Assessment & Evaluation in Higher Education
Vol. 37, No. 7, November 2012, 875–887

Assessing knowledge growth in a psychology curriculum: which students improve most?

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The purpose of this study was to gain insight into determinants of knowledge growth among first-year psychology students in a curriculum that uses the Progress Test (an assessment method for long-term retention of knowledge and knowledge growth) as its main assessment tool. To that end, the relation between the level of initial learning, prior knowledge, class attendance and individual study time, and Progress Test scores was analysed. The data showed that level of initial learning was positively associated with prior knowledge and class attendance. Further, level of initial learning was positively related to knowledge growth at the end of the first year of the curriculum. Students with higher levels of initial learning had a more extended knowledge base at the end of the first year of their curriculum than students with lower levels of initial learning. Prior knowledge, class attendance and individual study time did not have a significant relation with knowledge growth.

Keywords: assessment; long-term retention; knowledge growth; level of initial learning; progress test; prior knowledge; attendance; study time

Introduction

A central goal of any educational system is that students retain the information they learn during their study for future professional activity and that they expand their knowledge base during education and even afterwards. Next to that, a commonly accepted idea among teachers and in the literature is that assessment strongly influences student learning (e.g. Scouller and Prosser 1994). The first mentioned goal refers to knowledge growth, a mnemonic state in which the amount of retained and newly acquired information surpasses the amount of forgotten information. However, in educational practice students' knowledge growth is usually not monitored. Instead, knowledge is tested at the end of or during a particular course. After students pass the accompanying course test, the knowledge from this course will typically not be tested again. Consequently, students will possibly study in a way that will help them pass the test, but not in a way that will help them remember the knowledge for a long time. Therefore, we often do not encourage students to study for long-term retention and we also do not know how long students retain their knowledge and to what extent their knowledge base is expanded during their study. It seems that knowledge growth is not a core topic in educational practice. From an extensive literature search it appears that it is not studied extensively in educational research too. With this study we want to take a

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ISSN 0260-2938 print/ISSN 1469-297X online

http://dx.doi.org/10.1080/02602938.2011.581747
http://www.tandfonline.com

first step in studying factors related to knowledge growth within the psychology domain.

The present study was conducted in a Dutch problem-based learning (PBL) bachelor programme of psychology. When this programme started, the goal was to emphasise the importance of long-term retention of knowledge and to choose an assessment system that was congruent with this goal. In the present PBL curriculum, the basic knowledge of central domains of psychology is covered in the first two bachelor years. Each of these two years comprises eight sequentially programmed, five-week courses that all end with a 'course test'. This course test is formative and gives student feedback on how well they have mastered the subject matter that was studied during the preceding five-week course. Next to that, students take three summative Progress Tests (PTs) per year. More specifically, in each of the first two bachelor years, a PT is administered after the third course, the fifth course and the eighth course. A PT covers all (theoretical) topics from the first two years of the bachelor curriculum (i.e. 16 courses). The underlying idea for using this kind of assessment method is to avoid undesirable learning strategies as 'learning for the test' or 'cramming' (Van der Vleuten, Verwijnen, and Wijnen 1996). When students are retested a few times a year on the learning material, students need to (re)study the material in a way that helps them to remember it for a longer period of time than only for the upcoming test. By assessing them after every course, they are also informed on the efficacy of their study behaviour on a regular basis.

The PT has originally been developed in the context of medical education to assess knowledge growth (Van der Vleuten et al. 1996). Due to the specific scheduling of the PTs, a student's score on a PT reflects both initial learning, i.e. knowledge of the preceding course, as well as long-term retention, i.e. knowledge of the courses that were conducted prior to the preceding course. It should be noted that – ideally – the long-term retention component in the PT score becomes increasingly important as students move through the bachelor programme. To exemplify this, consider a student's score on the first PT in the first bachelor year and compare it with this student's score on the third PT in this year. A student's score on the first PT in the first year will be based on the initial learning of the third course and the long-term retention of the first and second course. By contrast, a student's score on the third PT of this year will be based on the initial learning of the eighth course in that year, and the long-term retention of the previous seven courses.

The notion that Progress Testing can measure knowledge growth has been empirically supported, albeit to a limited extent, in the medical domain. For example, Van Diest et al. (2004) demonstrated that medical students show a steady growth in knowledge during their pre-clinical years of studying. Students in this study showed a significant increase in percentage correct answers on subsequent PTs during their study. A study by Verhoeven et al. (2002) revealed similar results. Tan, Imbos, and Does (1994) compared medical students with different levels of knowledge growth and concluded that growth of knowledge in the first year of the curriculum has important predictive value towards the final level of knowledge at the end of the curriculum. Students with relatively large knowledge growth in their first year of college, tend to end up with more knowledge of the basic curriculum than students with relatively small knowledge growth in their first year.

