questionnaire online in LimeSurvey 1.19+ (Schmitz 2012). Students had to complete the questionnaire at home, and those who failed to complete it before the deadline were excluded from this study.

The questionnaire took approximately 20 minutes to complete. After completion, the students received a personal report which included background information on self-regulated learning, their personal score on each subscale and the scores of their fellow students divided in quantiles to allow comparison of their score to that of their fellow students. The reported personal scores were discussed in small-group meetings under supervision of a tutor to provide the students insight into their own study behavior.

The scores were used to investigate the development of students' self-regulated learning skills between the first and third year of medical school and to determine the association between self-regulated learning and academic performance. Data on academic performance was obtained from the university administrative system. All data were made anonymous.

Data analysis

Data were analyzed with the use of IBM SPSS AMOS version 18.0 (SPSS, Inc., Chicago, IL) and IBM SPSS Statistics version 21.0 (SPSS, Inc., Chicago, IL). Confirmatory factor analysis and Cronbach's alpha were used to investigate whether the constructs of the questionnaire fitted the model and to measure the internal consistency of the factors. A one-way ANOVA was performed to compare the level of self-regulated learning skills of the first and third-year medical students, a p value of <0.05 was considered significant. For the subscale reflection, *Welch F* was calculated since equal variances could not be assumed. Effect sizes, eta squared, were converted where 0.01, 0.06 and 0.14 indicate a small, medium, and large effect, respectively (Cohen 1988; Lakens 2013). The correlation between the self-regulated learning skills and the measures of academic performance were calculated with Pearson correlations and multinomial logistic regression analysis. Here, given the multiple comparisons, a more conservative p value of <0.01 was considered significant.

Results

Validation of the questionnaire

To validate the questionnaire, a confirmatory factor analysis was performed. The original six-factor model, developed by Toering et al. (2012) showed a mediocre fit in the current study; CFI was 0.86 (Byrne 2010) CMIN/d.f.-ratio was, with a score of 3.85, too high since this ratio is required to be less than 3.0, but the value of RSMEA, 0.055, was reasonable, since here a value less than 0.06 is required (Byrne 2010). In the first model, factor loadings of items 5, 13, 32, 29, 28, and 27 were low. These items belonged to the subscales planning (2), effort (1) and self-efficacy (3). By removing these items in the order of increasing factor loading, an adjusted model was obtained, which showed a good fit; a CFI of 0.93, a CMIN/d.f.-ratio of 2.94 and a RSMEA of 0.045. A summary of the χ^2 values, χ^2 differences and degrees of freedom of the adjusted model described above compared to a model with all factor loadings constrained equal is provided in Table 1. Since two groups of students were included in the study, factor invariance had to be tested between these groups. The χ^2 difference was not significant which indicates that the same constructs were measured in the first-year students and the in third-year students.

The internal consistency of the adjusted factors was strong (Table 2) and did not improve noteworthy when any other item within the factors was removed. Thus, the adjusted model was chosen to analyze the data.

Change of self-regulated learning skills

Table 3 shows the results of the comparison of the level of self-regulated learning skills of the first and the third-year medical students. On reflection, third-year students ($M = 20.4$) scored significantly higher than first year students ($M = 15.7$), *Welch F* (1, 944.417) = 221.918, $p < 0.001$, $\eta^2 = 0.152$, with the effect size indicating a large effect. No differences in level of self-regulated learning skills were found on the other subscales between first and third-year medical students.

Correlation with academic performance

Pearson correlation showed multiple significant relations between measures of academic performance in both year one and year three and the self-regulated learning skills, as reported in Table 2. To gain more insight in the direction and strength of the relations, a multinomial regression analysis was performed.

Multinomial logistic regression analyses showed that self-regulated learning skills explained a small proportion of the variance in GPA among first-year medical students: $R^2 = 0.086$, Model χ^2 (18) = 1592.612, $p < 0.001$ as well as some of the variance of the third-year students: $R^2 = 0.105$, Model χ^2 (18) = 38.735, $p = 0.003$ (Table 4 and Figure 1a for first-year and Table 5 and Figure 1b for third-year). Among the first-year students, the students with the lowest GPA (<5.4) reported

Table 1. Model summary of goodness of fit statistics for tests for invariance.

