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Impact of the transition from a conventional to an integrated contextual medical curriculum on students' learning patterns: A longitudinal study

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Abstract

Background: Until now, most research studying the impact of curriculum innovations on student learning patterns was restricted to short term or cross-sectional research.

Aim: Studying longitudinal changes in student learning patterns parallel to the implementation of a curriculum innovation from a discipline based to an integrated contextual medical curriculum (ICMC).

Methods: A *post hoc* study applying General Linear Model ANOVA one-way repeated-measures. The inventory of learning styles (126-item version) is used to determine changes in student learning patterns.

Results: Though not all hypotheses could be accepted, the results suggest a significant impact of the ICMC on learning processing strategies; regulation strategies; and on learning orientations. The clear build-up of the curriculum and vertical and horizontal integration of subject knowledge seem to have significantly reduced *lack of regulation* and promoted at an earlier stage *structuring*, *relating*, *critical processing* and *vocational-orientation*. The effect on use of *sources of knowledge, self-regulation of learning content* and *certificate-orientation* was less important than expected. It was yet not possible to confirm the hypothesis that ICMC students become better in translating study topics into their own phrasing or expressions; and neither the expected impact on *vocation-orientation* could be confirmed.

Conclusions: There is little doubt that the present results are important to curriculum (re)designers and those interested in the evaluation of curriculum reforms.

Background

Introduction

Many institutions have adopted innovative approaches to the medical curriculum in order to optimize graduate training. They expect that new medical doctors are life-long learners who flexibly adapt to new challenges in their professional environment. The new curricula also expect students to adopt different learning patterns and reposition the role of assessment and evaluation (Shaughnessy & Slawson 1999; Spencer & Jordan 2001). Studying learning patterns is important since they have been found to correlate with study persistence (Makinen et al. 2004) and with learning outcomes in terms of grades or performance indicators (Trigwell & Prosser 1991; Dejong 1995; Vermunt 1995; Busato et al. 1998; Lynch et al. 1998; Schunk 1998; Husman & Lens 1999; Meyer 2000; Pintrich 2000; Lindblom-Ylanne & Lonka 2001; Boyle et al. 2003; Masui & De Corte 2005).

However, there is hardly cross-sectional and almost no longitudinal research available that studied the impact of a curriculum innovation on learning patterns. Only in one study the effect of promoting a deep approach and the deterring impact of a surface approach to learning was clearly detected (Reid et al. 2005). But the particular curriculum innovation was rather restricted. In order to fill this gap in medical education research, we designed a naturalistic (Buckley 1998) *post hoc* study of longitudinal changes in student learning patterns parallel to the implementation of a curriculum innovation.

Practice points

- There is a shortage of longitudinal research on impact of curriculum innovation.
- The potential of an innovative integrated contextual curriculum is reflected by high its SPICES-profile.
- The clear build-up and vertical-horizontal integration reduced lack of regulation and promoted structuring, relating, critical processing and vocational-orientation.
- The effect on use of sources, self-regulation of content and certificate-orientation is less important.
- Follow-up studies are required to investigate whether this innovation helps students to become expert learners.

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But, to start with, the study first analysed to what extent the innovative curriculum was implemented as it was intended.

Curriculum context: The Ghent experience—Transition from a conventional to an integrated contextual medical curriculum (ICMC)

At Ghent University (Belgium), the conventional medical curriculum (CMC) used to be fully discipline based. It comprised a first year focused on basic sciences, a second and third year of biomedical sciences, two and a half year of clinical disciplines and one and a half year of clinical rotations.

In October 1999, a switch from a conventional discipline-based curriculum towards an integrated and contextual approach was performed (De Maeseneer 2003): patient-centred; student-centred; community oriented; problem and evidence based (Deveugele et al. 2005). One of the main educational goals of the new curriculum was to stimulate self-regulation of the student learning processes.

Research approach

The general research question focuses on the extent to which the curriculum innovation has resulted in changes in student learning patterns. But the question can be asked to what extent the actual implementation of the innovation reflects the intended curriculum innovation. This implies a control of 'treatment fidelity'. This is a critical question since the planned and delivered curriculum can be significantly different (Prideaux 2003). Therefore, the first research question is 'Does the delivered curriculum not differ too largely from the planned curriculum innovation?