Given that the final level of knowledge a student obtains is related to the knowledge growth in the first year, and considering that most programs in higher education aim at providing student with a strong final knowledge base, it is relevant for teachers to obtain insight into the factors that determine knowledge growth in the first year of the curriculum. To the best of our knowledge, no prior study has been directed at the identification of these factors. Therefore, in the current study we sought to fill this hiatus by identifying factors that correlate with knowledge growth. On the basis of relevant empirical evidence from the cognitive and educational psychology literature, we constructed a simple qualitative model, which contains a set of direct predictors of knowledge growth. Below, we will elaborate on these predictors and their relationship with knowledge growth.

As noted before, knowledge growth as measured by a PT taps on the sum of long-term retention of knowledge and initial learning. Thus, if we are to predict knowledge growth, our model should contain factors that affect long-term retention and factors that affect initial learning. The existing literature suggests that long-term retention is positively related to the level of initial learning. Furthermore, initial learning is known to be positively correlated with the level of prior knowledge, class attendance, and (sometimes) study time as will be shown in the next section. Therefore, the model we will use to predict knowledge growth will contain the aforementioned predictors. Subsequently, we will provide a description of these predictors.

Long-term retention of knowledge

Long-term retention of knowledge learned in school has been studied empirically in four domains: foreign language acquisition, high school mathematics, cognitive psychology and memory for novels studied in university art courses (e.g. Bahrick 1984; Conway, Cohen, and Stanhope 1992). Most studies show a rapid decline in knowledge in the first few years after the knowledge is acquired and a stabilisation of the retained knowledge from 6 to 25 years after acquisition. For example, Bahrick (1984) studied the retention of Spanish words learned in college over the course of 50 years. It appears that in the first 3–6 years after learning Spanish words, there is a sharp decline in retention. After that period losses stabilise and a substantial part of the knowledge (around 50% of the maximum score on a retention test on average) is retained until participants reach the age of 60. Around that age, the knowledge retained starts to decline again. A study of Bahrick and Hall (1991) showed a similar pattern of knowledge retention and loss. They studied the very long-term retention of algebra and geometry knowledge learned in high school with a retention period of 50 years. Their participants showed a rapid decline of algebra and geometry knowledge in the first 3–5 years after knowledge acquisition. After that period, knowledge retention stabilised.

Although most research suggests that very long-term retention of knowledge is better than usually expected, there is a substantial decline in knowledge in the first few years after it has been acquired (e.g. Conway, Cohen, and Stanhope 1991; Semb, Ellis, and Araujo 1993). From an educational perspective it is of importance to know how this rapid decline can be diminished, because knowledge growth depends on knowledge retention. The question, therefore, is: which factors facilitate long-term retention?

Level of initial learning

To investigate which factors facilitate long-term retention, Bahrick and Hall (1991), in their study, controlled for level of knowledge initially acquired after studying the materials for the first time (i.e. level of initial learning). They found that participants with the highest level of initial learning (at the beginning of the retention period) showed hardly any decline in knowledge, while participants with the lowest level of knowledge initially acquired showed a great amount of knowledge loss during the retention period. Similar results were found by Conway et al. (1991). Semb et al. (1993) also investigated the correlation between the level of initial learning and long-term retention. After a retention period of four months, there was no difference in decline between students with higher versus lower levels of initial learning. But after 11 months, the decline was larger for students with lower levels of initial learning. These studies suggest that level of initial learning is an important determinant of long-term retention of knowledge. If initial learning is of a high level, it is plausible that knowledge growth will be more extensive than when the level of initial learning is relatively low. In the present study we will therefore investigate whether level of initial learning also has a positive effect on knowledge growth.