Model description	χ^2	Df	$\Delta\chi^2$	ΔDf	Statistical significance
Adjusted model	2130.065	725			
Model with factor loadings constrained equal	2960.930	1450	830.865	725	NS

χ^2 = Chi-square; Df = degrees of freedom; $\Delta\chi^2$ = difference in chi-square between the models; ΔDf = difference in number of degrees of freedom between the two models; NS = Not significant at 0.05 level.

Table 2. Descriptive statistics of the six factors of the self-regulation of learning self-report scale, reliability coefficients and Pearson correlations.

	No of items	Mean	Minimum	Maximum	1	2	3	4	5	6
1. Planning	6	16.1	6	24	(0.86)					
2. Monitoring	6	17.8	9	24	0.417**	(0.79)				
3. Evaluation	8	29.9	17	40	0.484**	0.614**	(0.79)			
4. Reflection	5	17.4	5	25	0.033	0.067*	0.104**	(0.96)		
5. Effort	8	22.7	8	32	0.355**	0.385**	0.446**	0.031	(0.83)	
6. Self-efficacy	7	21.0	12	28	0.245**	0.227**	0.186**	0.075*	0.197**	(0.80)
7. GPA year 1[b]		2.6	1	4	0.070	0.144**	0.090*	0.209**	0.148**	0.048
8. GPA year 3[b]		2.5	1	4	0.133*	0.168**	0.180**	−0.080	0.247**	0.037

Numbers in parentheses are Cronbach's alpha.
[b]GPA; 1 = lowest 25%, 4 = highest 25% of the students included in this study.
*$p < 0.05$, **$p < 0.01$.

Table 3. Only the level of reflection is significantly different between the first and third year.

	Planning	Monitoring	Evaluation	Reflection	Effort	Self-efficacy
Year 1 Mean ± SD	16.0 ± 3.4	17.9 ± 3.1	29.9 ± 3.7	15.7 ± 6.3	22.7 ± 3.9	20.9 ± 3.1
Year 3 Mean ± SD	16.1 ± 3.3	17.6 ± 3.0	29.9 ± 4.0	20.4 ± 3.5	22.7 ± 3.9	21.2 ± 3.2
Test value	$F = 0.001$	$F = 2.272$	$F = 0.001$	$F^* = 221.918^{**}$	$F = 0.002$	$F = 1.621$
η^2				0.152		

SD = Standard Deviation. Test value = *F*-ratio with (1, 947) degrees of freedom. *Welch *F* with (1, 944.417) degrees of freedom. **Significant at 0.05 level.
η^2 = eta squared, with 0.01, 0.06 and 0.14 indicating small, medium and large effects.

significantly less reflection ($\beta = -0.099$, $p < 0.001$) and effort ($\beta = -0.106$, $p = 0.003$) than students with the highest GPA (>6.5). Students with a GPA of 5.4–5.9 reported significantly less monitoring ($\beta = -0.130$, $p = 0.01$) than students with the highest GPA. In addition, students with a GPA of 5.5–5.9 reported significantly more reflection ($\beta = 0.052$, $p = 0.01$) than students with the lowest GPA (<5.4).

Among the third-year students, the students with the highest GPA (>6.9) reported significantly more effort than students with the lowest and second highest GPA (Q1: $\beta = -0.190$, $p < 0.001$; Q3: $\beta = -0.130$, $p = 0.009$). No other differences in reported use of self-regulated learning skills were found between third-year students when focusing on their GPA.

Discussion

In this study, we attempted to answer two questions. First, do students' self-regulated learning skills change between the first and third year of medical school? Second, is there a relation between students' self-regulated learning skills and their academic performance?

