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Published in:
Assessment & Evaluation in Higher Education

DOI:
[10.1080/02602938.2019.1667954](https://doi.org/10.1080/02602938.2019.1667954)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2019

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):
van Woezik, T., Koksma, J., Reuzel, R., Jaarsma, D., & van der Wilt, G. J. (2019). How to encourage a lifelong learner? The complex relation between learning strategies and assessment in a medical curriculum. *Assessment & Evaluation in Higher Education*. <https://doi.org/10.1080/02602938.2019.1667954>

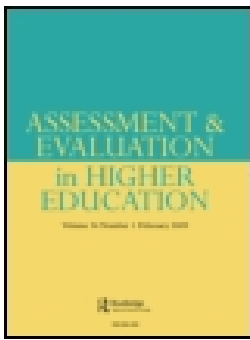
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To cite this article: Tamara van Woezik, Jur Koksma, Rob Reuzel, Debbie Jaarsma & Gert Jan van der Wilt (2019): How to encourage a lifelong learner? The complex relation between learning strategies and assessment in a medical curriculum, *Assessment & Evaluation in Higher Education*, DOI: [10.1080/02602938.2019.1667954](https://doi.org/10.1080/02602938.2019.1667954)

To link to this article: <https://doi.org/10.1080/02602938.2019.1667954>



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Published online: 23 Sep 2019.



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How to encourage a lifelong learner? The complex relation between learning strategies and assessment in a medical curriculum

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ABSTRACT

To foster lifelong learning skills, we need new didactic approaches with aligned assessment methods. Therefore, we investigated whether the outcomes of a project assignment show a different relation to learning strategies than a longitudinal knowledge-based assessment. We studied learning strategies of first year students of medicine and biomedical sciences ($n=248$) and performed hierarchical regression analyses for the learning strategies and grades of the longitudinal knowledge-based test and project assignment. Scores of students, measured with the Motivated Strategies for Learning Questionnaire (Likert scale 1–7), were relatively low for critical thinking (3.53), compared to rehearsal (4.40), elaboration (4.82), organisation (4.69) and metacognitive self-regulation (4.33). Knowledge based tests showed a significant relation to elaboration ($p < 0.01$). For the project-based assessment, we did not find a significant relation to any learning strategy ($p = 0.074$). Explained variance of the grades was low for all learning strategies ($R^2 < 0.043$). Different types of assessment did not discriminate between students with high or low scores on learning strategies associated with lifelong learning. An explanation is that the curriculum is not aligned with assessment, or students do not benefit in terms of grades. We conclude that, if assessment is to drive lifelong learning skills, this is not self-evident.

KEYWORDS

Lifelong learning; learning strategies; assessment; undergraduate medical education; curriculum

Introduction

The fields of medicine and science change continuously and rapidly. This means that it is important for doctors and other (bio-)medical professionals to cope with ongoing changes (Frenk et al. 2010). In order to do so, professionals in the medical field are encouraged to develop lifelong learning. This is based on the idea that ongoing critical reflection will help the medical professional of the future to cope with problems we cannot yet foresee. Thus, lifelong learning is seen as a critically important professional competency in this field (Wojtczak 2002; Li et al. 2010). Lifelong learning is associated with deep learning strategies like elaboration and critical thinking, and self-regulatory capacities (Candy 1991; Kirby et al. 2010; O'Sullivan et al. 2012). Obviously, one could already start at the undergraduate level to foster relevant deep learning and

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 Supplemental data for this article is available online at <https://doi.org/10.1080/02602938.2019.1667954>.

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self-regulatory strategies. Understanding this, many institutions for medical education currently redesign their educational programme accordingly (Mifflin, Campbell, and Price 2000; Lim 2012).

A lifelong learning curriculum enables students to accumulate knowledge, discuss this knowledge and reflect on it, and adjust learning strategies on the basis of new insights. To make such learning possible, there are some prerequisites to the education environment. First, the curriculum should give students genuine practice bases to learn from (Brigley et al. 1997). Second, habits of inquiry are important for reflection on oneself and medical practice, which will lead to an increased quality of medical practice (Westin, Sundler, and Berglund 2015). The best place to learn inquiry skills is in a community of practitioners that demonstrate them habitually (Irby 2011). On top of that, stimulating lifelong learning necessitates permission of a certain degree of self-direction. In this way, it is assumed, students will more naturally adopt skills like self-reflection, critical thinking and elaboration (Candy 1991; Garrison 1997; Bolhuis 2003; Blom and Severiens 2008).