Prior knowledge

The influence of prior knowledge on student learning has been abundantly established (e.g. Shapiro 2004; Thompson and Zamboanga 2004). Prior knowledge differs from the level of initial learning by the fact that prior knowledge is the knowledge students possess prior to enroling in a curriculum. Level of initial learning on the other hand is the direct result of student learning in a certain course. Prior knowledge seems to strongly determine the level of initial learning. For instance, Recht and Leslie (1988) showed that students with more prior knowledge of baseball were better at recalling and summarising a text about a baseball game and at assorting passage sentences from the original text for level of importance (importance was defined by seven baseball experts). Also Bransford and Johnson (1972) showed that prior knowledge has an effect on comprehending and recalling prose passages. While there are several theories on how prior knowledge affects initial learning, they all endorse the idea of prior knowledge as a kind of cognitive structure that lays the foundation for new learning (Shapiro 2004). However, the effect of prior knowledge on long-term retention is not known, neither is known whether prior knowledge also has an effect on knowledge growth. We will investigate prior knowledge as a possible determinant of knowledge growth, because of its effect on initial learning, which constitutes a part of knowledge growth.

Class attendance

Attending class is a factor that proved to have a positive association with initial learning in many studies (e.g. Gunn 1993; Marburger 2001; Romer 1993; Van Blerkom 1996). Because we expect initial learning to be a part of knowledge growth, we will include class attendance as another possible factor that influences knowledge growth. We are aware of the fact that class attendance can represent different things (for example conscientiousness or motivation), though it is very plausible that students who are more interested in the subject matter, who are more focused on obtaining high grades or motivated in some other way will be more likely to attend classes than students who are less interested in the subject matter or who are less focused on academic achievement. To consider class attendance as a pure indicator of motivation to learn (e.g. Pintrich 1999; Romer 1993; St. Clair 1999; Van Berkel and Schmidt 2000) is probably too strong a statement. However, in line with other research (e.g. Busato et al. 2000) indicating a positive association between motivation, level of initial learning and academic success, we do expect students who attend more classes than others to show more knowledge growth.

Study time

A fourth factor that may influence knowledge growth is the amount of time students spend at their study. In some studies, study time was positively related to academic achievement (e.g. Schuman et al. 1985), whereas other studies revealed a negative effect or no effect on achievement (e.g. Plant et al. 2005). In educational practice it is rather common to attach importance to increasing students' individual study time, but research has still not resolved the issue whether study time has a positive effect on study success. Also whether study time has an effect on knowledge growth is yet unknown. For this reason, we will investigate the influence of study time on knowledge growth. Because of the contradictory results found in earlier research, we are not able to predict in which direction the influence of study time on knowledge growth will be.

To summarise, while knowledge growth is an important goal in educational practice, it has not been studied extensively in educational science. We do know that on average students show knowledge growth (Van Diest et al. 2004; Verhoeven et al. 2002) and we have some notion of what factors might influence long-term retention (Bahrick and Hall 1991; Conway et al. 1991, 1992; Semb et al. 1993) and level of initial learning (Recht and Leslie 1988; Thompson and Zamboanga 2004; Van Blerkom 1996). Furthermore, knowledge growth in the first year is positively correlated with student knowledge at the end of a curriculum. Hence, we reasoned that it would be important for educators to know which factors are related to first-year knowledge growth. The purpose of the present study is to identify a number of relevant factors. To this aim, we formulated a descriptive model to predict first-year knowledge growth on the basis of level of initial learning, prior knowledge, class attendance and study time.

Method

Participants

Participants were 224 (68 male and 156 female) Dutch students of the cohort enroled in a PBL psychology curriculum in 2003. In the Netherlands, students can only enrol in a university bachelor curriculum if they have finished pre-university education (VWO in Dutch) or have finished at least one out of four years in higher vocational education. This is a requirement for all Dutch universities and makes the group of participants commensurable with other groups of Dutch first year (psychology) students. Of the 224 participants, 190 finished pre-university education and 34 went to an institute of higher vocational education before enroling in the psychology bachelor curriculum at hand. In the Netherlands, psychology topics are not part of pre-university education programmes. The majority of the participants therefore did not study any psychology topics in their former education. The mean age of the participants was 19.52 years with a range of 17.08–26.92. The mean grade (on a 10-point scale) the participants obtained during their first year of the curriculum at hand was 5.61 (standard deviation 1.35). Unlike US or UK bachelors, students in the curriculum of the current study spend most of their time studying core psychology topics.