Concerning the first question, we hypothesized that students' self-regulated learning skills would change during medical school. However, we found that the levels of most self-regulated learning skills did not differ between the first and third year at medical school, except reflection, which was higher in the third year. Although in the curriculum self-regulated learning skills are emphasized, the overly structured character of the curriculum leaves little room for the students to develop and apply these skills (Premkumar et al. 2013). Nevertheless, this finding was unexpected. Not only have other studies reported that more mature students, as our third-year students are compared to our first-year students, showed higher levels of self-regulated learning (Kell & van Deursen 2003; Reio & Davis 2005; Premkumar et al. 2013), some researchers also showed a positive development of the use of self-regulated learning skills within just 15 months after enrolment in university (Downing et al. 2009). It is however possible that, since only the best students are accepted for medical school (Razack et al. 2012) these students already score relatively high at entrance, and therefore show little development of self-regulated learning during medical school

Table 4. The importance of reflection on academic performance in year 1.

		95% CI for Odds Ratio		
First-year GPA	B (SE)	Lower	Odds Ratio	Upper
Group 1 versus 4				
Intercept	3.638 (1.256)*			
Planning	−0.023 (0.041)	0.901	0.977	1.059
Monitoring	−0.100 (0.051)	0.818	0.905	1.001
Evaluation	0.048 (0.044)	0.962	1.050	1.144
Reflection	−0.099 (0.020)*	0.871	0.906	0.942
Effort	−0.106 (0.036)*	0.839	0.900	0.965
Self-Efficacy	0.015 (0.041)	0.936	1.015	1.101
Group 2 versus 4				
Intercept	2.255 (1.190)			
Planning	0.039 (0.041)	0.960	1.040	1.127
Monitoring	−0.130 (0.050)*	0.796	0.878	0.970
Evaluation	0.010 (0.043)	0.928	1.010	1.100
Reflection	−0.047 (0.019)	0.919	0.954	0.991
Effort	−0.047 (0.034)	0.892	0.954	1.020
Self-Efficacy	0.015 (0.040)	0.939	1.015	1.098
Group 3 versus 4				
Intercept	1.387 (1.142)			
Planning	0.014 (0.134)	0.940	1.014	1.095
Monitoring	−0.095 (0.049)	0.826	0.909	1.001
Evaluation	0.022 (0.042)	0.942	1.022	1.110
Reflection	−0.028 (0.019)	0.937	0.972	1.008
Effort	−0.047 (0.033)	0.894	0.954	1.018
Self-Efficacy	0.039 (0.039)	0.963	1.039	1.122

$R^2 = 0.086$ (Cox & Snell), 0.091 (Nagelkerke). Model χ^2 (18) = 1592.612, $p < 0.001$. B = slope, SD = standard deviation, CI = confidence interval.
*$p < 0.01$.
GPA; 1 = lowest quartile, 4 = highest quartile of the first-year students included in this study.

itself (i.e. ceiling effect). It would be interesting to measure self-regulated learning skills in a more heterogeneous student population, where entry requirements are not as high as for medical school, in order to investigate if their level of self-regulated learning skills at start of university leaves more room for improvement.

In addition, most people have a strong assumption that children and adults do not need to be taught how to learn and how to manage their learning behavior (Bjork et al. 2013). It is often expected that everyone will gradually acquire learning skills during school, at home and in other situations (Bjork et al. 2013). Research showed that self-regulated learning skills can be taught, but they have to be specifically emphasized (Zimmerman, 1989; Hong & O'Neil 2001) and students need to be provided with appropriate instructions (Brydges et al. 2015). It might be that medical schools too easily assume that students develop these self-regulated learning skills anyways, and therefore not explicitly teach their students how to do so.