Method

Treatment fidelity

In view of answering this question, the *delivered* curriculum was evaluated by using the SPICES model (Harden et al. 1984). Central themes in this model are: Student-centred versus teacher-centred; Problem based versus information gathering; Integrated versus discipline based; Community based versus hospital based; Electives versus standard programme; and Systematic versus apprenticeship-based education. In line with the approach of other researchers (van den Berg 2004), students, teaching and educational staff members assessed both curricula based on these criteria.

Research subjects of the longitudinal comparison

Students involved in the study were enrolled in the matriculating classes of 1998 (CMC) and 1999 (ICMC) and participated in the study during the first 4 years of medical education. Questionnaires were distributed 8 weeks after the start of the academic year within three successive years from the second until the fourth study year. Participation was voluntary.

The following student background variables were controlled in both student groups: prior educational level and educational level of parents (higher education or not), occupational prestige level (Treiman 1977; Elchardus 1979), age, gender, prior (secondary school) education (hours of mathematics, sciences, Latin, Greek). In addition, information was gathered about final scores secondary school, admission test scores, grade point average (GPA) scores and progress test scores.

Statistical analysis

Prior to analyses, variables were examined for accuracy of data entry, missing values, outliers and normality. Non-response was analysed to study possible sample bias by means of two sample *t*-tests and *chi*-squared tests.

In view of the longitudinal within-subjects comparison *ANOVA* one-way repeated-measures was applied, using the general linear model. In this longitudinal within-subject design, only data of subjects who succeeded four successive curricular years were withheld. A p-value of <0.05 was stated as the level of significance. Trend coefficients have been calculated to study the consecutive changes in the dependent variables over time. It was decided not to take into account the data of the first-year students because the expected bottom effect (lack of expected impact) after only 8 weeks of experiencing the medical curriculum.

Research instrument: The inventory of learning styles

The inventory of learning styles (ILS) (Vermunt 1998) has been developed in the context of higher education, and—in the present study—is used to study student learning patterns. The ILS (126-item version) was adopted to the medical curriculum in cooperation with the University of Maastricht (van Luijk et al. 1999). Students were asked to judge on a five-point scale the degree to which the described items corresponded to their usual way of learning, their views towards or their motives for studying. A principal component analysis was used to define the factor structure of the subscales. We could distinguish 25 subscales with 107 items of the original 126. Ten unreliable factors (*Cronbach* $\alpha < 0.60$) and six factors with a too low variability were omitted. Confirmatory factor analysis of the studied factors was used to check if all parameters represent acceptable fit (structural equation modelling). A cut-off value close to 0.06 for root mean square error of approximation (Hu & Bentler 1998) and a goodness-of-fit-index and adjusted goodness-of-fit-index (Medsker et al. 1994) of 0.90 are considered as critical goodness-of-fit parameters (Van der Veken et al. 2007). The final version of the instrument helps to determine three learning patterns: (1) processing strategies (*structuring*; *critical processing*; *expressing*; *use of sources of knowledge*; and *relating*); (2) regulation strategies (*self-regulation of learning content*; and *lack of regulation*); and (3) learning orientations (*vocation-orientation* and *certificate-orientation*).

Hypotheses

Considering the theoretical base, and the way learning patterns are measured, the following hypotheses are put forward: (1) ICMC students will structure to a higher extent elements of

the subject matter into holistic units (*structuring*) and relate more parts of the subject matter to each other and to earlier acquired knowledge (*relating*); (2) due to the introduction of tutorials and individual scientific projects, ICMC students will significantly increase the tendency to form personal views about study topics (*critical processing*) and consult more and different sources of knowledge (*use of sources of knowledge*); (3) ICMC students are expected to be more capable of translating study content into personal phrasing or expressing (*expressing*).

Because one of the main goals of the ICMC was to foster self-regulation of student learning processes, we expect (1) ICMC students to score higher on *self-regulation of learning content*; and (2) to be less unregulated in terms of learning (*lack of regulation*).

Since in the ICMC students are introduced into community oriented medicine, we presume that (1) this will increase the *vocation-orientation*; and the curriculum is partially vertically integrated, (2) we expect a decrease in *certificate-orientation*.

Results

Results about treatment fidelity

Figure 1 illustrates the SPICES-results of a comparison between both the CMC and the ICMC.

