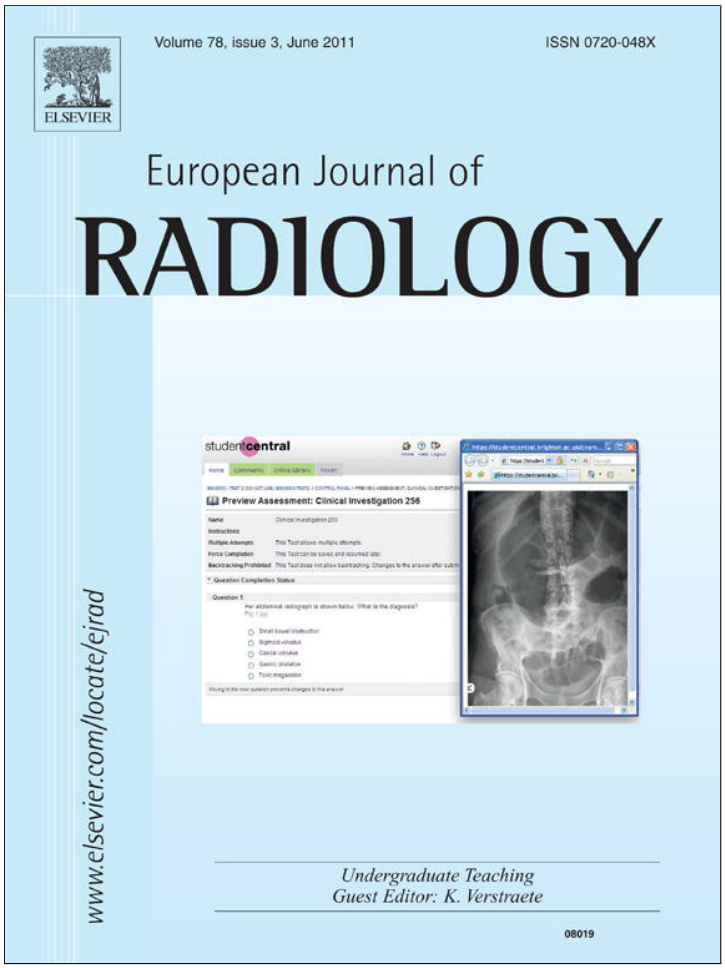

European Journal of Radiology 78 (2011) 326–333

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

The Perceived long-term impact of the radiological curriculum innovation in the medical doctors training at Ghent University

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ARTICLE INFO

Article history:
Received 2 June 2010
Accepted 14 June 2010

Keywords:
Radiology
Curriculum
Undergraduate medical education
Perception
Teaching methods

ABSTRACT

Objectives: How do students experience and perceive the innovative undergraduate radiology curriculum at Ghent University, and what explains differences in student perception?
Methods: A survey was presented to the 2008 cohort of students enrolled in the undergraduate medical curriculum at Ghent University. The survey focused on their experiences and perceptions in relation to the innovative undergraduate radiology teaching.
Results and conclusion: The present research results point at a favorable perception of the innovative radiology curriculum components. The study points – both during pre-clinical and clinical years – at the appreciation for curriculum components that combine traditional curriculum components (ex-cathedra lessons with syllabus) with distance learning components such as E-learning and E-testing. In clinical years – as expected – students switch to the application of knowledge and skills and therefore heavily appreciate practice linked curriculum components.

1. Introduction

In recent years, many medical schools have undergone curricular reforms and have implemented innovations regarding the content and instructional design of the teaching and learning experience. A main goal of these curriculum innovations is to enhance the efficiency and efficacy of the teaching approach, resulting in better learning performance. Consequently, research stresses the importance to reconsider the nature of the learning environment [1–3]. In this context, Hutchinson [4] points out that "the teaching methods should build on learners' experience, creating collaborative environment". Other authors point at different innovative features of the learning environment, such as action learning and group work [5], an emphasis on the interactivity of the learning environment [6], the expansive use of multimedia [7–9], the adoption of E-learning [8,10–16], etc. The approach of "blended" learning [9,17] – in which face-to-face instruction is mixed with E-learning – appears to be particular useful and efficient in terms of learner achievement and satisfaction. Although there are a lot of variation in radiological education across institutions in US, Canada and Europe [18–20], the value of effective and efficient radiology teaching [21–23], based on sound principles derived from evidence based learning theories [24] is very important for the future of radiology as a profession.