To develop such a curriculum, one should take care to align new education methods with assessment methods. After all, student perceptions and performance on an assessment may influence their learning strategies (Nicol and Macfarlane-Dick 2006). There is a difference in the degree to which learning behaviour relates to assessment, as some assessment methods are better at predicting future clinical performance than others, especially when they explicitly focus on clinical reasoning behaviour (Wilkinson and Frampton 2004). Reasoning along these lines, one would look for assessment methods that stimulate learning strategies such as elaboration and critical thinking. We assume that a relation exists between performance on different types of assessment (focussed on knowledge retention or lifelong learning skills) and learning strategies, and that students adjust their learning strategies accordingly.

The Motivated Strategies for Learning Questionnaire (MSLQ) is widely used to assess motivation and learning strategies, including those that are associated with lifelong learning skills: elaboration, critical thinking and metacognitive self-regulation (Pintrich et al. 1993; Duncan and McKeachie 2005). We already know that students show better motivation and study results when they participate in a curriculum focussed on lifelong learning (O'Shea 2003; McMillan et al. 2007; Murad et al. 2010; van Vliet, Winnips, and Brouwer 2015). However, the effects of learning strategies may differ as studies show inconsistent results. For instance, Pizzimenti and Axelson (2015) show a positive relation between elaboration, critical thinking and grade point average (GPA), whereas others imply that metacognitive self-regulation is a better predictor of study success (Kassab et al. 2015), or even find a negative association with performance (Stegers-Jager, Cohen-Schotanus, and Themmen 2012).

One possible explanation for these differences may be that most of this research on MSLQ-defined learning strategies and lifelong learning is focused on GPA scores. The problem with outcomes such as GPA or course grades is that they are often based on assessment of knowledge only. However, if students are still required to take standardised knowledge tests, they might not benefit from adapting new learning strategies like critical thinking (Shumway and Harden 2003; Rear 2019). In that case, better test results may actually be achieved by learning strategies such as rehearsal, and students will keep on using these. Therefore, we should not only assess whether students have good study results and GPA scores based on knowledge assessment in general, but also whether the assessment aligns with what we ask of students and what they learn (Palmer and Devitt 2007). Some studies indeed assess skills and attitude specifically as outcomes of a curriculum that educates for lifelong learning, but these have led to heterogeneous results, too (Loyens, Magda, and Rikers 2008; Lounsbury et al. 2009).

Projects are considered to promote deep learning strategies, as they are commonly less focussed on knowledge retention and leave more room for students to define and develop the project themselves. Moreover, they are considered to be appropriate assessment methods for evaluating deep learning strategies. However, surprisingly few studies target the relation between new forms of assessment and learning strategies. One study shows a positive relation

between self-regulated learning ability and e-portfolio achievement (Cheng and Chau 2013). Other studies show no relation between deep learning strategies and case-based examination (Turan and Konan 2012), or short essay questions (Reid, Duvall, and Evans 2007). As for now, it is not clear what kind of assessment method fits with each respective learning strategy. Intuitions about which assessment methods will work, and why, need more scrutiny and sophistication, since multiple choice tests can in some circumstances assess deep learning strategies, or project reports can fail to do so (Williams 2006; Hift 2014). Therefore, we test the hypothesis that deep learning strategies are identified better by project-based assessment compared to knowledge based assessment.

Understanding the relation between learning strategies and assessment formats is critically important for understanding the mechanisms and effectiveness of a curriculum that intends to foster lifelong learning. Therefore, we aim to study this relation, and offer some putative explanations. The research question we address in the present paper is: what is the relation between MSLQ-defined learning strategies and assessment formats targeted at knowledge acquisition or lifelong learning skills?

Methods

Participants

A new undergraduate medical and biomedical science curriculum of the Radboudumc in Nijmegen, the Netherlands, started in September 2015. At the end of the first semester, in January 2016, all 460 first year students were asked to participate in this study. Of these students, 334 (72.6%) studied medical sciences, 126 (27.4%) studied biomedical sciences, 314 (68.3%) were female and 146 (31.7%) were male.