The first theme (*student-centred vs. teacher centred*) reflects low scores because educational strategies are mainly teacher focused. But the inclusion of small group work, and skills/attitude and community oriented sessions in the new curriculum resulted in a 2-score.

Evaluation of the second theme (*problem-based vs. information gathering*) indicates that in the new curriculum and in each curriculum year, PBL was introduced as a basic format, resulting in a score of 5. As made clear in Table 1, in the first-year PBL-small group, skills/attitude development and community-based activities raise from 0% in the CMC to 11% (combination c, d and e in Table 1) in the ICMC. In the third year, research activities rise from 0% to 16%.

In relation to the third theme (*integrated vs. discipline based*) the ICMC scores very high since this curriculum consists of a sequence of integrated units focusing on knowledge, skills and attitudes from the basic, biomedical and clinical sciences. The first two and a half years of this integrated curriculum centre on the healthy normal body. The attention paid to horizontal integration results in basic science disciplines not being taught as solitary disciplines but as themes or from an organ perspective (Lie 1995). At this stage, clinical examples are introduced with plenty of real life examples. Definitions concerning vertical integration all share a focus on integrating basic domain knowledge and clinical knowledge (Romeyn 1969; Rangachari 1997; Koens et al. 2005). This means that student experience at least a partial vertical integration. In the second two and a half year cycle of the new curriculum, the same body systems are elaborated from a clinical point of view.

From then on, this curriculum can be catalogued as completely horizontally and vertically integrated.

Evaluation of the fourth theme (*community based vs. hospital based*) results in high scores when considering the ICMC. In the first year, topics of health risks are discussed. In the second year, all students are confronted with the care for 'elderly and extreme care patients' and every student has to follow up a family with a newborn baby during the coming 3 years. They learn to share experiences with other professional disciplines in supporting 'challenged' city neighbourhoods. They learn to consider diagnosis from a community perspective, and to propose solutions. During the fourth year, there is shift of attention to primary health care, and to the role of the general practitioner in collaboration with other health

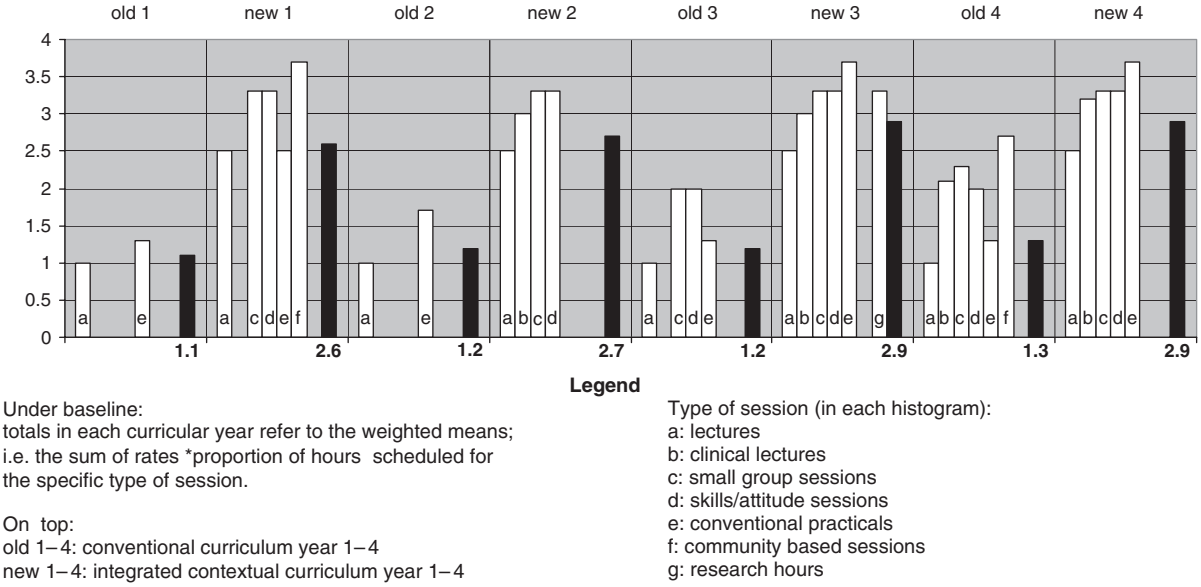

Figure 1. SPICES distribution and rating of various education sessions in conventional (old 1–4) and integrated contextual (new 1–4) curricular years at Ghent University.