Krathwohl, Bloom, and Masia [25] have founded that educational objectives can be structured along three learning domains: cognitive (what we think and believe), affective (what we feel and experience), and psychomotor (what we do). They describedthe affective learning as "emphasizing a feeling tone, an emotion, or a degree of acceptance or rejection" (p.7). It is known that attitudes are strong predictors of behavior [26,27] and that they playa mediating role in the relationship between clinical competences and performance [28]. The redesign of a learning environment will not automatically influence its efficiency and efficacy and/or result in better learning performance. Research consistently emphasizes that the way students experience and perceive their learning environment mediates the efficiency and efficacy of an innovative design [29,30]. In addition, these perceptions differ depending on the specific learning needs of students in the pre-clinical or clinical phase of their medical training [31].

The emphasis on student experiences and perceptions introduces the relevance of studying student attitudes towards curriculum innovations. The present study builds on the critical role of student perceptions as it is linked to the evaluation of a large scale innovation project in radiology teaching at Ghent University, Belgium. The originality of the present study is that the entire radiology curriculum is studied as it is interwoven with the seven-year medical curriculum. As such, also the long-term effects on student perceptions of the different key elements of the curriculum innovation can be unveiled and analyzed.

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doi:10.1016/j.ejrad.2010.06.022

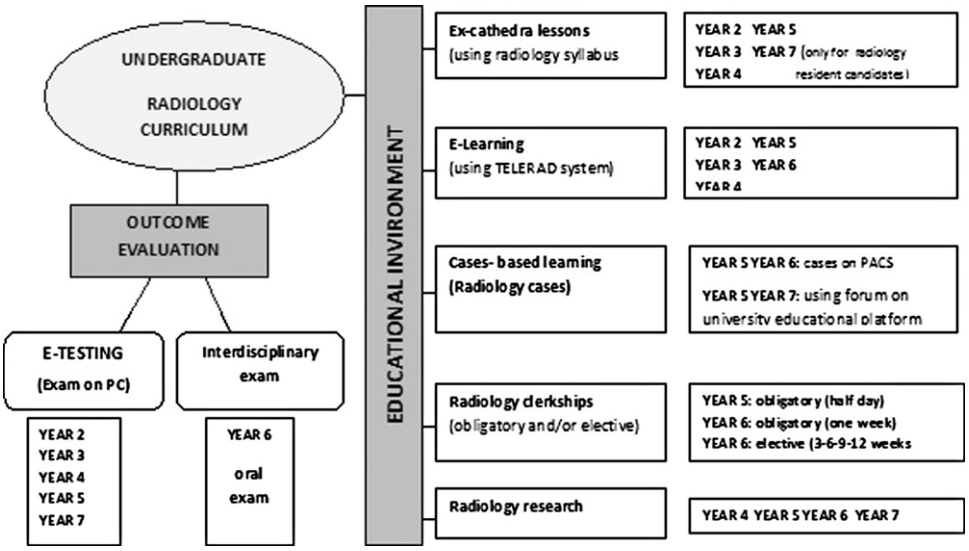

Fig. 1. Design of the undergraduate radiology curriculum at Ghent University.

1.1. Description of the undergraduate radiology curriculum at Ghent University

At Ghent University a large scale curriculum reform was introduced in 1999 with a switch from a conventional medical curriculum (CMC) to an integrated contextual medical curriculum (ICMC). The main features of the latter are: patient centered, student centered, community oriented, problem and evidence based learning and teaching [32]. Within an ICMC curricula attention is paid to a horizontal integration by linking different disciplines to a specific central theme, and vertical integration by embedding four continuous curriculum "lines" in the program: medical skills, exploration of the health system, medical problem solving, and an individual scientific project.

The place of radiology in an ICMC curriculum is well defined. Radiology is integrated in different modules covering body systems or body part (like thorax, abdomen, musculoskeletal system) in the pre-clinical and clinical part of the training. The basic structure of the Ghent University undergraduate radiology curriculum is shown in Fig. 1. At the same time, also the different didactical approaches are highlighted: a radiology syllabus, radiology teaching sessions, an E-learning environment, radiology PC based assessment, radiology clerkships, radiology related scientific research activities, and radiology cases. We give an outline of the key characteristics of these six components.