Material

The Motivated Strategies for Learning Questionnaire (MSLQ) was used to assess learning strategies among our student population (Pintrich et al. 1993). Other questionnaires to assess learning strategies that encompass lifelong learning skills were available, such as the LASSI (Olaussen and Braten 2010), SDLRS (Guglielmino and Hillard 2007), PRO-SDL (Stockdale and Brockett 2011) and SDLRSNE (Fisher, King, and Tague 2001), but we used the MSLQ because it inquires into current use of learning strategies more directly. The MSLQ measures nine learning strategies, of which we used the following five in this study: rehearsal, organisation, elaboration, critical thinking and metacognitive self-regulation. We considered the three learning strategies elaboration, critical thinking and metacognitive self-regulation as characteristic indicators of lifelong learning skills (Blom and Severiens 2008). However, this should not be taken to mean that the other learning strategies are less important, or should be viewed as inhibiting lifelong learning (Candy 1991; Pintrich et al. 1993). The MSLQ is comprised of a seven-point Likert scale (1–7), on which students indicate the extent to which they (dis-)agree with 81 statements. Next to the five learning strategies we used in this study, the MSLQ measures four more learning strategies and six motivation strategies. The questionnaire was provided in English, its original language. Dutch students are familiar with English, since much of the learning materials used in the curriculum is in English as well.

Context

The new curriculum of the Radboudumc incorporates self-directed and practice-based learning to promote the development of lifelong learning. Self-directed learning translates into learning methods that incorporate setting learning goals, devising a learning plan, and reflecting on the learning process (Knowles 1975). Practice-based learning means that students use experiences

from practice such as contacts with doctors or patients, to formulate problems that they would like to solve (Wilson 2012). This translates into a curriculum with patient contact, lectures, working groups and self-study assignments. The student can choose to follow certain extra courses or use specific education forms as the student believes necessary for his or her learning programme.

The new curriculum started in 2015, and during the first two years is similar for both medicine and biomedical sciences students. Self-directed learning allows students to set their own learning goals to some extent, but main goals for the overall curriculum and specific goals for courses remain predefined. The curriculum is built up by different educational tracks, for instance 'Mechanisms of health and disease' and 'Projects', which are two large tracks of 24 and 9 ECTS (European Credit Transfer System; study points), respectively. 'Professionalism' and 'Context, science and innovation' are smaller (4 and 5 ECTS, respectively). All tracks run throughout one year and consist of different small courses or modules. See Table 1 for an overview of the curriculum.

The self-directed and practice-based learning environment is most prominent in the module 'Projects', which encompasses the Innovation Project. First year students need to define a problem in the field of medicine or biomedical science and try to think of an innovative solution to this problem. They collaborate with real world partners, perform a context analysis based on stakeholder interviews and try to realise part of their innovative idea. The substantial size and duration (eight months) of the Innovation Project makes it a suitable environment to investigate our main research question.

To complete the Innovation Project, students need to use self-directed learning strategies: they need to set learning goals, reflect on their knowledge, and think critically about what they need to do. Students employ a human centred, design thinking method that is quite new to medical education (van de Grift and Kroeze 2016; Badwan et al. 2017). Examples of innovations that students developed are a virtual reality experience of an operation room to reduce pre-operative patient anxiety and a system for Parkinson patients to help them roll over in bed during the night.

The track 'Mechanisms of health and disease' comprises the largest part of the curriculum (24 ECTS). The assessment of this track consists of longitudinal knowledge tests. Each of these longitudinal tests consists of 80 multiple choice questions. Its longitudinal character is reflected in testing for currently relevant knowledge, as well as knowledge that was taught before the period in which the test takes place. That is, 20–50 questions are about knowledge the students acquired from the start of the first semester, and 30–60 questions are about knowledge the students acquired over the more recent period of ten weeks preceding the test. As such, this assessment method provides students with insight in both their current knowledge as well as their knowledge development.

Procedure

The study results used for this research project are the grades for the Innovation Project, and the grades for the longitudinal knowledge tests of the track 'Mechanisms of health and disease'.

Table 1. Timeline of academic year, including division in quartiles, semester and summary of the tracks.

Quartile	Q1		Q2		Q3		Q4	
Week	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40
Semester	1				2			
Track	Mechanisms of health and disease Projects Context, science and innovation Research (Biomedical sciences)/Practice and principles of medicine (Medicine) Professionalism Patient contact							

Students completed the longitudinal test four times per semester, so eight times in total during the academic year which runs from September to July. All first semester tests took place before the students filled out the MSLQ questionnaire, and second semester tests took place after administering the questionnaire (see Table 2).