Table 1. SPICES distribution and rating of various education sessions in conventional (OLD) and integrated contextual (NEW) curricular years at Ghent University.

		Year 1									Year 2									Year 3									Year 4								
Type of sessions	Curriculum	h*	prop**	S	P	I	C	E	S	Rate	h*	prop**	S	P	I	C	E	S	Rate	h*	prop**	S	P	I	C	E	S	Rate	h*	prop**	S	P	I	C	E	S	Rate
Lectures	Old	421	0.75	1	1	1	1	1	1	1.0	386	0.66	1	1	1	1	1	1	1.0	361	0.58	1	1	1	1	1	1	1.0	343	0.62	1	1	1	1	1	1	1.0
	New	361	0.65	1	2	4	2	1	5	2.5	318	0.65	1	2	4	2	1	5	2.5	314	0.56	1	2	4	2	1	5	2.5	252	0.62	1	2	4	2	1	5	2.5
Clinical lectures	Old	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	65	0.12	1	3	3	4	1	1	2.1
	New	*	*	*	*	*	*	*	*	*	74	0.15	1	4	5	2	1	5	3.0	11	0.02	1	4	5	2	1	5	3.0	33	0.08	1	4	5	3	1	5	3.2
Small group sessions	Old	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	76	0.12	2	3	3	2	1	1	2.0	30	0.05	2	3	3	4	1	1	2.3
	New	12	0.02	2	5	5	3	1	5	3.5	38	0.08	2	5	5	2	1	5	3.3	35	0.06	2	5	5	2	1	5	3.3	6	0.01	2	5	5	2	1	5	3.3
Skills/attitude sessions	Old	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	38	0.06	2	3	3	2	1	1	2.0	15	0.03	2	3	3	2	1	1	2.0
	New	42	0.08	2	4	4	4	1	5	3.3	60	0.12	2	4	4	4	1	5	3.3	74	0.13	2	4	4	4	1	5	3.3	60	0.15	2	4	4	4	1	5	3.3
Practicals	Old	140	0.25	1	2	2	1	1	1	1.3	196	0.34	1	2	2	1	1	1	1.7	143	0.23	1	2	2	1	1	1	1.3	68	0.12	1	2	2	1	1	1	1.3
	New	140	0.25	1	3	4	1	1	5	2.5	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Comm.-based sessions	Old	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	30	0.05	2	3	4	5	1	1	2.7
	New	3	0.01	2	4	5	5	1	5	3.7	*	*	*	*	*	*	*	*	*	39	0.07	2	4	5	5	1	5	3.7	55	0.14	2	4	5	5	1	5	3.7
Research hours	OLD	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	New	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	90	0.16	2	4	5	3	1	5	3.3	*	*	*	*	*	*	*	*	*

Notes: *Total of scheduled hours; **Proportion of scheduled hours.

care workers. Students explore preventive health care and identify health risks and their prevention at the individual level and community level.

Evaluation of the fifth theme (*elective vs. uniform*), results in a level 1-score since all students follow the same programme. In view of the last theme (*systematic vs. apprenticeship based*), all educational sessions of the ICMC aim at the final goals of the medical education with a strong focus on training for practice; this results in a high score. This is in sharp contrast with the conventional curriculum.

Following the approach of van den Berg (2004), the weighted mean was calculated for every theme, i.e. the sum of rate × proportion of hours scheduled for the specific type of session. The results reflect an overall score of 1.2 for the CMC and a score of 2.8 for the ICMC. The latter reflects a clearly higher SPICES-oriented profile.

Results in relation to the research question about the longitudinal impact of the curriculum innovation

Quality of samples. The response rate to successive administrations decreased from an initial high of 0.89 to a low of 0.76 on the final administration to students in the CMC cohort and from an initial 1.00 to 0.64 on the final administration to students in the ICMC cohort. The response rate to successive administrations during the 4 years decreased. Data of 57% of the subjects could be incorporated in the longitudinal analysis. This smaller sample is still representative as to educational level of parents, prior (secondary school) education, MAT-scores, progress test scores, age and gender in both curricula (Table 2). The respondents of the ICMC cohort score higher on the prestige-index of their parents, and differ in the extent they studied more sciences at secondary school level.