Educational context

As said before, the educational context of the study at hand is PBL. PBL is an instructional approach that uses academically or professionally relevant 'problems' as a starting point for student learning. A problem usually consists of a realistic description of a phenomenon, event or, for example a psychological case (Schmidt 1993). Students meet twice a week in small groups of approximately 10. They first analyse the problem, generate possible explanatory hypotheses, build on one another's ideas, as well as identify key issues to be studied further. These activities, based on their prior knowledge, allow students to construct a shared initial explanatory theory or model explaining the problem at hand (Schmidt 1993). After this period of teamwork, they disperse for a period of individual study to work on learning issues they have identified as a group. After three days they meet again and are expected to share and discuss their findings, as well as to refine their initial explanations based on what they have learned. Students then move on to analyse a new problem, or if new learning issues requiring further study are identified during this phase, the process described above would be repeated. During these meetings a tutor is present to guide students' learning in the problem analysis and reporting phases. The tutor's role is to facilitate the processes involved when students co-construct knowledge through discussions and sharing of ideas (Hmelo-Silver and Barrows 2006). Thus, PBL can be seen as a cyclical process consisting of three phases: initial problem analysis, self-directed individual learning, and a subsequent reporting phase (Barrows 1988; Hmelo-Silver 2004; Schmidt 1993).

Instruments

PTs are administered three times in the first year of the bachelor programme. Each PT consists of approximately 200 items covering the knowledge domain as a whole and reflecting the (final) objectives of a curriculum. For each administration, a new test is constructed. PT items are presented in a true/false format. This means that students have to judge propositions on their accuracy. An example of a true/false item in the category social psychology is: 'The results of the famous Darley and Latané (1968) experiment can be explained better by diffusion of responsibility than by pluralistic ignorance'. If students do not know the answer to a certain question, they can choose to answer with a question mark. To discourage guessing students' scores on a PT are calculated by subtracting the amount of incorrect answers from the amount of correct answers. Questions that are answered with a question mark are not rewarded or penalised.

The PT is a test with proper construct validity and modest reliability (e.g. Blake et al. 1996). The reliability coefficients for the PTs used in this study as well as the construct validity of the PT have been calculated. Cronbach's alpha for the first PT was α = .56, for the second PT α = . 67 and for the third PT α = .76. Because students have the opportunity to choose to answer questions with a question mark, the amount of questions used to calculate reliability coefficients differ between the different PTs. This means that reliability coefficients are calculated on the basis of the questions that are answered by the students with 'true' or 'false'. In line with other validation studies of the PT (e.g. Van Leeuwen et al. 1995), construct validity was assessed by measuring growth. Mean scores of the three PTs were compared to each other. Mean performance increased across the three PTs with the highest score associated with the third PT (see Table 1). This indicates mean growth of knowledge.

Knowledge growth was assessed by subtracting the score on the first PT from the score on the third PT for every student. The first PT was administered after 15 weeks of studying to make sure that the difference between prior knowledge and newly acquired knowledge would be clear. The third PT was administered at the last day of the academic year. In that way, the increase of knowledge after one year of study of every student is calculated. The reliability of such difference scores has been the topic of a thorough discussion. The reliability of a measure represents the ability of that measure to distinguish among people on a particular trait or true score, and differences between scores tend to be less reliable than the scores themselves (Lord 1956). A low reliability of a measure reduces statistical power because the relationship with any other variable cannot be larger than the square root of this reliability. However, with respect to difference scores it has been demonstrated that the reliability is only problematically low when all individuals in a sample display nearly the same difference (Rogosa and Willett 1983). In that case, the variation in difference scores attributed to 'true change' will be small. Rogosa, Brandt, and Zimowski (1982) showed that the variation in true difference scores is small when the correlation between the single constituent scores is high. In addition, Rogosa and Willet (1983) demonstrated that the decrease in reliability of difference scores due to an increase of the single-score correlation is smaller when the reliability of the single scores is high, i.e. a Cronbach's $\alpha \geqslant .80$. In the present study, the reliability of the third PT was fairly high, whereas the reliability of the first PT was low to moderate. Furthermore, the correlation between the scores on the third and the first PT was moderate ($r = .60$). Hence, the power of the statistical analyses that involve the PT change score will be sufficient.

Level of initial learning was assessed with the formative course tests at the end of each course during the first year of the programme. Formative tests are not rewarded with credits, but are used to give students feedback on their level of knowledge acquired at the end of the accompanying course. In every first year course, a different sub-domain of psychology is covered. Students start, for example with a course on social psychology. Course tests reflect the learning objectives of the course and generally consist of a combination of a rather large amount of multiple choice items, combined sometimes with some essay questions or short answer questions. When essay or short answer questions are used to test

Table 1. Number of participants (*N*) per PT, mean scores and standard deviations.

