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Introduction

Many institutions have adopted innovative approaches to the medical curriculum in order to better prepare their graduates for professional life in the 21th century. They expect that new medical doctors should be lifelong learners who can flexibly adapt to new challenges in their professional environment. This would probably rather be reflected by differences in student's learning patterns than by the outcome on traditional exams or other assessments (Shaughnessy & Slawson 1999;Spencer & Jordan 2001).

In our search for instruments to measure this learning patterns we decided to explore the benefits of the model of Vermunt (Vermunt 1998) that brought together five learning concepts in one instrument: two general learning conceptions, namely a constructivistic one, where learning is seen as knowledge building and competence development as a personal responsibility of learners (Byrnes-James 1996), and a reproductive one, where learning is intake of information for fact retention and three additional learning conceptions, namely learning by using knowledge; learning as being stimulated by educational environment; and learning by co-operation with other students.

In the present study we adapted this questionnaire to the medical curriculum in cooperation with the University of Maastricht[1] and studied psychometric quality, specificity and variability of this instrument.

Discription of the Inventory of Learning Styles

The Inventory of Learning Styles (ILS)(Vermunt 1998) has been developed in the context of higher education, and helps to study three different levels of student learning. The executing level is represented by processing strategies; the control level by regulation strategies; and the third level by learning conceptions and learning orientations. Key characteristics are represented in table 1.

This theory is based on a broad spectrum of learning models: cognitive styles(Allport 1937;Riding & Douglas 1993), 'Onion-model'(Curry 1983), study approach and orientation(Entwistle 1988;Marton 1988;Ramsden 1988), student's approach to learning (Biggs 1993;Pask 1976) (Entwistle & Waterston 1988;Reynolds 1997) , phenomenographic approach (Biggs 1979) [2] [3] of student learning, underlying conceptions of learning an learning intentions [4], study orchestration(Biggs 1979;Meyer 1991) and studaxology(Biggs 1979;Janssen 1996).

This ILS-application(Vermunt & Vermetten 2004) mirrors the position of other researchers(Pintrich 1999) who stressed the importance of integrating motivational and cognitive elements. The ILS is a recognised instrument in the literature(Vermetten, Lodewijks, & Vermunt 1999;Vermetten, Vermunt, & Lodewijks 1999;Vermunt 1996;Vermunt 1998) and has been linked to a broad spectrum of (innovative) educational models(Biggs 1979;Biggs 1993;Janssen 1996;Meyer 1991;Pask 1976;Reynolds 1997).
In this study students were asked to indicate on a five-point scale the degree to which the described items correspond to their own practice, views or motives. The ILS asks students to report about their usual way of learning.

Methods

Participants and procedures

The sample of this study consisted of 350 Ghent University medical students. Five cohorts are identified. The first one contains 88 students (cohort-1996) who entered medical school in 1996 at the Ghent University before the introduction of entrance selection. The second one - containing 72 students - started their medical education in 1997 (cohort-1997). This is the first cohort that had to pass a central organised entrance test. The next cohort of 54 students started in 1998 (cohort-1998). These three cohorts entered the traditional medical curriculum.The fourth and the fifth group of students entered the reformed hybrid curriculum in respectively 1999 (58 students – cohort-1999) and 2000 (78 students – cohort-2000). In order to make all cohorts comparable, the success in reaching a bachelor degree is included as a second criterion. This is obtained after three successfull years of study without failing one of the three final examinations of each curricular year. We could expect namely that the success rate became much higher after the introduction of the selection procedure. Cohort-1996 entered unselected, but more students dropped out due to failing examinations in the first three years. Cohort-1997 entered after a 'light' version of entrance examination (only test about information handling – no test about sciences) an for that reason also in this group more students dropped out in the first curricular years.
The educational level of parents is defined within 2 categories :

- one or both of the parents obtained a higher educational degree;
- both parents did not.

In order to code the profession of parents the occupational prestige scale developed by Treiman(Treiman 1977) and translated to the Belgian context by Elchardus(Elchardus 1979) is used. This can be considerated as an appropriate measure for the socio-economic status of the student's environment. Three characteristics of the final year of their secondary school are defined: the amount of lessons (of 1 hour) of mathematics and sciences scheduled weekly and the presence of classical languages (Latin, Greek). For each characteristic of that final year two categories are compared between the two cohorts:

- more or less than 6 hours of mathematics a week, called a major for maths;
- more or less than 5 hours of sciences a week, called a major for sciences; and
- presence or absence of classical languages.

The first year of application the candidates were submitted to a test that evaluates the quality of information handling (MCAT–informatin handling) and a test about knowledge of sciences (chemistry, physics, maths and biology – MCAT-sciences).