The respondents are representative regarding to all of the nine studied ILS scores. The ICMC respondents are only not representative for *vocation-orientation*. Comparing participants between both curricula, ICMC students are only different from their CMC colleagues concerning *relating* and *vocation-orientation*.

Impact on learning patterns. Table 3 summarizes the descriptive results and the results of the statistical analyses. The changes in three learning patterns are documented: (1) processing strategies (*structuring*; *critical processing*; *expressing*; *use of sources of knowledge*; and *relating*); (2) regulation strategies (*self-regulation of learning content*; and *lack of regulation*); and (3) learning orientations (*vocation-orientation*; and *certificate-orientation*).

Our expectations about the changes of learning pattern in ICMC student's processing strategies are partially confirmed when we perceive that they structure to a higher extent elements of the subject matter into a whole (*structuring*). In both curricula a significantly higher score can be observed for the changes in this learning pattern, but the change pattern is clearly different. There is no change between the second and third CMC years and a clear change in the fourth year. The change in the ICMC occurs already 1 year earlier.

In contrast to our prediction, ICMC students do not relate significantly more parts of the subject matter to each other

and/or to their prior knowledge (*relating*). Students in both curricula reflect significantly higher scores.

The table also reveals an overall increase in the tendency of students to express personal views about study topics (*critical processing*) and the capability to translate study content into personal opinions or expressions (*expressing*). The expected differential impact of introductory tutorials and individual scientific projects does not occur. In contrast, the ICMC students reflect a significant increase in *use of sources of knowledge* in the fourth ICMC curricular year. There is no such significant change in the CMC students.

In the context of the learning patterns related to *regulation strategies*, we observe a higher score (but not significantly) in the fourth ICMC curricular year for the learning pattern related to *self regulation of learning content*. But the ICMC students perform significantly better on *lack of regulation* from the third year on.

In the context of the learning pattern in the *learning orientations*, we observe, as predicted, that the ICMC students perform significantly different when it comes to their *certificate-orientation* (learning orientation) in the fourth curricular year (downward but not significantly). There is no change for this item in the students taking the CMC. On contrast, the *vocation-orientation* increases independent of the type of curriculum. The hypothesis that introducing community oriented medicine and vertical integration would increase *vocation-orientation* is therefore not confirmed.

Discussion

In general, we can state that the curriculum innovation did affect learning patterns in a different way as compared to the learning patterns of students in a CMC. But there is not a general overall impact and not all the hypotheses have been confirmed.

Our findings—though not always consistent were not confirmed by a number of earlier studies; e.g.

- the statement that learning patterns are not expected to be influenced by the particular learning context of undergraduate education (Newble & Entwistle 1986);
- that efforts to encourage a deep and deter a surface approach did not alter in a significant way ILS-scores in a longitudinal study (Reid et al. 2005); and
- the finding that academic intrinsic motivation is a rather stable construct and the opinion that it is therefore not be easy to change academic intrinsic motivation at a later stage (Gottfried et al. 2001).

On the other hand, our results are in line with the findings of other authors (Lonka & Lindblom-Ylanne 1996; Vermetten et al. 2002; Masui & De Corte 2005). These researchers report a differential impact because of changes in the design of the learning environment. In one study (Minnaert & Van der Hulst 2000), it was found that in a rather stable educational context, the intercorrelations between first and second administration of ILS are higher than in a context in which conventional teaching methods are replaced by innovative approaches.

The conflicting findings could be related to a more general debate. Some authors (McManus et al. 2004) stress e.g. that personality and student learning patterns are not mere correlates of approaches to work, workplace climate, stress, burnout and satisfaction with a medical career, but rather 'causes' of them. Personality characteristics are therefore to rather have an indirect impact on academic achievement through the learning patterns.

