Title: Scholastic achievement in high school explained? Validation of a longitudinal structural equations model
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Abstract

The purpose of the study is to shed light on the mechanisms behind scholastic achievement in high school by testing a structural equations model based on the work by Vermunt (1998). It was presumed that self-regulation of learning would predict scholastic achievement and that learning orientations would predict self-regulation of learning. A survey tapping self-regulation and learning orientations based on the Inventory of Learning Styles (ILS) was administered to a fairly large sample of Finnish first-year high school students. A similar survey was repeated when the students were attending high school for their third year resulting in 245 participants who took part in both surveys. In addition, data were collected on scholastic achievement from multiple sources: national matriculation exam results, final grade point average (GPA) and self-reports of 9th grade GPA. The primary analyses were carried out within a structural equation (SEM) framework. The analyses resulted longitudinal SEM model that accounted for 40 % of the variance in performance on the matriculation exam. The model applied for several subgroups of students, but not in all subject domains. To conclude, self-regulation may not only have a small, but statistically significant effect on GPA at university as shown by previous studies, but on scholastic achievement in high school. However, the path coefficient from self-regulation to scholastic achievement was not very high. Further work is needed to determine if students are having difficulty in performing the basic cognitive activities required. The next step is that researcher study in more detail how changes in self-regulation affect scholastic achievement and how self-regulation of learning can be promoted.

Scholastic achievement in high school explained? Validation of a longitudinal structural equations model

Introduction and aims

There is a growing awareness of the fact that it is not the amount of work student put into their schoolwork that makes a difference (Wagner, Schober & Spiel, 2008; Nandagopal, 2006), but it is the *quality* of study processes. There is also a rapidly growing number of high quality studies on student self-regulation proposed as a central construct in understanding student performance especially in the context of higher education (for a review, see Vermunt & Vermetten, 2004). However, it is hard to find studies on student self-regulation of learning in general upper secondary education published in English.

This state of affairs appears strange as a requirement of task-level and curricular-level of self-regulation has been built into at least Finnish general upper secondary education ("high school") as a result of curricular reform. Students are not only expected to acquire an understanding of extensive amounts of text, but to draw up a personal study plan to cover the two to four years they "choose" to spend in high school. The situation is that, on the one hand there is very good data on scholastic achievement based on standardized tests (i.e. matriculation exam), but there is limited understanding of the mechanisms leading to variation in achievement. Of particular interest is the role of student self-regulation of learning in predicting student achievement.

Theoretical model

The present study is based on Vermunt's (1998) model of the learning process, in which regulation activities are in a central role. Regulation activities, which essentially can be performed by the learner in the case of self-regulation or by another person in the case of external regulation, refer to activities that steer cognitive activities such as selecting main points and looking for relations. Examples of regulation activities are orienting on a task, monitoring whether the learning process proceeds as planned, diagnosing the cause of difficulties, and taking action to resolve those difficulties (Vermunt & Vermetten, 2004). The authors also make a distinction between self-regulation of learning *process and outcomes* defined according to the aforementioned definition of self-regulation and self-regulation of *content*. Self-regulation of content refers to consulting literature and sources outside the syllabus.

According to Vermunt's model, the way in which students process subject matter is directly influenced by regulation strategies, which in turn are influenced by learning orientations (and mental models of learning). Learning orientations refer to the whole of students' personal goals, intentions, motives, expectations, attitudes, concerns, and doubts concerning their studies. However, in the present study we use scholastic achievement as a measure of learning instead of self-reported processing strategies. It is worth noting that in subsequent work, Vermunt and colleagues have studied learning styles (i.e. patterns of components subsuming, i.e. types of regulation, learning orientations, mental models of learning and types of cognitive processing.)

The purpose of the study is to shed light on the mechanisms behind scholastic achievement by testing a structural equations model based on the work by Vermunt (1998). The design is longitudinal as recommended by Schunk (2008), and involves one cohort of students answering a survey at the beginning and end of their studies.