The questionnaires were distributed eight weeks after the start of the academic year 1999-2000 to the students of 1st until the 4th curricular year and eight weeks after the start of the academic year 2000-2001 to the students of that 1st curricular year. The same students were asked one year later to complete a new questionnaire. Participation was in both occasions was voluntary.
Since not all students returned their questionnaires, some response bias may have confounded the results. In order to examine this possibility, we compared respondents and non-respondents on the mentionned curriculum-independent variables.

Data analysis
Prior to the analyses, variables were examined for accuracy of data entry, missing values, outliers and normality.
Two sample t-tests and chi-squared tests were conducted to examine whether background variables differed between the student cohorts. The internal consistency of the ILS-questionnaire is controlled by means of principal component analysis. We used Varimax with Kaiser Normalisation with the Statistical Package for the Social Sciences (SPSS© Version 12.0). Loadings above .500 are retained. Based on the results of exploratory factor analyses, confirmatory factor analyses using AMOS statistical package (AMOS™ Development Corporation Version 6.0.0) were conducted on the three subscales. A cut-off value close to .06 for Root Mean Square Error of Approximation(Hu & Bentler 1998) and a Goodness-of-Fit-Index and Adjusted Goodness-of-Fit-Index(Medsker, Williams, & Holahan 1994) around .900 are considered as parameters representing an acceptable fit for the constructs. We controlled the quality parameters within the five cohorts.
This procedure was executed for the three subscales independently. After the validation of good fit constructs of this subscales we conducted confirmatory factor analysis in other to calculate the values of estimates of correlations of each factor in one overall construct.
Based on the mean correlation-values (by regression weighting following maximum likelihood estimates with AMOS) and the number of correlations in 6 categories (I: correlation-value <= .100; II: correlation-value >.100 - <=.200; III: correlation-value: >.200 - <=.300; IV: correlation-value: >.300 - <=.400; V: correlation-value: >.400 - <=.500; VI: correlation-value: >.500), we ranked the studied factors from less to more specificity. We calculated the correlation ranking value by summating all absolute values of each correlation and defined 3 specificity categories:
A: factors strongly uncorrelated (correlation ranking below 4);
B: factors mixed correlated and uncorrelated (correlation ranking between 4 and 4.5); and
C: factors strongly correlated (correlation ranking above 4.5).
Mean ILS-scores were compared between the five cohorts for the first appeal; independent samples t-test (two-sided) were applied; a p-value of <.05 was stated as the confidence level; and the effect size was calculated using the Cohen's d value.
In a second step we compared mean ILS-scores within each cohort (and for the whole sample) between the first and second appeal; paired samples t-test (two-sided) were applied; a p-value of <.05 was stated as the confidence level; and the effect size was also calculated using the Cohen's d value.
Based on these comparisons we ranked the factors from less to more variability. We called this value 'variabilty ranking', which is a sumscore of each measure of difference studied in between and within the 5 student cohorts. Each small effect size received a rank of 1; each medium effect size a rank of 2; and each long effect size a rank of 3. As for the specificity we defined 4 variability categories:
(1) low variability: variability ranking below 8;

(2) medium variability: variablility ranking from 8 to 11;
(3) high variability: variability ranking form 12 to 15; and
(4) very high variability: variability ranking above 15.

Results

Three hundred and thirty seven (337) students introduced completely their forms (overall response rate of 96%) at the first occasion; and 291 did it on the second appeal (overal response rate of 83%). In comparing the different student cohorts bias may have confounded the results (table 1).

Table 1: Comparison of the characteristics of parents, prior education, MAT-, GPA-scores, age and gender (Ghent University – students starting medical education from 1996 until 2000)

Comparing the five cohorts on curriculum-independent variables, we found for the first appeal no differences as far as participation rate, gender and age at the start of medical education are concerned. Nore are the cohort-1996 different from the cohort-1997 for any characteristic.
We found some differences concerning the socio-economic and educational background of parents. In this way the prestige-index of the parents was quite higher in cohort-1998 (as the educational level of their parents was significant higher) compared to cohort-1996 and cohort-2000 as in cohort-1999 compared to cohort-1996.
Concerning prior education of students the comparison revealed that the five samples were quite homogenious concerning sciences as a major in secondary school, with exception for cohort-1996 that scored significant lower than cohort-2000; a clear increase of the proportion of major for maths in cohort-1999 and cohort-2000; a significant decline for classical languages starting from cohort-1998 on; and at last a significant lower endscore in secondary school for cohort-1998.
Admission Test Scores for sciences was equal between the 3 concerned student groups (cohort-1998, cohort-1999 and cohort-2000). The scores for information handling were significant lower in cohort-2000 than the two other cohorts concerned.
Academic outcome expressed as PGT and GPA-scores is quite homogenious in all cohorts. Although PGT of cohort-1997 and cohort-1998 are clearly lower than in the other samples and GPA-scores are significant higher in cohort-2000 than in the other ones.