Variable	*N*	*M*	*SD*
Progress Test 1	218	22.06	6.93
Progress Test 2	218	28.01**	9.93
Progress Test 3	212	37.07**	13.25

Note: **Significant difference ($P < 0.001$) with preceding PT.

knowledge, the questions are corrected on the basis of exemplary answers. None of the course tests consisted of solely essay questions or other ‘open’ test formats. Grades on course tests are expressed on a 10-point scale with 5.5 indicating a satisfactory score. For every student the mean grade on the eight formative first-year tests was calculated. The resultant mean grade was taken as a proxy for level of initial learning.

Study time was estimated by the students themselves. Directly after each course, students fill out a compulsory and anonymous course evaluation form in which they have to estimate the time spent on self-directed learning activities during the preceding five-week period. In this evaluation form, there is also space for general comments of the students. Considering the content and amount of remarks, one can assume that the participants did feel free to be honest in their evaluation of the courses. Research from Moust (1993) showed that for relative short periods of time (i.e. two months), students’ estimates of their time spent at studying are a valid measure of the real time spent studying. For every student the mean estimate on the eight courses was calculated and used as a proxy for study time.

Class attendance was measured by the numbers of time students were absent from their tutorial groups as registered by their tutors. Every course consists of approximately nine meetings. Students are obliged to attend at least seven out of nine meetings per course to have the course registered. Nonetheless, students sometimes choose to attend fewer classes than are obliged. We added the number of meetings students missed during the first year to obtain an attendance score.

Prior knowledge, finally, was measured directly after the students enroled in the curriculum. They were required at that stage to take a training PT to get acquainted with the test procedure. The examination setting of this training PT is completely similar to the setting of a ‘real’ PT (including invigilators) to make sure students make this test as if it was a real test. The reliability coefficient for this PT was calculated as well. Cronbach’s alpha for this training PT was $\alpha = .52$.

Procedure

The data were routinely collected during the academic year 2003/2004. To investigate whether the level of initial learning, prior knowledge, class attendance and study time predict knowledge growth a regression analysis was conducted.

Results

Regression model

We conducted a multiple regression analysis to determine the predictors of knowledge growth.

Predictors of knowledge growth

The multiple regression analysis examined the effects of level of initial knowledge, prior knowledge, class attendance and study time on knowledge growth. The means and standard deviations for all variables are displayed in Table 2 and the zero-order correlations are reported in Table 3. Table 3 shows that knowledge growth was significantly correlated with the level of initial knowledge, class attendance and prior

Table 2. Means and standard deviations for all variables in the regression analysis.

Variable	*N*	*M*	*SD*
Knowledge growth	186	15.06	10.82
Level initial learning year 1	186	5.76	1.34
Absence year 1	186	3.50	3.94
Study time year 1	186	13.67	3.13
Prior knowledge	186	12.89	7.36

knowledge. Level of initial learning was significantly correlated with class attendance and prior knowledge. Class attendance and prior knowledge were also significantly correlated. Study time did not significantly correlate with any of the other variables.

Assumptions for regression were checked and found tenable. There were no signs of multi-collinearity, as correlations between variables did not exceed (±).80 and tolerance coefficients ranged between .692 and .965. Tolerance coefficients lower than .2 indicate multi-collinearity. Errors were approximately normally distributed and independent as a Durbin–Watson value of 2.076 was obtained. According to Field (2005) this value should be between one and three to assume independent errors. The closer this value is to two, the more likely it is that the assumption of independent errors holds true.

Using the forced entry method, a significant model emerged. $F(4, 181) = 19.79$, $p < 0.01$, adjusted $R^2 = .289$, MSE = 83.27 predicting knowledge growth. Knowledge growth was significantly predicted by level of initial learning ($\beta = .524$, $p < 0.001$). Students with a higher level of initial learning showed more knowledge growth during the first year of the bachelor curriculum than students with a lower level of initial learning. Prior knowledge, class attendance and study time did not significantly predict knowledge growth.

Discussion and conclusion

The aim of this study was to gain insight into determinants of knowledge growth of first-year students within a psychology curriculum with a PT as its main assessment instrument combined with formative course tests. To that end, the relationship between level of initial learning, prior knowledge, class attendance and individual study time, and knowledge growth was analysed. The data showed that level of initial learning played an important role in predicting knowledge growth in the first

Table 3. Zero-order correlations of the variables in the regression analysis.