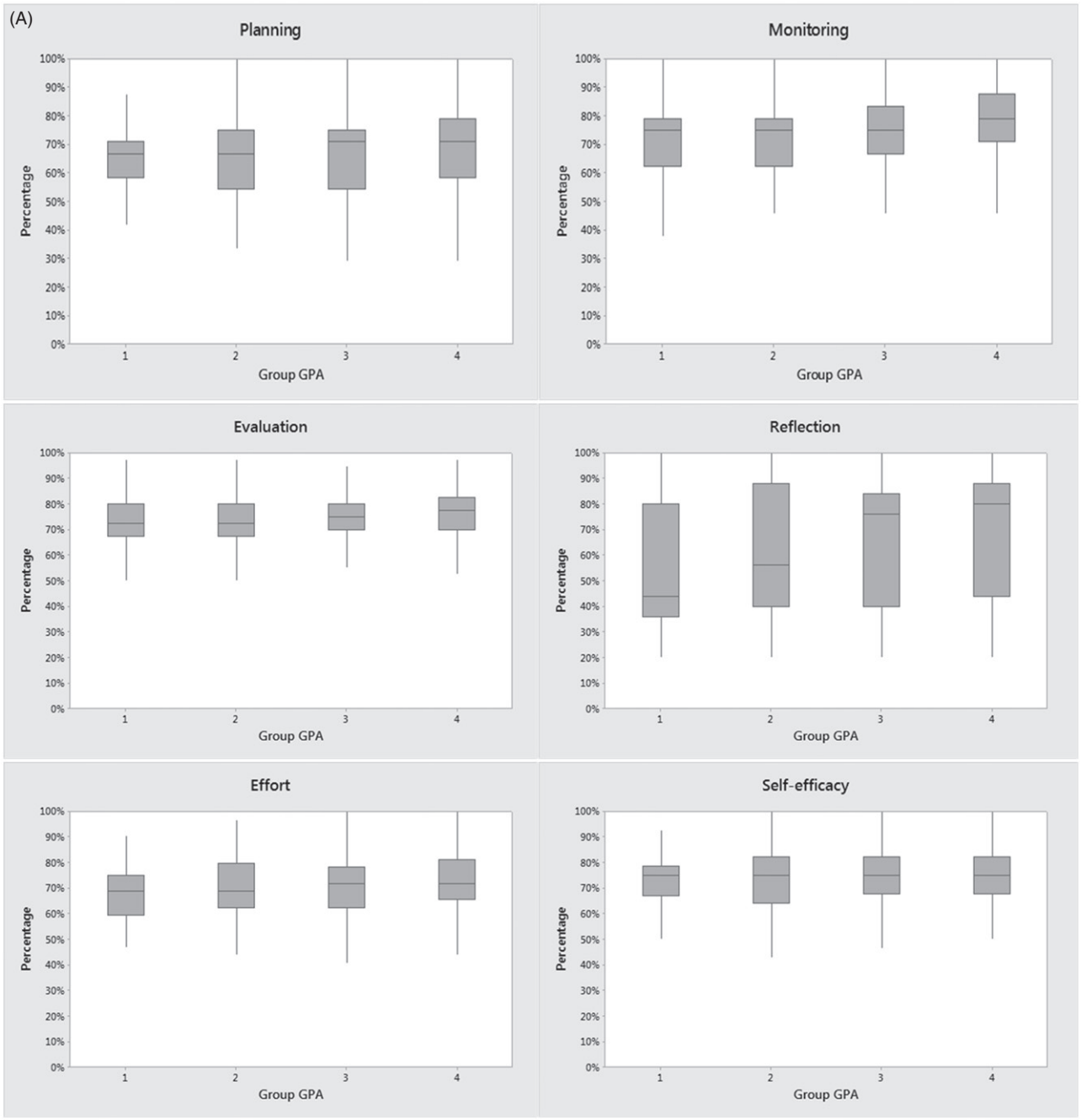
Further, people often have a flawed mental model of how they learn and remember (Bjork et al. 2013) and tend to overestimate their self-regulated learning skills (Zimmerman 2008), especially when they do not have knowledge of the criteria and standards of good performance (Kostons et al. 2012). It is possible that first-year students overestimated their use of self-regulated learning skills more than third-year students, and thus, reported a higher use of self-regulated learning skills. The question however remains why there is one skill that does develop, i.e., reflection. Future research with a longitudinal design is required to gain more insight in the thoughts of students on self-regulated learning.

Our second hypothesis was that high level self-regulated learners would achieve higher grades during medical school than low level self-regulated learners, since many studies had shown that self-regulated learners are more effective learners (Nota et al. 2004; Toering et al. 2009), who attain higher grades in high school (Nota et al. 2004) and university (Ablard & Lipschultz 1998). This study confirmed that some variation in performance could be explained by the students' self-regulated learning skills, both in the first-year and in the third-year, but a large part of the variation remained unexplained. In the first-year, a relation was found between academic performance and reflection, effort and monitoring. The finding that reflection is important for academic performance is not surprising, since reflection is the key to transform knowledge about learning into behavior (Ertmer & Newby 1996). Previous research showed that learners who display greater control of their learning are academically more successful (Zimmerman 1986; Wolters 1998). Reflection allows learners to make changes in their future learning behavior. Reflection is seen as the center of learning, and the more people reflect the more automatic and efficient the entire learning process becomes.