The present study differs clearly from earlier studies that focused on curriculum innovations because of the longitudinal evaluation approach; e.g. the studies that focused on the expected outcomes of a PBL reorientation of the medical curriculum (Albanese & Mitchell 1993; Berkson 1993; Vernon & Blake 1993; Colliver 2000a, b; Hmelo-Silver 2004). The results of these studies started a debate about the characteristics of valid evaluation approaches for curriculum innovation (Thomas 1997). A key element in these critics is the lack of longitudinal evaluation research. Also cross-sectional studies did not show an improvement in reported quality of learning or changes in learning patterns (Lonka & Lindblom-Ylanne 1996; Busato et al. 1998) since these are not helpful to analyse intra-individual change, and are marred by possible cohort effects. It is only in the few available attempts to set up longitudinal research that a significant impact could be found. Busato et al (1998) did e.g. detect differences in learning patterns in a longitudinal design namely an increase in reported use of a meaning-directed learning style. Also Watkins (Watkins & Hattie 1985) reported significant changes in a longitudinal study. The fact that our findings are in line with these longitudinal studies is therefore reassuring.

The *impact on learning processing strategies* was clear for structuring and for *use of sources of knowledge*. But not all hypotheses have been confirmed. Students in the ICMC did not relate more parts of the subject matter to each other and/or to their prior knowledge (*relating*); nor seemed the introduction of PBL-tutorials and the scientific projects elicit the expected impact on the capacity to translate study topics into own phrasing or *expressions*. We can explain the fact that no significant differences were observed in *critical processing* considering the type of curriculum. The ICMC did not present sufficient tasks focusing on literature searches and processing; mostly exhaustive course material were prepared by the teaching staff.

Concerning the *impact on learning regulation strategies*, we could detect that students in the third year of the ICMC scored clearly lower for *lack of regulation*. Both curricula are still very comparable in the earlier curriculum years because both the horizontal and vertical integration of the subjects are only completely operational from the end of the second year on. The complete vertical and horizontal integration of course content finally helps to reduce in a significant different way the *lack of regulation*. This is reconfirmed in the fourth ICMC year. This is in line with other research (Dejong 1995; Busato et al. 1999; Vermetten et al. 1999; Boyle et al. 2003) and of great importance because there is evidence that *lack of regulation* is a key indicator of being unsuccessful in higher education (Minnaert 2000). The second element, related to the learning pattern in regulation strategies refers to *self-regulation of student's learning content*. The differential impact of the ICMC is less clear. We think that due to the low proportion of time

Table 2. Comparison of the characteristics of parents, prior education, MAT-, GPA-scores, age, gender and ILS-scores of those students who filled in the questionnaires in all occasions (labelled with 'respondents') with those who cooperated only at the start of the study (labelled with 'non-respondents') and between the two cohorts participating in het longitudinal study.

	Conventional curiculum				Integrated contextual curriculum				Respondents type of curriculum			
	Respondents	Non-respondents			Respondents	Non-respondents			Conventional	Integrated contextual		
	$N=34$	$N=20$			$N=30$	$N=28$			$N=34$	$N=30$		
			t (2,52)	χ^2			t (2, 56)	χ^2			t (2, 62)	χ^2
% male	44.1	25.0		1.24	50.0	42.9		0.08	44.1	50.0		0.05
Age at start of med education	17.99	18.06	−0.914		18.03	20.89	−1.017		17.99	18.03	−0.578	
Socio-economic and educational backgroud of parents												
Prestige-index parents	70.67	67.00	1.204		68.14	61.42	2.112*		70.67	68.14	0.998	
% No higher education parents	3.1	11.1		0.27	6.9	20.8		1.18	3.1	6.9		0.01
Prior education												
% Major maths	38.8	36.8		1.56	51.7	37.0		0.70	38.8	51.7		0.10
% Major sciences	46.9	50.0		0.01	80.0	56.0		2.64	46.9	80.0		5.93*
% Classical languages	35.3	20.0		0.77	36.7	33.3		0.00	35.3	36.7		0.02
% High score secundary education	25.0	14.3		0.14	47.8	52.6		0.00	25.0	47.8		1.75
Admission test Scores												
Score for science	14.33	14.00	0.648		13.90	14.08	−0.400		14.33	13.90	1.017	
Score for information handling	13.27	12.95	0.987		13.27	13.24	0.071		13.27	13.27	0.018	
Academic outcome												
Grade point average score year 2	675	659	0.872		708	701	0.354		6.75	708	−1.755	
Progress test score year 2	11.94	12.25	−0.110		12.16	15.76	−0.877		11.94	12.16	−0.062	
Progress test score year 4	43.63	39.05	1.083		44.82	54.01	−1.392		43.63	44.82	−0.214	
ILS-scores			t (2,52)	p			t (2,56)	p			t (2,62)	p
Processing strategies												
Structuring	3.688	3.700	−0.051	0.96	4.033	3.693	1.823	0.07	3.688	4.033	−1.908	0.06
Critical processing	3.574	3.751	−1.123	0.27	3.828	3.803	0.187	0.85	3.574	3.828	−1.857	0.07
Expressing	3.897	3.800	0.442	0.66	3.800	3.982	−1.105	0.27	3.897	3.800	0.570	0.57
Use of sources of knowledge	2.787	2.488	1.465	0.15	3.042	2.839	1.141	0.26	2.787	3.042	−1.397	0.17
Relating	3.603	3.900	−1.383	0.20	4.033	3.821	1.042	0.23	3.603	4.033	−2.184	0.03*
Regulation strategies												
Lack of regulation	2.791	2.984	−1.133	0.16	2.744	2.992	−1.432	0.13	2.791	2.744	0.275	0.78
Self regulation of learning content	2.510	2.367	0.610	0.55	2.733	2.453	1.385	0.17	2.510	2.733	−1.105	0.27
Learning orientatations												
Vocation orientation	3.757	3.875	−0.561	0.58	4.050	3.741	2.075*	0.05	3.757	4.050	−1.990	0.05*
Certificate orientation	3.029	3.113	−0.315	0.75	3.100	2.982	0.631	0.53	3.029	3.100	−0.313	0.76