	1	2	3	4	5
1. Knowledge growth	–	.547**	−.292**	.017	.134*
2. Level initial learning year 1		–	−.452**	.112	.250**
3. Absence year 1			–	−.099	−.234*
4. Study time year 1				–	−.118
5. Prior knowledge					–

Note: *Significant at the 0.05-level. **Significant at the 0.01-level.

year of the curriculum. Students with higher scores on formative course tests had a more extended knowledge base of psychology at the end of the first year of the curriculum than students with lower levels of initial learning. However, prior knowledge, class attendance and individual study time did not significantly predict knowledge growth.

The results of this study concerning level of initial learning are in line with previous research on long-term retention of knowledge. Bahrick and Hall (1991), Conway et al. (1991), and Semb et al. (1993) found better retention scores for students with higher levels of initial learning. Although we do not know how and if students prepare themselves for the course tests and PTs during the year, we do know that students with higher levels of initial learning have forgotten less (whether or not by relearning) and/or have acquired more knowledge at the end of the first year of the curriculum. Even though it might seem a rather obvious conclusion that gaining high grades on course tests often results in high grades on PTs, it is of much interest for curricula using PTs or other assessment methods for retesting knowledge, but also when no tests for long-term retention are administered. It seems that students that do not obtain a high level of understanding the first time they study the learning material, easily fall behind compared to students that do obtain a high level of understanding of the learning material the first time. These students forget relatively much more than students who start with a high level of initial learning and are not able to compensate this during the year with for example restudying the learning material. This can have implications for educators' decisions on assessment. Long-term retention and knowledge growth seems to be connected to a solid base of initial learning. It might therefore be beneficial to stimulate students to study on a regular basis in a meaningful way and retest them on their knowledge, to prevent them from cramming. The advice to study on a regular basis is in line with research on the spacing effect (e.g. Delaney, Verkoeijen, and Spirgel 2010; Dempster 1988). The spacing effect refers to the finding that with the same amount of time spent on studying, spacing the learning episodes has a beneficial effect on learning over massed learning episodes. The advice to study in a meaningful way stems from the fact that the study was conducted within a PBL curriculum where students are encouraged to constructively process the learning materials (Hmelo-Silver and Barrows 2006).

The results of this study concerning prior knowledge are not in line with other research. Where prior knowledge has a positive effect on learning in general (e.g. Thompson and Zamboanga 2004), it did not predict the level of knowledge growth. Nevertheless, it did have a significant correlation with level of initial learning. We found the same pattern of results for the class attendance variable. Class attendance did not significantly predict knowledge growth, but it did significantly correlate with level of initial learning. The fact that prior knowledge and class attendance did significantly correlate with the level of initial learning could be explained by the educational context of this study. Students in PBL schools are challenged to activate their prior knowledge while discussing problems and this will help students integrate new knowledge into their existing knowledge base (e.g. Schmidt 1993). It is plausible that this will enhance the level of initial learning. Although it is unclear why prior knowledge and class attendance did not predict knowledge growth, it could be that the relation between prior knowledge and attendance on the one hand and knowledge growth on the other hand, is mediated by level of initial learning. Future research is of course necessary to investigate this possibility.

Study time did not significantly predict knowledge growth, nor did it have a significant correlation with the level of initial learning. This is in line with research from Kember et al. (1995). They investigated the relationship between learning approaches, study time and academic performance and concluded that there is no simple relationship between these three variables. Ineffective learning approaches often demand much study time and will probably result in lower academic performance, but an effective learning approach will not result in higher academic performance without investing a proper amount of time.

This study showed that level of initial learning is of predictive value for knowledge growth at the end of the first year of the psychology curriculum under study. Knowledge growth in the first year is important because it appears to be indicative for knowledge growth at the end of the curriculum (Tan et al. 1994). There are, however, still some issues unresolved. For example, we do not know how students prepare themselves for the course tests and PTs. We did not control for restudying. Students, who show more knowledge growth than others, could for instance restudy the material more often than others (Driskell, Willis, and Copper 1992). The study time measure used in this study indicated the amount of time students spent on the particular courses, during the courses. It did not assess the amount of time students spent on restudying study material (or summaries) from other courses. Furthermore, we do not know what explains the differences in level of initial learning. Prior knowledge and class attendance were positively associated with level of initial learning, but did not predict knowledge growth. Perhaps there are other factors, for instance type of learning strategy, which were not investigated in this study that could play a role. Future research will be necessary to address these questions.

The present study was conducted in an educational setting rather than in an experimental one. Results should therefore be interpreted with caution and one should be careful with generalising it to different situations. Nevertheless, it was a first step in finding the determinants of knowledge growth in a psychology curriculum with an assessment instrument that focuses on long-term retention

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