Effort was also related to first-year academic performance. According to Hong and O'Neill (2001), effort is necessary to actually use the other self-regulated learning skills one possesses. Effort is crucial to reach the goals a learner has set (Hong & O'Neil 2001) and is required to persist on difficult tasks (Pintrich & Degroot 1990; Hong & O'Neil 2001). It is therefore not surprising that first-year students with higher levels of effort obtain higher grades. Regards to monitoring, not the students with the lowest GPA reported the lowest level, but those with the second lowest GPA. This could be the result of the so called Kruger–Dunning effect; poorly performing learners rarely monitor their learning and consequently are unlikely to notice that they are not doing so (Ertmer & Newby 1996; Kruger & Dunning 1999; Langendyk 2006; Kostons et al. 2012). This latter finding could explain why we did not find a lower level of monitoring in the poorest performing students, but we did find it in those students who did perform a little better. These students were perhaps more aware of the fact that they did not monitor their learning very well.

In the third year of medical school, only effort was to some extent related to performance differences. As described before, effort can be seen as the perseverance to reach goals and accomplish tasks and assignments. Perseverance is especially required when examinations and assignments get more difficult, and students need to make a bigger effort to successfully complete them. Perseverance, or self-discipline, has also been put forward by other studies as the main predictor of academic performance, and is even surpassing IQ and previous performance (Duckworth & Seligman 2005). It is therefore not surprising that effort stays important throughout medical school.

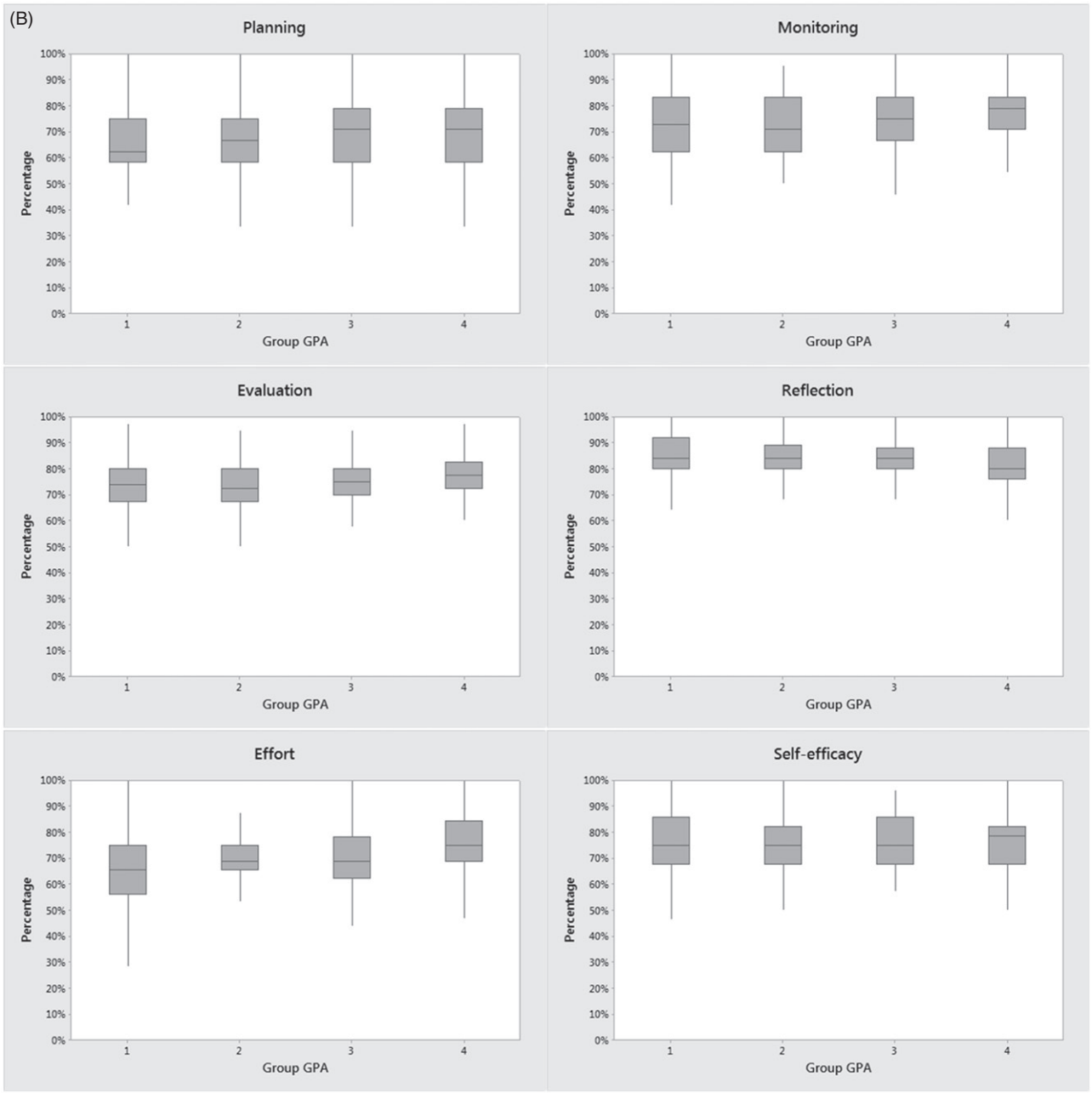
Reflection and monitoring were not related to third-year academic performance. The third-year students all showed