Two grades were given for the Innovation Project; for a group project report and an individual reflection at the end of the year. The final grade consisted of the mean of these two grades. The group report reflected the process and results of a period of eight months in which students came up with a relevant medical problem and a fitting innovative solution. In the individual reflection essay, students reflected on the group process, their personal effectiveness, and their individual learning. A rubric was used to assess the Innovation Project report, which was also available to the students.

Students visit weekly coaching groups (in the track 'Professionalism') to reflect on their development and check whether they are still on the right track. The coaching groups also comprise assignments based on which the students receive study credit points. One assignment that the students had to complete for the coaching groups is filling out the MSLQ. When the students finished the questionnaire, they could see their own score and use that to reflect on their learning process.

Before filling in the MSLQ, students received information about the research project. Informed consent was obtained for the use of the results of the questionnaire and study results of the Innovation Project and the longitudinal knowledge tests. This study was approved by the ethical review board of the Netherlands Association for Medical Education (NVMO-ERB), file number 604.

Statistical analyses

The distribution of students' scores on rehearsal, elaboration, organisation, critical thinking and metacognitive self-regulation was assessed. The MSLQ does not have predefined cut-off scores, so a comparison to the overall mean score provides insight in the trends of scores. To gain more insight in this trend, the scores on learning strategy scales were compared to the mean scores of students of 10 other studies in comparable groups (Pintrich et al. 1993; Dahl, Bals, and Turi 2005; Turan and Konan 2012; Mazumder 2014; Kassab et al. 2015; Pizzimenti and Axelson 2015; Van Nguyen et al. 2015; Bruso and Stefaniak 2016; Hamid and Singaram 2016).

A hierarchical multiple regression analysis was performed to investigate which learning strategies relate to a better performance on both the longitudinal knowledge tests and the Innovation Project. For the Innovation Project we used the combined grade of the group project report and individual reflection of the Innovation Project (test score 1), and for the longitudinal tests we used the average grades of the longitudinal tests of semester 1 (test score 2) and semester 2 (test score 3). These grades were used to calculate three separate regression analyses, with the three test scores as dependent variables, and the five mean scores of the learning strategy scales as independent variables.

To get a more detailed understanding of the potential difference in learning strategies between students that score high on the longitudinal tests and the students that score high on

Table 2. Timeline of academic year.

Quartile Week	Q1		Q2		Q3		Q4	
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40
Semester			1				2	
Longitudinal test	X	X	X	X	X	X	X	X
Innovation project				X				X
MSLQ				X				

Moments (X) that students take the longitudinal test, hand in the Innovation Project report and fill out the MSLQ.

the Innovation Project, we calculated subsequent univariate regression indices for those relations that turned out to be significant in the first, multivariate regression model.

Type of study and gender were considered as co-variables. Study and gender might be of importance in this study, since the study population has around 30% male students and around 30% biomedical sciences students. T-tests were conducted to determine differences between men and women, and between students of medicine and biomedical sciences. In subsequent regression analysis, the influence of these differences on study results was considered.

Results

Description of population

A total of 248 out of 460 students (53.9%) participated in the study. Of these first-year students, 169 (68.1%) women and 79 (31.9%) men participated. Within this group, 188 (75.8%) were medical students and 60 (24.2%) were students of biomedical sciences. The mean age of the first-year participants is 18.7 years, with a range of 18 to 26 years. These data indicate that the study population is comparable to the general student population of Radboudumc students. See [Table 3](#) for an overview.

Boxplots for the learning strategy scales of the Motivated Strategies for Learning Questionnaire for our student population are shown in [Figure 1](#). Students' mean scores are 4.40 for rehearsal, 4.82 for elaboration, 4.69 for organisation, 4.33 for metacognitive self-regulation and 3.53 for critical thinking.

Comparison to other study populations

We compared the learning strategy scales of the MSLQ for our own students with other studies that used the MSLQ. We selected studies on 10 other student populations that also reported MSLQ mean scores (Pintrich et al. 1993; Dahl, Bals, and Turi 2005; Turan and Konan 2012; Mazumder 2014; Kassab et al. 2015; Pizzimenti and Axelson 2015; Van Nguyen et al. 2015; Bruso and Stefaniak 2016; Hamid and Singaram 2016). Data of these studies came from students of various backgrounds in the Netherlands, Norway, USA, Bangladesh, Vietnam, South Africa, Bahrain and Turkey. The mean MSLQ scores for these populations and the Radboudumc population are shown in [Figure 2](#). Radboudumc students score similar compared to other countries on almost all learning strategies, except critical thinking. We could not calculate significance values, but found that Radboudumc students score 18% lower on critical thinking.