The research question is the following: 1) How and to what extent does student self-regulation predict scholastic achievement in high school? 1.1. Does the model apply equally different subgroups of students (male/female, students on study tracks specializing in e.g. sports, science etc. / regular students)? 1.3. Does the model apply equally for different subject domains?

Method

Participants

The population of this study consisted of all first-year students from all "ordinary" ($N_{students}$ = 985; $N_{schools}$ = 10) high schools in a Finnish middle-sized city. Only two institutions were excluded from the population: the night school and the high school where teacher training is carried out. The students were followed up during their third year of study. The sampling strategy was to choose every third student in alphabetical order (n=328). Students were from 16 years of age on the first survey.

Data collection procedure

As mentioned in the introduction, the students filled in a questionnaire in the very beginning of their studies (i.e. first year after approximately one month of high school) and again during the third year of study. Most of the students filled out the questionnaires during the school day. The number of students who filled in the questionnaire twice was 245 (142 girls and 103 boys). 37 students dropped out of school before follow-up questioning and 46 students failed to fill in the questionnaire a second time.

Materials

The students´ self-regulation strategies and learning orientations were assessed using the Inventory of Learning Styles (ILS), developed by Jan Vermunt (1994) translated into Finnish as Roosendahl and Vermunt (1996) found the ILS to be applicable to upper secondary school students based on factor structure.

In addition, students´ matriculation exam results and final grade point average (GPA) were used as indices of student achievement. Furthermore, there were student reports regarding their 9^{th} grade GPA. For the result on the matriculation exam, two indices were used: 1) the total amount of points, which reflects the amount of subjects chosen for the exam as well as performance and, 2) the average amount of points (i.e. total amount of points divided by number of subjects). The latter measure is considered the best measure of general scholastic achievement for the purpose of international comparison (Vahtera, 2007, 576). However, the best measure for inter-student comparison is the test of language arts as the subject is the only mandatory subject on the matriculation exam. As for mathematics, it is worth noting that there are two versions of the test: basic math and advanced math. Thus, the students taking a math test have to be treated as two separate groups. The final GPA and the self-reported 9^{th} grade GPA included all subjects.

Analysis

The primary analyses were carried out within a structural equation framework using MPlus (Version 4.1, Muthen & Muthen, 1998-2006) in which the robust maximum likelihood (MLR) was used. The analyses were done is two phases. *First,* we specified confirmatory factor analysis models (i.e. measurement models) at both measurement times to test whether a) the measures of self-regulation and b) the measures of learning orientations formed distinct factors on the basis of which one could construct composite indices in order to simplify further analyses. Since the model regarding the learning orientations did not converge and the literature was not conclusive on the issue of which orientations predict self-regulation, we carried out regression analyses to select predictors of self-regulation. *Secondly,* we built a longitudinal structural equation model based on both theoretical considerations and previous research to explain high school achievement with self-regulation at both measurement points as the central (latent) variable, two orientations (Personal interest and Self-test orientation) as predictors of self-regulation and self-reported ninth grade GPA as the other predictor.

The goodness-of-fit of the models was assessed by the use of the following indicators: comparative fit index (CFI: values range between 0 and 1 and should be greater than 0.90, but preferably greater than 0.95, Hu & Bentler, 1999), root square error of approximation (RMSEA; values 0.05 or below indicating a good model; Browne & Cudeck, 1993), and the standardized root-mean-square residual (SRMR; values 0.05 or below indicate a good model, Jöreskog & Sörbom, 1996) and model-fit χ^2. As the chi square is known to be conservative (i.e. prone to Type II errors), in this study values of less than 2 or 3 times the degrees of freedom were considered to indicate reasonable fit.

Results

Measurement models for central variables: confirmatory factor analysis

By using confirmatory factor analysis, we first tested whether the two-factor model of self-regulation (with self-regulation of content and self-regulation of process and outcomes as two distinct factors) would be applicable to the data. The result was that the fit indices showed moderate fit at both measurement points (Time 1: $\chi^2(34)=67.09$, $p=0.0006$, CFI=0.94, TLI=0.93, RMSEA=0.056, SRMR=0.046; Time 2: $\chi^2(34)=77.17$. $p<0.001$, CFI=0.93, TLI=0.90, RMSEA=0.074, SRMR=0.052).