Psychometric qualities of the ILS-questionnaire

Seven subscales refer to processing strategies; four to regulation strategies; and five to learning orientations. Building on principal component analysis we distinguished 16 subscales with 68 items of the original 126 ones.Then factors were rejected due to unreliability (Cronbach alfa < .600). The factor structure is represented in table 2. We founded Cronbach α-values above .70 for eleven subscales and above .60 for the other five subscales. The confirmatory factor analysis based on the separate subscales of the ILS-questionnaire indicates that all parameters represent a a borderline acceptable fit for each of the three subscales (table 3).

Table 2 Characteristics of the ILS-subscales(Vermunt & Vermetten 2004) and SPQ-subscales(McManus, Richards, & Winder 1999) (on the two levels as they were validated in this study) based on students starting medical education in Ghent University from 1996 until 2000 (n=337).

Factors (nb. of items)	Variable label	Cronbach α	Description of subscales
		ILS – EXECUTIVE LEVEL - Processing strategies (n items : 26)	
Structuring (N=5)	STRU	.871	structuring elements of the subject matter into a whole
Critical Processing (N=6)	CRIT	.729	forming one's own view on the subjects that are dealt with, drawing one's own conclusions, and being critical of the conclusions drawn by textbook authors and teachers
Expressing (N=2)	EXPr	.846	capable of translate studied subject in own phrasing or expressing

Memorising (N=4)	MEM	.723	repeating and learning by heart facts, definitions, lists of characteristics
Rehearsing (N=3)	REH	.643	Learning facts, definitions and lists of characteristics by rehearsing them
Use of sources (N=4)	SOU	.664	Consulting different sources of knowledge
Relating (N=2)	REL	.657	Relating parts of the subject matter to each other and to preknowledge
		ILS - CONTROL LEVEL – Regulation strategies (n items = 22)	
Leadership (N=5)	LEAD	.813	going in front in group (learning) activities, not hiding one's own opinion
Lack of regulation (N=9)	LACK	.868	monitoring difficulties with the regulation of one's owns learning processes
Self regulation of content (N=3)	SELF	.788	Consulting literature and sources outside the syllabus
External regulation of learning results (N=5)	EXT	.683	External regulation of learning results: letting an external source regulate one's learning process. Letting oneself be directeby e.g. questions, tests and study directions provides in learning materials or by teachers
		ILS – CONCEPTUAL LEVEL – Learning orientations (n items = 20)	
Ambivalent (N=6)	AMB	.767	a doubtful, uncertain attitude toward the studies, one's own capabilities, the chosen academic discipline, the type of education, etc
Vocation-oriented (N=4)	VOC	.723	studying to acquire professional skill and to obtain a job
Certificate-oriented (N=4)	CERT	.711	striving for high study achievements; studying to pass examinations and to obtain certificates, credit points, and a degree
Decided in choice (N=4)	DECID	.623	made up decision about professional future
Growing intrest about learning (N=2)	INTR	.827	expecting that studying will be increasingly interested

The ILS-items are scored from (1) fully disagree to (5) fully agree. The sum scores for each subscale are standardised within a range from one to five.

Table 3 Summary of the fit indices for ILS-subscales factor models – Results of the confirmatory factor analysis on the ILS and SPQ-construct of this study (students starting medical education in Ghent University from 1996 untill 2000).

	N=337			
Fit indices	X^2 (df, X^2/df)	GFI	aGFI	RMSEA
ILS – constructs – separate subscales				
ILS - Processing strategies	660.9 (278, 2.38)	.868	.834	.063
ILS – Regulation strategies	475.3 (203, 2.3)	.889	.862	.062
ILS – Learning orientations	421.6 (160, 2.64)	.894	.861	.068
Combination of all ILS-subscales	4269.0 (2506, 1.70)	.760	.727	.045

Bringing the three ILS-subscales together in one construct didn't result in a acceptable fit based on the condition that GFI- and aGFI-values should be around .900 while the RMSEA-value is very acceptable (<.050). Nevertheless we can use this construct for estimating the specificity of each factor based on the estimates of correlation by standardized regression weighting.

Vanaf hier heb ik te weinig tijd om vandaag (vrijdag) verder uit te diepen. Van zodra ik verder kom laat ik zeker weten

Specificity of mean ILS-scores

Uit tabel 5 blijkt een sterke correlatie voor amper 12 van de 120 getoetste correlaties (>.500) en een matige correlatie (<.500 and >.400) voor 14 andere. Er is een quasi onbestaande correlatie (<.100) voor 27 van de getoetste correlaties en een beperkte correlatie(>.100 and <.200) voor 30 andere getoetste correlaties; samen bijna de helft van de correlaties.