Relation between learning strategies and study results

To analyse the relation between learning strategies and study results, we performed three multivariate regression analyses ([Table 4](#)). These analyses show a high effect for elaboration and the longitudinal knowledge tests. Regarding the Innovation Project, the highest effect was for rehearsal.

Based on these results, we performed subsequent univariate regression analyses for the strongest relations. Elaboration shows a relation with semester 1 longitudinal tests ($\beta = 0.207$,

Table 3. Descriptive data on gender and type of study in the study population.

Gender	N (percentage)	Study	N (percentage)
Female	169 (68.1%)	Medical Sciences	188 (75.8%)
Male	79 (31.9%)	Biomedical Sciences	60 (24.2%)

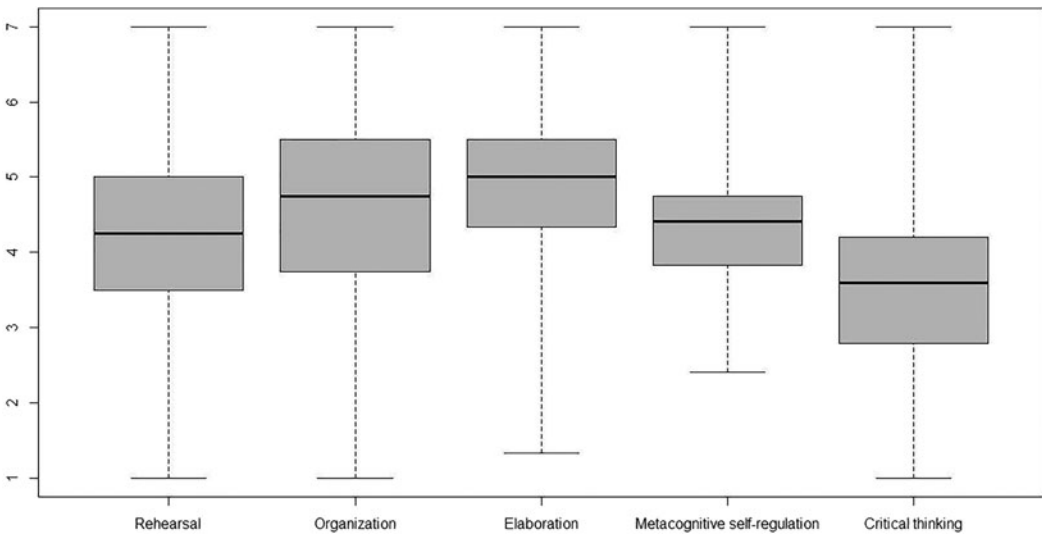


Figure 1. Boxplots of Radboudumc students' scores on MSLQ learning strategy scales: Rehearsal (median = 4.25, IQR = 1.50); Elaboration (median = 4.83, IQR = 1.33); Organisation (median = 4.75, IQR = 1.50); Metacognitive self-regulation (median = 4.33, IQR = 0.92); Critical thinking (median = 3.60, IQR = 1.20).