Formal ex-cathedra lessons building on a radiology syllabus persist throughout all years of medical training starting in year 2. Students receive prior to the lecture handouts of all slides. A handbook, underpinning the syllabus and recommended for future reading is available.

Also *E-learning applications* are a well integrated component of the radiology teaching approach at Gent University. An open-source E-Learning system is in use since 2003. A key element in this environment is the self-assessment exercises developed with Telerad system. The system developed is especially designed in view of working with a rich variety of medical imaging output. Different types of questions can be adopted (multiple choice, click-on, fill-out word(s) and open questions), building on cases, and radiology images. Students get automated individual feedback in view of updating their knowledge and skills. In the Ghent context, all *radiology exams are set up via PC*'s and this consistently in all curriculum years; with the exception of year 6 where an interdisciplinary oral examination is adopted. This focused radiology exam is set up to assure that no students "skip" radiology as a key component in the interdisciplinary context.

A fourth key component of the innovative ICMC curriculum – from year 5 on – is the *clinical clerkship*. Different types of radiology clerkships are provided for clinical years students.

For the students of year 5, an observation-based visit of the radiology department is planned during half a day. Clear goals guide this required structured, and guided clerkship:

1. To demonstrate the working of radiology department (the equipment, patient flow, image flow, reporting, administrative and logistic work, personnel involved, timing, waiting rooms, etc.).
2. To learn to work with radiological CDs from different hospital settings.
3. To learn to work with web-based PACS and solve radiological cases.
4. To answer E-learning exercises.

Students of year 6 stay for a longer period in the radiology department; usually for 1 week and they get specific tasks to be carried out. This required radiology clerkship is a key ingredient that contributes to their involvement in the interdisciplinary oral examination at the end of year. The goals of this clerkship are:

1. To follow a selected number and type of radiological examinations.
2. To improve the skills related to the interpretation of radiology images.
3. To learn working with web-based PACS (case-based learning) and CDs.
4. To participate in routine clinical practices.
5. To learn developing radiology prescriptions (Guidelines for appropriate use of radiology: "when to order and what").
6. To attend clinical-radiology conferences and multidisciplinary team meetings.

Students of the last training year (year 7) are split into two groups: (1) potential Radiology Residency candidates staying for a period of 12 weeks at the radiology department, and (2) candidates opting for other medical specializations. The latter stay for a period of 3–6–9 weeks depending on their specialization option>. The goals of these clinical elective clerkships are:

Table 1
Measurement of reliability of the Evaluation Radiology Teaching Concept Scale (ERTeCS).