Scores on the self-regulated learning subscales are provided in percentages, where 100% equals the maximum score on the subscale.
The numbers 1 till 4 of GPA represent the first-year GPA of the students: Q1: GPA <5.4; Q2: GPA 5.4-5.9; Q3: GPA 6.0-6.5 and; Q4: GPA > 6.5.

Figure 1. (A) Distribution of self-regulated learning skills in different first-year GPA groups. Scores on the self-regulated learning subscales are provided in percentages, where 100% equals the maximum score on the subscale. The numbers 1 to 4 of GPA represent the first-year GPA of the students: Q1: GPA <5.4; Q2: GPA 5.4–5.9; Q3: GPA 6.0–6.5 and; Q4: GPA > 6.5. (B) Distribution of self-regulated learning skills in different third-year GPA groups. Scores on the self-regulated learning subscales are provided in percentages, where 100% equals the maximum score on the subscale. The numbers 1 to 4 of GPA represent the third-year GPA of the students: Q1: GPA <5.8; Q2: GPA 5.8–6.3; Q3: GPA 6.4–6.9 and; Q4: GPA >6.9.

higher levels of reflection than the first-year students. Further research is needed to clarify why these skills are less important in the third year of medical school than in the first year. However, a large proportion of the variance in academic performance, both in the first as in the third year, was not explained by the self-regulated learning skills. Previous research already indicated that participation and attendance of lectures and skills training, which is related to effort, had the largest impact on first-year academic performance (Stegers-Jager et al. 2012). In addition, this study showed that deep learning negatively influenced the first-year grades, and they suggested that deep learning strategies were only



Scores on the self-regulated learning subscales are provided in percentages, where 100% equals the maximum score on the subscale.
The numbers 1 till 4 of GPA represent the third-year GPA of the students: Q1: GPA <5.8; Q2: GPA 5.8-6.3; Q3: GPA 6.4-6.9 and; Q4: GPA > 6.9.

Figure 1. Continued.

valuable in combination with attendance (Stegers-Jager et al. 2012). Future research is required to investigate whether attendance would explain the difference in performance among the students in this study.

Although this study has identified several interesting findings regarding the change of self-regulated learning skills during medical school and their relation to academic performance, some limitations are worth mentioning. One notable limitation of this study is the use of a cross-sectional design, while a longitudinal design would have been more appropriate. Still, a cross-sectional design is deemed acceptable since the groups are comparable in age and gender, the sample size is large, the response rate is comparable, and all students attended the same medical school and in the same curriculum. It is therefore appropriate to assume that all students will change in a similar way (William & Darity 2008).