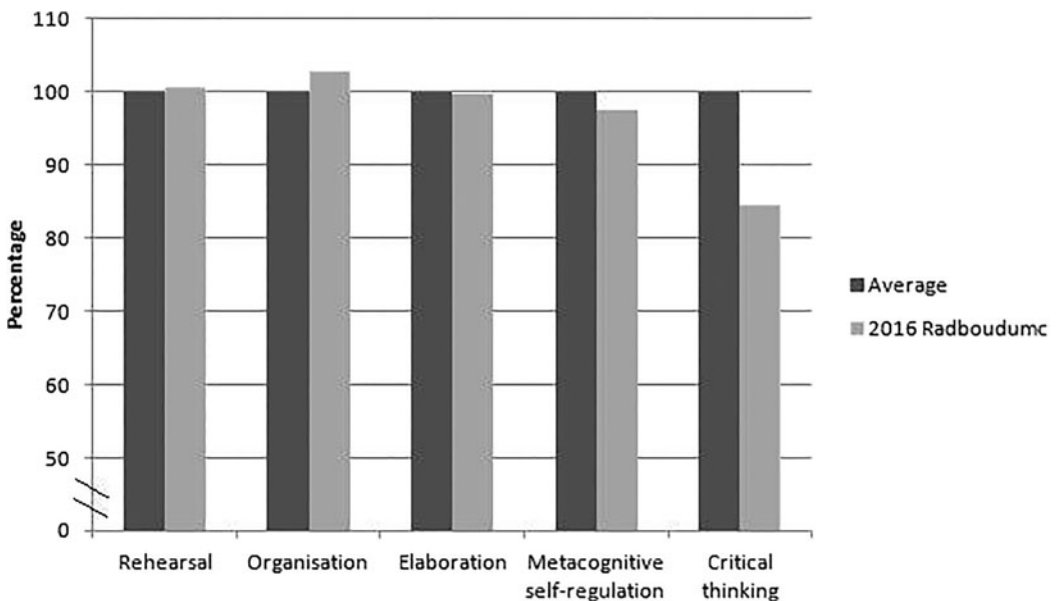


Figure 2. Comparison of mean scores on MSLQ learning strategy scales between other studies and the Radboudumc 2016 first-year students in percentages. For Rehearsal, these scores are 4.37 and 4.40, respectively; for Elaboration 4.82 and 4.81; for Organisation 4.56 and 4.69; for Metacognitive self-regulation 4.44 and 4.33; and for Critical thinking 4.18 and 3.53.

$t(246) = 3.266, p = 0.001$) which has a significant portion of explained variance ($R^2 = 0.043, F(1, 239) = 10.66, p = 0.001$). The relation between elaboration and semester 2 longitudinal tests was also significant ($\beta = 0.181, t(246) = 2.80, p = 0.006$) and has a significant explained variance ($R^2 = 0.033, F(1, 232) = 7.84, p = 0.006$). For the Innovation Project, there was a non-significant relation with rehearsal ($\beta = 0.118, t(246) = 1.798, p = 0.074$). The proportion of explained variance was low ($R^2 = 0.014, F(1, 227) = 3.233, p = 0.074$). To understand these relations better, we analysed the data further on study and gender influences.

Table 4. Step 1 of three multivariate regression analyses.

	Longitudinal test Semester 1		Longitudinal test Semester 2		Innovation project	
	β coeff.	p value	β coeff.	p value	β coeff.	p value
Rehearsal	0.011	0.873	0.087	0.246	0.081	0.296
Organisation	-0.017	0.843	0.035	0.681	0.019	0.830
Elaboration	0.221	0.007*	0.147	0.076	0.043	0.607
Metacognitive self-regulation	0.034	0.693	-0.019	0.827	0.018	0.843
Critical thinking	-0.077	0.299	-0.001	0.986	0.055	0.473

Grades of the students on the three tests are dependent variables and the five MSLQ learning strategy scales are independent variables. * significant under $\alpha=0.01$

Study and gender influences

T-tests indicated no differences between men and women on study results. We tested for differences between medical and biomedical students and found no differences for study results on the first semester test ($t(246) = 1.867, p=0.064$). We did find differences for both the second semester test ($t(239) = 2.539, p=0.013$) and the Innovation Project study results, with medical students scoring higher than biomedical students ($t(234) = 4.908, p < 0.001$). See Table 5 for a complete description of the study results and comparison for study and gender.

Subsequent regression analysis shows that the difference in results for both semester 2 longitudinal tests ($\beta = 0.313, p = 0.037$) and the Innovation Project ($\beta = 0.755, p < 0.001$) are accounted for by the type of study, more so than the student reported learning strategies.

Discussion

Medical education is embracing lifelong learning, in line with demands from the medical field (Frenk et al. 2010). The current research project investigated the relation between students' lifelong learning strategies and performance. Contrary to our hypothesis that project-based assessment will show a strong relation to deep learning strategies, we found low explained variances by learning strategies for both grades on the longitudinal knowledge tests and the Innovation Project.