Subscale[a]	α	Statements[a]	*N*	Mean	SD
Radiology teaching	0.81 (*N* = 4)	Radiology is well integrated into the medical training as a whole	977	4.16	0.84
		Radiology courses is well integrated in whole of the block-system, which makes it easier for me to place, interpret and process the learning substance	977	4.14	0.87
		The lecturer is aware of the contents of the curriculum and the lessons benefit from this (no overlap, reference to other courses)	977	4.08	0.85
		Knowledge of the radiology lecturers goes beyond radiology in strict sense (topical matters, clinic, etc.)	977	3.82	0.89
Radiology syllabus	0.72 (*N* = 4)	Learning objectives of radiology syllabus are clear formulated	977	3.94	0.91
		The radiology syllabus is clear structured (main and second points are distinguished, syllabus is easy to process)	977	3.38	1.02
		Radiology syllabus contains sufficient references to further sources where background information can be found	977	3.64	0.88
		The reference book for radiology has well chosen (comprehensible, student friendly, practical-oriented, etc.)	977	3.47	0.89
Radiology E-learning	0.91 (*N* = 6)	E-learning is very useful	977	4.35	0.82
		E-learning exercises are accessible (from home or elsewhere)	977	4.20	0.92
		E-learning exercises are a good addition to the radiology syllabus	977	4.30	0.84
		I am familiar with E-learning exercises	977	4.04	0.92
		I am able to perform E-learning exercises independently	977	4.18	0.83
		The feedback during E-learning exercises is useful	977	4.14	0.83
		I use the feedback during the E-learning exercises	977	4.03	0.96
		E-learning exercises are essential to the preparation for my exams	977	4.26	0.91
Radiology E-testing	0.84 (*N* = 5)	PC exam is corresponds to the learning objectives	977	4.13	0.65
		There was clarity in advance concerning the PC exam (multiple choice questions, open questions, interpretation of images, theory, etc.)	977	4.06	0.80
		The exams questions on PC correspond to the expectations (both in terms of degree of difficulty and type of questions, etc.) lecturer creates by with example questions, method of teaching and e-teaching	977	3.73	0.80
		The PC exam questions are worded such that if you have studied the subject, you can come away from exam satisfied	977	3.71	0.83
		I think that E-testing is a good, reliable way of taking exams (the result reflects my knowledge and skills)	977	4.07	0.72
Radiology clerkship	0.88 (*N* = 14)	During the radiology clerkship I was able to attend various radiological examinations	355	3.90	0.73
		I am able to solve the clinical questions posed during radiological examinations	355	3.32	0.60
		My skills to interpret radiological images improved during the clerkship	355	3.13	0.70
		During the clerkship I learned to work with radiological CD's from the various hospitals	355	3.53	0.64
		I am able to work independently with radiological CD's from the various hospitals	355	3.33	0.63
		During the clerkship I learned to work with web-PACS system	355	3.35	0.67
		I am able to work independently with web-PACS system	355	3.33	0.68
		During the clerkship I learned to correctly prescribe a radiological examination	355	3.07	0.75
		I am able to correctly prescribe a radiological examination independently	355	3.53	0.66
		I believe taking part in multidisciplinary staff meetings during the radiology clerkship offers added value to the clerkship	355	3.22	0.58
		I found my participation in multidisciplinary staff meetings during the radiology clerkship informative and fascinating	355	3.12	0.53
		There is sufficient variation in the tasks the student must perform during the clerkship	355	3.25	0.67
		I improved my knowledge of radiology during the clerkship	355	3.24	0.66
		I believe the supervision by docent and radiologists was optimal during clerkship	355	2.86	0.65
Radiology cases	0.69 (*N* = 4)	The sufficient number of cases are offered to solve	355	3.60	0.73
		Working in small groups on a particular radiology case is interesting because you learn from each other by discussing things together	355	3.38	0.89
		Working in small groups on a particular radiology case interesting because the problem is solved more quickly	355	3.10	0.87
		Working in small groups on a particular radiology case interesting, because we can solve the case using forums on the university's electronic learning platform	355	2.90	0.93
Radiology research	0.95 (*N* = 5)	The research task was very interesting, I found it fascinating and informative	355	3.92	0.16
		I received enough support and supervision from my promoter and co-promoter	355	3.96	0.19
		I have adequately helped to find suitable sources of information (internet, periodicals, books, etc.) to be able to carry out my research	355	3.97	0.12
		I had sufficient time to be able to carry out my research carefully	355	3.92	0.18
		Carrying out scientific work in Radiology offers added value for my training	355	3.97	0.12

N = number of respondents, *M* = mean, SD = standard deviation, α = Cronbach's α.

[a] The items are scored from "totally disagree" (1) to "totally agree" (5).

1. To attain a high level of radiology image interpretation.
2. To learn developing prescription according to the guidelines for appropriate use of radiology.
3. To deal with a variety of radiology cases.

As a fifth component, students get the opportunity to carry out a *radiology related scientific study* (such as developing a literature research review or setting up a small scale experimental study). The latter is available from the fifth year on.

Lastly, the curriculum innovation entails working *with radiology cases*. This was usually introduced in year 5 and 6, in the context of the clinical-radiology clerkships. Since 2008–2009, "web-based cases" have been introduced in year 5 and 7 in the context of interactive guided working sessions. The students are expected to work together in small groups to discuss and to solve the cases using the electronic discussion forum that is part of an electronic educational learning platform at Ghent University. Teaching staff gives feedback about the case solutions, and focus accuracy and the rationale presented to ground the decisions. These case solutions are also essential part of the subject to be studied in view of final exam.