Then we examined the five-factor model of learning orientations. Due to the fact that including all items resulted in the fact that the model did not converge, we decided to discard two items from the Personal interest scale (n and s) and two items from the Certificate orientation scale (e and m). The decisions were based on an analysis of the content of the items as well as by a reliability analysis. Despite the elimination of these items, the fit indices indicated a relatively poor fit of the model at both measurement points.

As the literature was inconclusive on the issue of which orientation predicts self-regulation, we carried out a standard regression analysis to determine the best predictors of self-regulation. It turned out that, based on data from Time 2, only Personal interest and Self-test orientation predicted Self-regulation of learning process and results. As for self-regulation of content, the only predictor was Personal interest. Thereafter, we examined a two-factor model of orientations (i.e., a model containing Personal interest and Self-test orientation) using confirmatory factor analysis. The results suggest a relatively good fit between the model and the data: (Time 1: $\chi^2(19)=30.77$, $p=0.04$, CFI=0.94, TLI=0.92, RMSEA=0.052, SRMR=0.044; Time 2: $\chi^2(19)=37.49$, $p=0.0069$, CFI=0.94, TLI=0.92, RMSEA=0.064, SRMR=0.050).

Being assured by the confirmatory factor analyses that the scaled indeed represent distinct factors and in order to simplify further analyses, we formed composite indices to represent Self-regulation of process and results, Self-regulation of content, Personal interest and Self-test orientation. In subsequent analyses, these sum indices are used instead of the corresponding factors.

Structural equation model

Next, we built a structural equation model to test if self-regulation, a latent variable with Self-regulation of process and results and Self-regulation of content as its indicators, would predict scholastic achievement. Self-reported ninth grade GPA was included as a predictor of scholastic achievement.

First, we examined a model predicting the total amount points on the matriculation exam. (See Figure 1, Model 1). According to the model, past scholastic achievement (self-reported ninth grade GPA) was by far the most significant predictor of matriculation exam performance (Beta = 0.58), which could be expected. As for self-regulation of learning, it turned out to be a rather modest, but statistically significant predictor (Beta = 0.20) of matriculation exam performance. As expected, the personal interest orientation clearly predicted (Beta1 = 0.43; Beta2 = 0.39) self-regulation at both measurement points. Also the self-test orientation also predicted self-regulation. The model accounted for 40 % of the variance of the dependent variable and the fit indices suggest a satisfactory fit between the model and the data ($\chi^2(22)=36.36$, CFI=0.98, TLI=0.96, RMSEA=0.05, SRMR=0.04).

Secondly, we examined a model in which we substituted total amount of points by average amount of points. The resulting model, Model 3, was almost identical with Model 2. The only clear difference was that in Model 2, self-regulation was a weaker predictor of performance (Beta=0.15).

Thirdly, we constructed a model predicting final GPA. According to the model, past scholastic achievement (self-reported ninth grade GPA) was by far the most significant predictor of final GPA (Beta = 0.71), which could be expected. As for self-regulation of learning, it turned out to be a rather modest, but statistically significant predictor (Beta = 0.18) of final GPA. As expected, the personal interest orientation clearly predicted (Beta1 = 0.43; Beta2 = 0.34) self-regulation at both measurement points. Also the self-test orientation predicted self-regulation, but only at Time 2 and to a marginal extent (Beta=0.14). The model accounted for 56 % of the variance of the dependent variable and the fit indices suggest a satisfactory fit between the model and the data ($\chi^2(22)=32.77$, CFI=0.98, TLI=0.97, RMSEA=0.05, SRMR=0.04).