Variability of mean ILS-scores

Table 4 Comparison between medical curriculum cohorts (Ghent University – students starting medical education from 1996 untill 2000 in Ghent University

Comparison between the five student cohorts revealed:

- no variation at all for only 3 factors: rehearing and relating (both processing strategies); and lack of reagulation (regulation strategy);
- strong variation for 4 factors: critically processing and expressing (both processing strategies); and ambivalence and vocation-orientation (both learning orientations); and

- in between variation for the other factors.

When comparing the scores in successive years (within each student cohort) we detected a quite different variability pattern:

- very low variation for 3 factors: memorising (processing strategy); external regulation of results (regulation strategy); and vocation-orientation (learning orientation);
- very high variation for only 2 factors: relating (processing strategy); and ambivalence (learning orientation); and
- in between variation for the other factors.

Discussion

Zo blijken 11 van de 16 factoren overwegend ongecorreleerd te zijn. Amper drie vertonen sterke correlaties onderling. Alle drie (*critical processing, rehearsing, relating*) zijn processing strategies die naast onderling met elkaar te correleren bovendien de volgende correlaties vertonen:

- *rehearsing* correleert sterk negatief met *lack of regulation* (regulation strategy) and *ambivalence* (learning orientation);
- *relating* correleert sterk met *structurating* and *expressing* (both processing strategies).

Several authors(Lonka & Lindblom-Ylanne 1996;Masui & De 2005;Vermetten, Vermunt, & Lodewijks 2002) describe at least some effect of changing learning environment on students' approaches to learning.

Other studies(Eley 1992;Vermetten, Lodewijks, & Vermunt 1999) concluded that learning processes or strategies are susceptible to changes in the learning context.

Some authors(McManus, Keeling, & Paice 2004) stressed the importance of these learning patterns by claiming that personality and student's approaches to learning are not mere correlates of approaches to work, workplace climate, stress, burnout and satisfaction with a medical career, but causes of them. This author argues that personality characteristics merely have an indirect effect on academic achievement by means of students' approaches to learning ….

Als het zo is dat de leeromgeving sterk bepalend is voor student's approaches to learning dan kunnen we op elk subscale wijzigingen verwachten als deze omgeving effectief verandert.

Op basis van de bevinding dat zij beter scoren bij hoger traditonal curricular years, kunnen we verwachten dat voor 4 van deze factoren de score verbetert bij longitudinale vergelijking van opeenvolgende studiejaren onafhankelijk van het type curriculum (critical processing; expressing; voactional orientation; and decided in choice).

Het zal heel wat moeilijker zijn om veranderingen door curriculum-innovatie waar te nemen bij de 11 meest stabiele factoren: structuring and relating (both processing strategies); leadership and lack of regulation (both regulation strategies); certificate orientation (learning orientation); surface strategy and strategic or achieving motivation (SPQ-factors);

Indien deze factoren na curriculum-innovatie toch beter ontwikkelen weegt deze verandering om die reden ook zwaarder door.

At last, the *memorising* strategy hardly changed and seemed to be a stable learning pattern. We understand that memorising is probably an 'established' strategy, that has become crystallized and remains relatively stable during a school-career(Schmeck 1983).

Further research

Limitations

Two limitations of the present study should be considered. The instrument used do not reflect the actual learning behaviour, but rather students' conceptions(Evans, Kirby, & Fabrigar 2003;Vermetten, Lodewijks, & Vermunt 1999). Although the use of this type of instruments is common practice in educational research, it is important to acknowledge its limitations. The questionnaires could be completed anonymously. As a consequence we suppose that students were honest about their approaches to learning and that it could be justifiable to use self-reports.
Another source of bias could be related to the comparability of the samples. Despite the reassuring homogenity of the studied samples for curriculum-independents characteristics, analysis results still have to be interpreted with caution when considering a generalisation to the specific student population.

Conclusions

Op basis van deze studie kunnen we besluiten dat de psychometrische kwaliteit van de aangepaste ILS-68 item version ruimschoots voldoet om gebruikt te worden als evalutatietool in medical education. Door beide vragenlijsten te combineren wordt een ruim beeld gekregen van leerpatronen van medische studenten op basis van maar liefst 16 parameters. We hebben kunnen aantonen dat drie grote categorieën van variabiliteit zijn te onderscheiden. Zo vonden we 11 factoren die zeer stabiel bleken te zijn in de vergeleken studentencohortes; 14 factoren waarvan we verwachten dat zij gunstig zullen beïnvloed worden door innovatieve leeromgevingen; en 6 factoren die vooral gunstiger lijken te ontwikkelen van freshmen to more expert learner in traditionele curricula.

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