Since the start of the curriculum, anecdotal evidence points at positive student attitudes towards this new instructional program. But a formal, and systematic evaluation was – up till now – not set up. The present article centers on the results of a cross-sectional longitudinal study to study the perceived impact of the new curriculum as derived from student attitudes.

1.2. Research questions

In view of this study, one key research question is studied: What is the nature of student attitudes towards the key components of the innovative radiology curriculum. In addition, we explore to what extent student perception shifts depending on their training year.

2. Materials and methods

2.1. Participants and procedures

The students enrolled as second to seventh year medical students at Ghent University were invited to participate in the study. A total of 1117 students were asked to complete questionnaire, focusing on their attitudes towards the different radiology curriculum components. First year students were not asked to participate in this survey since radiology is only part of the curriculum from the second year on.

Participants filled out the questionnaire anonymously after obtaining informed consent. The questionnaire was accompanied by a letter giving background information about the objectives of the study. Participation was voluntary and students were informed that neither participation nor non-participation would affect their grades. Ethical approval was granted by the Human Investigation Ethical Committee of the Ghent University Hospital.

2.2. Design and development of the Evaluation Radiology Teaching Concept Scale (ERTeCS).

The Evaluation Radiology Teaching Concept Scale (ERTeCS) consists of 104 items focusing on background variables, student perceptions in relation to radiology curriculum components, mastery of radiology knowledge and skills, and the orientation towards the radiology profession. This new questionnaire was developed after analysis of the literature, observation of radiology teaching activities and on the base of focus groups interview results. Two focus group sessions were set up [33] with students from different training years, to identify the way they perceive the curriculum, what they consider to be critical to learn and to be taught. This resulted in a preliminary framework that – in combination with the literature review results – was discussed with radiology teaching experts and academic staff from Ghent University and Maastricht University to assure the appropriate content focus of the questionnaire.

Of the 104 items, 74 focus on radiology curriculum components. Out of these 74 statements, 63 items focused in particular on student attitudes towards specific undergraduate radiology curriculum components. Each item was developed as a statement, and respondents were invited to indicate their level of agreement on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Eight open ended questions were presented to give students the opportunity to give comments and suggestions about different aspects of the radiology learning environment. For example "give further comments or explain your answer choice on certain item about radiology E-learning". Lastly, seven knowledge test radiology multiple choice questions and three radiology image interpretation questions were presented to the students. Lastly, items were added centering on demographics, such as study year, gender, type of student (regular student versus student with an Individualized Study Trajectory), academic performance indicators (pass grades of former academic year).

Table 2
Goodness-of-fit indices.

Subscale	X^2	p	GFI	CFI	RMSEA
Radiology teaching	31.936	<.001	.984	.979	.124
Radiology syllabus	65.091	<.001	.966	.918	.180
Radiology E-learning	510.729	<.001	.880	.903	.159
Radiology clerkship	97.017	<.001	.915	.957	.073
Radiology cases	11.412	.003	.994	.985	.069
Radiology research	224.90	<.001	.920	.940	.212
Radiology E-testing	156.00	<.001	.940	.921	.176

GFI, goodness-of-fit index; CFI, comparative fit index; RMSEA, root mean square error of approximation.

2.3. Psychometric quality of the ERTeCS attitude scale

In the present article, we mainly focus on the 63 items capturing student attitudes towards the radiology curriculum components. These items were developed to develop a better understanding of student perceptions about the learning environment. Seven subscales can be distinguished, considering what component is being focused upon: "Radiology teaching", "Radiology syllabus", "E-learning", "E-testing", "Radiology clerkship", "Radiology cases" and "Radiology research". Standardized sum-scores were calculated for the entire attitude scale and for each specific subscale (min 1–max 5). The exploratory and confirmatory factor analyses were applied to study the factor structure and fit of the subscales. Using exploratory factor analysis we eliminated items with weak factor loadings. This led to the final 44-item scale. Table 1 lists the items, structured according to the seven components. The scale structure, obtained on the base of the exploratory factor analysis was next analyzed on the base of confirmatory factor analysis. Building on the criteria presented by Bentler [34], the resulting goodness-of-fit indices reflect a moderate to good fit of the model (Table 2). Nevertheless, we have to stress large RMSEA indices that will require special attention in subsequent research about the instrument. In Table 1, we also report Cronbach's α for each subscale. This reliability coefficient ranges from 0.72 to 0.95 reflecting acceptable to very good reliability scores.