Notes: Independent samples t-test: *$p < 0.05$ and $p > 0.01$; Sign of t-test refers to higher(+) or lower(−) score of respondents vs. non-respondents; χ^2-values are Yates corrected: *$p < 0.05$ and $p > 0.01$

Table 3. Results longitudinal trend-analysis (year 2 to year 4) of ILS-subscales within and between both types of medical curriculum (general linear model-*ANOVA*-repeated measures).

	Mean scores CMC $N=34$			Mean scores ICMC $N=30$			Effect of year Test within-subjects contrasts			Interaction effect: year * curriculum Test within-subjects contrasts		
							Multivariate test			Multivariate test		
	Year 2	Year 3	Year 4	Year 2	Year 3	Year 4	*F* (*p*-value)	*F* (*p*-value)	Pattern (partial eta squared)	*F* (*p*-value)	*F* (*p*-value)	Pattern (partial eta squared)
ILS – Processing strategies												
Structuring	3.688	3.641	3.924	4.033	4.307	4.200	2.903 (0.06)	5.843 (0.02)*	Linear (0.09) S	4.935 (0.01)*	9.045 (0.004)**	Quadratic (0.13) M
Critical processing	3.574	3.726	3.765	3.828	4.016	4.068	7.853 (0.001)**	14.582 (<0.001)**	Linear (0.19) M	0.097 (0.91)	0.185 (0.67)	Non
Expressing	3.897	4.088	4.103	3.800	3.900	4.000	3.590 (0.03)*	7.121 (0.01)*	Linear (0.10) S	0.315 (0.73)	0.001 (0.97)	Non
Use of sources of knowledge	2.787	2.846	2.713	3.042	2.992	3.233	0.383 (0.67)	0.506 (0.48)	Non	3.273 (0.04)*	4.407 (0.04)*	Quadratic (0.07) S
Relating	3.603	3.941	3.971	4.033	4.167	4.317	6.243 (0.003)**	12.691 (0.001)**	linear (0.17) M	0.607 (0.55)	0.213 (0.65)	Non
ILS – Regulation strategies												
Lack of regulation	2.768	2.863	2.835	2.744	2.593	2.508	1.360 (0.26)	2.382 (0.13)	Non	2.534 (0.09)	5.091 (0.003)**	Linear (0.08) S
Self-regulation of learning content	2.510	2.639	2.549	2.733	2.756	3.022	1.702 (0.09)	3.451 (0.07)	Non	2.180 (0.02)	1.992 (0.16)	Non
ILS – Learning orientations												
Vocation-orientation	3.757	4.015	4.125	4.050	4.200	4.392	9.904 (<0.001)***	19.428 (<0.001)***	Linear (0.24) M	0.668 (0.52)	0.026 (0.87)	Non
Certificate-orientation	2.436	2.347	2.426	2.612	2.605	2.427	0.769 (0.47)	1.492 (0.23)	Non	2.396 (0.10)	1.201 (0.28)	Non