A second limitation is that we investigated the difference in self-regulated learning between the first and third year at medical school, while some students' skills might change in later years once the connection with their future professional life becomes more apparent, such as during clerkships. We, however, deliberately chose to measure the change in the pre-clerkship phase since the impact of the medical school curriculum is more visible in these years, while the hospital setting might influence the students more during their clerkships, and the various hospitals might influence students' learning behavior in different ways.

Table 5 The importance of effort for academic performance in year 3.

		95% CI for Odds Ratio		
Third-year GPA	B (SE)	Lower	Odds Ratio	Upper
Group 1 versus 4				
Intercept	3.483 (1.727)			
Planning	0.004 (0.061)	0.891	0.891	1.131
Monitoring	−0.032 (0.075)	0.835	0.835	1.123
Evaluation	−0.051 (0.061)	0.844	0.951	1.071
Reflection	0.095 (0.050)	0.997	1.099	1.212
Effort	−0.190 (0.052)*	0.747	0.827	0.915
Self-Efficacy	0.048 (0.056)	0.940	1.049	1.170
Group 2 versus 4				
Intercept	3.502 (0.1608)			
Planning	−0.033 (0.056)	0.867	0.967	1.079
Monitoring	−0.019 (0.070)	0.856	0.981	1.125
Evaluation	−0.089 (0.056)	0.821	0.915	1.021
Reflection	0.102 (0.046)	1.011	1.107	1.212
Effort	−0.100 (0.048)	0.824	0.905	0.994
Self-Efficacy	0.029 (0.052)	0.929	1.029	1.140
Group 3 versus 4				
Intercept	1.454 (1.645)			
Planning	0.028 (0.058)	0.918	1.029	1.152
Monitoring	0.022 (0.074)	0.885	1.022	1.181
Evaluation	−0.051 (0.059)	0.848	0.951	1.066
Reflection	0.050 (0.042)	0.969	1.052	1.141
Effort	−0.130 (0.050)*	0.848	0.878	0.969
Self-Efficacy	0.062 (0.054)	0.957	1.064	1.184

$R^2 = 0.105$ (Cox & Snell), 0.112 (Nagelkerke). Model χ^2 (18) = 38.735, $p = 0.003$. B = slope, SD = Standard deviation, CI = confidence interval.
*$p < 0.01$.
GPA; 1 = lowest quartile, 4 = highest quartile of the third year students included in this study.

A final concern is the tool we used to measure the students' self-regulated learning skills. Some students may have overestimated their self-regulated learning skills, which may have influenced the findings. Other methods previously described to measure self-regulated learning are computer tasks, thinking-aloud protocols, observations, interviews, and structured diaries (Zimmerman 2008). However, when using computer tasks, the focus is on measuring changes in self-regulated learning during performance, and not over a longer time. Moreover, the other methods are less suited for a study in a large student population such as the present, and are less effective in a cross-sectional approach. Since the SRL-SRS has been found to be a valid and reliable measure of self-regulated learning (Toering et al. 2012; Lucieer et al. 2015) we decided that this questionnaire was the best option to use in this study.

Conclusion

Although medical schools aim to graduate medical doctors who are also lifelong learners, we found that most self-regulated learning skills did not change during medical school, except for the skill reflection. Although the first-year students reported already high levels of self-regulated learning skills, many factors can negatively influence these skills. Students need to be taught how to regulate their learning behavior, they need to receive sufficient instructions, and they need to be supported by teachers. Medical schools should evaluate their curriculum to see to what extent they truly stimulate their students to develop self-regulated learning skills, and which aspects can hinder this development.

In addition, not only effort, but also reflection and monitoring, explain a small part of the variance in academic performance during medical school. Future research is required to gain understanding of this limited role, and to understand what other factors are related to academic performance in medical school.

Glossary

Self-Regulation Theory: As applied to medical education, describes the cyclical control of academic and clinical performance through several key processes that include goal-directed behavior, use of specific strategies to attain goals, and the adaptation and modification to behaviors or strategies to optimize learning and performance.

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Declaration of interest: The authors have no declarations of interest to report. This study was supported by Erasmus MC.

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