We were unsure whether we would find a positive relation between longitudinal knowledge test grades and elaboration. Literature on deep learning strategies helps to interpret our findings. Elaboration is a deep learning strategy, as are critical thinking and metacognitive self-regulation. Some researchers also gather organisation under this category (Duncan and McKeachie 2005; Cheng and Chau 2013). Research on deep learning strategies often shows a positive relation to general study outcomes (McKenzie, Gow, and Schweitzer 2004; McKenzie and Gow 2004; Blom and Severiens 2008; Pizzimenti and Axelson 2015), and lifelong learning skills (Dahl, Bals, and Turi 2005). Deep learning strategies are known to ensure long-term knowledge (Watson et al. 2004; Birenbaum and Rosenau 2006). As this was assessed by the longitudinal knowledge tests, it is hardly surprising that a learning strategy like elaboration is related to this outcome. We did not expect, however, that this would be the only association.

Indeed, the lack of relation between the project-based assessment and learning strategies did surprise us. We expected that the project assessment would require students to use critical thinking strategies and metacognitive self-regulation, since the project needed planning within a group and was often based on integration of multiple theories (Kivela and Kivela 2005; Loyens, Magda, and Rikers 2008). Our results do not confirm these expectations. However, research in this area is not consistent, since our findings do align with findings from Turan and Konan (2012) and Reid, Duvall, and Evans (2007), who could not find a relation between lifelong learning strategies and forms of assessment targeted at deep learning either. To understand this, we think it's important to further consider (1) the learning outcomes, (2) the learning programme and (3) the learner.

Table 5. Description of mean study results per group and t-tests.

Test	Male	Female	T-score	<i>p</i> value	Bio-medical		T-score	<i>p</i> value
					Medicine	sciences		
Longitudinal test Semester 1	6.34	6.41	0.619	0.537	6.44	6.23	1.867	0.064
Longitudinal test Semester 2	6.27	6.28	0.064	0.949	6.37	5.98	2.539	0.013*
Innovation-project	6.74	7.02	1.656	0.100	7.14	6.35	4.908	<0.001**

* significant under $\alpha=0.05$, ** significant under $\alpha=0.001$

First, regarding the learning outcomes, it could be argued that the students have not used the self-reported learning strategies in the first semester tests, as the MSLQ was administered at the end of the first semester. Usually, students are assumed to be flexible about their learning strategies (Pintrich et al., 1993). However, as we did not find major differences in the relation between first semester tests and second semester tests regarding the relation with MSLQ learning strategies, we do not think this accounts for the results. Moreover, the flexibility of the students was probably reduced in the current curriculum due to time pressure. So we assume they used learning strategies they scored highest on the MSLQ, because in case of cognitive overload, these are more easily employed (van Merriënboer and Sluijsmans 2009). One would expect students with a higher score on critical thinking to surface in the results and we did not see this. We therefore think a better explanation is that the assessment type might not have enabled students to showcase deep learning strategies, whereas these may have been present in group discussions or elsewhere during the education programme (Reid, Duvall, and Evans 2007). Indeed, Turan and Konan (2012) suggest that good collaborative learning efforts are important for learning outcomes, next to individual strategies. That is, the ability to collaborate is important for certain assignments that benefit from feedback or debate. Perhaps this influenced the study outcomes as well. We therefore further investigate student's learning behaviour in project groups in a qualitative study. A quantitative approach to relating collaboration skills and assessment outcomes is of interest for further research.

Second, given the nature of our learning programme, we found the scores on learning strategy scales surprising. The context of the research was a curriculum based on self-directed learning principles. Particularly during the project, students had ample experience with personal autonomy, self-management in learning and independent pursuit of learning, which is in line with the ideas of Candy (1991). Associated with this type of education is the development of elaboration, critical thinking and metacognitive self-regulation (Garrison 1997; Thomas, Bennett, and Lockyer 2016). In contrast, we found relatively low scores on critical thinking. One explanation is that the curriculum as a whole was not consistent in terms of lifelong learning, with courses that demanded other learning strategies or more time, scheduled next to the project and coaching. Students are more likely to employ surface learning strategies under time pressure or stress, which may have been the case in the crowded timing of the project deadline and longitudinal tests (Cobb et al. 2013; Zhang, Peterson, and Ozolins 2011). An aligned curriculum with both space and time for exploration within the project, will foster deep learning even more.

Third, focussing on the learner, we should not forget that more factors contribute to success than the potential to use certain learning strategies. It is important to mention that students must take tests to be accepted to (bio-)medical sciences education in the Netherlands. Previous research has shown that the selection process influences the results in the first year of education (de Visser et al. 2017). The nature of our selection method could explain the learning strategies scores and the relatively high effect of elaboration. That is, we select for certain learning strategies because we use tests in which students need to show their knowledge and application of knowledge. Also, we think that assessment could drive learning in the sense that students will alter their learning strategies based on how they performed on assessments (Shumway and Harden 2003; Nicol and Macfarlane-Dick 2006). Therefore, we expect the learning strategies for

second year students to be a further indication of which strategies are encouraged. Subsequent research will be conducted on the way assessment and the new curriculum as a whole have an influence on which learning strategies students use.