Notes: *F*-test: *$p<0.05$/**$p<0.01$/***$p<0.001$; 'S' and 'M' refer to effect size correspoding to partial eta squared values; *S* = small effect; M = medium effect (Tabachnick & Fidell 2007b); As ILS-items vary from (1) fully disagree to (5) fully agree and on each subscale the scores on the respective items are summated and standardised, scores range from one to five. Multivariate tests evaluate the effect over time of each variable (labelled with effect of year) or evaluate the effect of the interaction of time and type of curriculum (labelled with interaction effect: year * curriculum). Tests of within-subjects contrasts evaluate a linear or quadratic pattern of the effect.

devoted to educational strategies that build on a PBL-format, the ICMC did yet not fulfil its potential.

The study of the *impact on learning orientations* revealed that second-year ICMC students reflect a significantly higher *vocation-orientation* and evolve to a significantly higher level in the following year as compared to CMC subjects. But, this increase is not different between both curricula. We are rather surprised that although large efforts were invested in the community-orientation in the different course subjects, the growth itself is not different between both curricula. This could partially be explained by a percentage of the students that prefer in the end a clinical specialisation instead of a community oriented medical profession. This could also help to explain why there was not a significant larger decrease in the *certificate-orientation* in the ICMC. Grades are important for these students in view of getting access to the specialisation.

Directions for future research

Follow-up studies could investigate if the innovative curriculum did—next to changes in student learning patterns—also help in the actual growth and development of students in becoming expert learners. This is important since a number of other relevant research questions remain unanswered:

- is the outcome of the curriculum innovation worthwhile in terms of time and funds;
- what is the longer term impact (e.g. in terms of the professional competencies); and
- what is the impact of the curriculum change on actual knowledge acquisition and retention?

Limitations

Some limitations of the present study should be considered. The research instrument used to determine learning pattern did not reflect the actual learning behaviour, but rather student conceptions about their own learning patterns (Vermetten et al. 1999; Evans et al. 2003). Although the use of this type of instruments is common practice in educational research, it is important to acknowledge this limitation.

Another source of bias could be related to the consecutive repeated administration of the same research instruments. We nevertheless think that a 1-year interval will not have influenced answering patterns of students.

Other background characteristics than age, gender, prior education, educational and occupational prestige level of parents, admission test, grade point average and progress test scores of the students involved in the study were not taken into account. We consider those differences as having a minor influence to our findings. Differences in the learning context such as time-on-task, academic achievement, organisational characteristics and characteristics of the teaching staff, might also have resulted in emerging differences in learning approaches. We believe that these factors, happening in the same university, with the same teaching staff and in a time-interval of only 4 years, are almost identical in conventional en integrated contextual curricula.

A last limitation is related to the sample. Despite the reassuring non-response analysis, analysis results still have to be interpreted with caution when considering a generalisation to the specific student population.

Conclusions

Until now, most research studying the impact of curriculum innovations was restricted to short term or cross-sectional research. In the present study, a longitudinal design was adopted to study the impact of a comprehensive curriculum intervention on medical student learning patterns. This can be considered as a rather exceptional approach in the research literature. In addition, treatment fidelity was checked to compare the planned and the implemented curriculum.

Although not all the hypotheses could be confirmed, the results suggest significant effects of the ICMC on learning processing strategies, learning regulation strategies, and on learning orientations. The clear build-up of the curriculum and the vertical and horizontal integration of subject knowledge seem to have significantly reduced the *lack of regulation* and to promote at an earlier stage in the curriculum *structuring*, *relating* and *critical processing*. The effect on *use of sources of knowledge* and *self-regulation of learning content* appeared only in the fourth ICMC year and was less important as expected. It was yet not possible to confirm the hypothesis that students in the ICMC become better in translating study topics into their own phrasing or *expressions;* and neither the expected impact on *vocation-orientation* and *certificate-orientation* could be confirmed. Nevertheless, there is little doubt that the present results are important to curriculum (re)designers and those interested in the evaluation of curriculum reforms.

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