Fourthly, we tested Model 1 involving different grouping variables (gender, track, basic or advanced math). The model turned out equally applicable to male and to female students ($\chi^2(48)=65.56$, CFI=0.97, TLI=0.95, RMSEA=0.056, SRMR=0.056). The model applied equally to students on special tracks and regular students although with regular students, the orientations of the students served to predict self-regulation more ($\chi^2(48)=65.37$, CFI=0.97, TLI=0.95, RMSEA=0.055, SRMR=0.052). Furthermore, it applied equally to students taking basic and advanced math ($\chi^2(48)=70.03$, CFI=0.95, TLI=0.93, RMSEA=0.068, SRMR=0.064). In all of these analyses, the proportions of chi square were distributed approximately evenly among the subgroups of students.

Finally, we tested if the matriculation test score in Model 1 could be replaced by the score in language arts or mathematics. In the case of language arts, the model remained essentially the same except for the fact that the coefficient of determination was smaller ($R^2=0.30$). This can be explained by the fact that self-reported ninth grade GPA was a significantly weaker predictor (Beta=0.49) of achievement in high school language arts than of general study success. The fit indices suggest a relatively good fit between the model and the data ($\chi^2(48)=70.03$, CFI=0.95, TLI=0.93, RMSEA=0.068, SRMR=0.064). However, the model did not predict math performance as the path from self-regulation to math performance turned out non-significant.

Theoretical and educational significance of the study

The theoretical significance of the study is that it validates ideas put forward by Vermunt (1998). It lends confirmation to the notion that learning self-regulation may not only make a small, but statistically significant difference in GPA at university as shown by previous studies, but also in upper secondary education. The entire model predicts approximately 40 % of performance. However, a closer look reveals that self-reported self-regulation does not predict performance in all subjects. To conclude, the study suggests that the model in question may be a viable one for the target population, but not for all subjects. It is likely that the formulation of the items on the ILS applies best to subject domains requiring extensive reading and the organization of one’s understanding into the form of essays. It is also worth noting that the values of path coefficient from self-regulation to achievement were not very strong. Thus, for the purpose of interventions it would be wise to assess the degree to which the students have problems in actually performing the basic cognitive activities required. Also the motivation and mental models of learning of the student could be examined. The next step is that researchers study is more detail *how* changes in self-regulation affect student achievement and how student self-regulation can be promoted.

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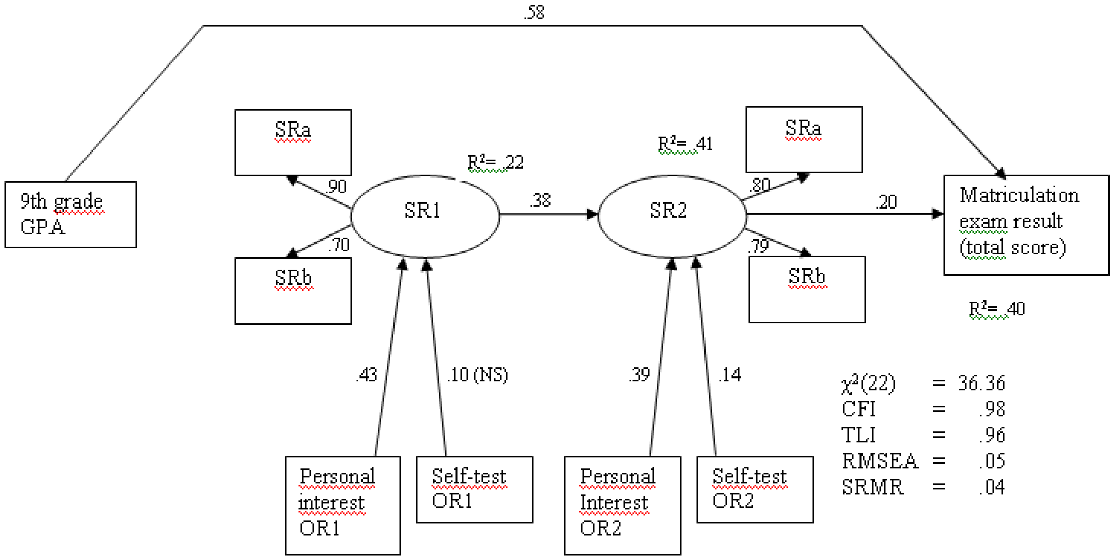

Figure 1. Model 1