Different assessment methods will better match a curriculum that fosters lifelong learning. Other researchers have offered some directions which we think would fit well and are useful to consider for those developing a lifelong learning curriculum. For instance, formative assessment will help to encourage deep learning approaches, because it reduces the anxiety that is present in high-stakes assessment (Cobb et al. 2013). Anxiety for assessment can change learning behaviour, even in a course that focuses on open and autonomous learning (Van Woezik, Reuzel, and Koksma 2019). Another problem is that either assessment requirements for students or assessment instructions for teachers are unclear, resulting in a situation where the use of deep learning strategies is not properly rewarded (Turan and Konan 2012). Indeed, a good way forward is to explicitly include critical thinking skills in development and evaluation of a course (Rear 2019). These adjustments help to properly align the assignment with learning strategies such as critical thinking and metacognitive self-regulation.

A limitation of the current project is that we included only students of the Radboudumc. Although the student population shows diversity, the results are not easily generalised to the larger population of (bio-)medical students. Also, self-reported measures are sometimes regarded as a limitation, but research has shown that self-reported measures can be used for reliable assessment of learning strategies (Dornan, Scherpbier, and Boshuizen 2003). Previous research does indicate that not only assessment method, but also sophistication of the assessment is an important factor in alignment with deep learning strategies (Palmer and Devitt 2007). Given that the assessments were used for the first time, sophistication is a point of improvement. Furthermore, the students had to fill out the questionnaire during a session of an obligatory meeting, which means that they might not have been intrinsically motivated to fill out the questionnaire, affecting its outcome. On the other hand, this outweighs the possibility that only motivated students might have participated had the test been voluntary.

Other research on lifelong learning strategies and outcomes of assessment is scarce, and we hope future research can help to understand the relation better. It will be important to take into account perceptions of the students with regard to the assignments, to get insight in the alignment between the assignment and promotion of lifelong learning skills (Reid, Duvall, and Evans 2007). The value of assessing lifelong learning skills by writing a report should also be considered. Possibilities to detect lifelong learning skills could be lost in the translation from practice to paper. We are currently investigating this in a qualitative study.

On a more practical note, curriculum changes can lead to unexpected outcomes, due to organisational issues (Timmins 2008). The curriculum might show a different effect than we expected, because of the transition phase. Especially a lack of good organisation sparks stress and anxieties in students, which leads to different study approaches (Zhang, Peterson, and Ozolins 2011). Moreover, students are likely to use efficient strategies and deviate from the formal curriculum when they view it as inappropriate in terms of achieving learning goals (Luscombe and Montgomery 2016). In our case, there might have been confusion about the meaning of self-directed learning among both teachers and students. Previous studies have shown that this is problematic, as students and teachers then associate self-directed learning with lack of support (Dornan et al. 2005) or self-teaching (Shanley 2007). A curriculum in transition places a burden that compromises the ability to fully engage in self-directed learning strategies for the project. It also could have led to diminished sense of control over learning tasks for the students. Such negative associations restrain students from using associated learning strategies (Fishman 2014). It is thus important to *take time* for curriculum changes (Timmins 2008).

Conclusions

In conclusion, learners with learning strategies in line with lifelong learning do not necessarily outperform students with a more surface learning approach. This could be due to the nature of assessments or of the curriculum. Although we gained more insight into the relation between learning strategies and assessment methods, it remains difficult to draw a definitive conclusion. Qualitative research can provide better insight into the mechanisms of the relation between assessment and learning strategies. This could help explain the relation between learning strategies and project grades, and the relation between elaboration and longitudinal test scores. In all, our research raises concerns about the translation of lifelong learning skills into assessment. If assessment is to drive lifelong learning skills, this is not self-evident and warrants a more elaborate reconsideration of the conditions under which this works. We believe that more attention needs to be given to the construction of assignments and assessments, to make sure that perceptions and expectations of students and teachers are properly aligned with lifelong learning development.

Data availability statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Disclosure statement

The authors declare no competing interests. The authors alone are responsible for the content and writing of the article.

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