For the purpose of this report, an independent English translator rendered the original Dutch questionnaire to English. A native speaker translated the statements back to Dutch.

Table 3
Results of the general linear model (ANOVA) in relation to the differences in student attitude towards components of the radiology curriculum according to training year.

Curricula component[a]	Mean scores (SD) – *N*							ANOVA	
	Total *N* = 977	Year 2 *N* = 192	Year 3 *N* = 219	Year 4 *N* = 211	Year 5 *N* = 161	Year 6 *N* = 122	Year 7 *N* = 72	Test between subjects – *F*	Effect size (partial Eta squared)
Radiology teaching	4.05 (0.69)	3.56 (0.61)	3.09 (0.69)	4.21 (0.66)	4.23 (0.57)	4.40 (0.56)	4.27 (0.63)	39.90**	0.17
Radiology syllabus	3.61 (0.68)	3.13 (0.60)	3.69 (0.65)	3.71 (0.67)	3.68 (0.63)	3.88 (0.62)	3.64 (0.67)	27.72**	0.12
E-learning	4.19 (0.69)	3.57 (0.64)	4.26 (0.63)	4.17 (0.59)	4.42 (0.67)	4.52 (0.53)	4.54 (0.57)	54.61**	0.22
E-testing	3.94 (0.59)	3.90 (0.16)	4.04 (0.66)	3.85 (0.65)	3.83 (0.64)	4.09 (0.63)	3.97 (0.65)	5.12**	0.03
Radiology clerkship	3.29 (0.41) *N* = 355	–	–	–	3.13 (0.36)	3.34 (0.34)	3.57 (0.46)	35.73**	0.17
Radiology cases	3.50 (0.61) *N* = 355	–	–	–	3.37 (0.65)	3.12 (0.58)	3.17 (0.60)	7.04**	0.04
Radiology research	3.94 (0.69)	–	–	–	3.94 (0.12)	3.95 (0.17)	3.96 (0.10)	0.57	0.003

** $p < .001$.
[a] The items are scored from "totally disagree" (1) to "totally agree" (5).

2.4. Statistical analysis

In views of studying our research questions, statistical analyses were carried out with SPSS version 15 (Statistical Package for the Social Sciences, SPSS, Chicago, IL, USA). Quantitative data were initially analyzed with descriptive statistics after controlling accuracy of data entry, missing values and outliers. Analysis of variance (ANOVA) and multiple pairwise comparison (Tamhane's *T*2 post hoc test) were used to compare attitude scores of students enrolled in different training years. *P* value was set at .05 to decide about the significance in differences. Effect sizes were calculated using Cohen's *d*.

3. Results

3.1. Response rate and profile of respondents

A total of 977 (response rate 87.5%) completed and returned the questionnaire: year 2 ($n = 192/235$; 81.7%), year 3 ($n = 219/250$; 87.6%), year 4 ($n = 211/223$; 94.6%), year 5 ($n = 161/188$; 85.6%), year 6 (122/147; 82.9%), year 7 ($n = 72/84$; 85.7%). Sixty-five percent of the respondents are female ($n = 634$) and 35% are men ($n = 343$). Most of the respondents were regular students (94%) and only 6% were enrolled with an Individualized Study Course program.

3.2. Student perceptions of the undergraduate radiology curriculum

Table 3 documents the mean standardized sum-scores in relation to the overall ERTeCS attitude scale and in relation to the seven subscales. Average perceptions are larger than 3, indicating rather high student appreciation levels for the different curriculum components. The highest average appreciation level is expressed in relation to E-learning ($m = 4.19$). The lowest appreciation level is found in relation to the radiology clerkship ($m = 3.29$) the latter is of course only based on input of fifth to seventh year students.

3.3. Differences in student perception about the components of the radiology curriculum

Table 3 reports – next to standardized sum-scores and standard deviations for the perceptions in relation to the subscales – the results of the analysis of variance with year of training as factor. The results show significant differences across the training years in relation to all radiology curriculum components, with the exception of radiology research: radiology teaching ($F = 39.90$, $p < .001$), radiology syllabus ($F = 27.72$, $p < .001$), E-learning ($F = 54.61$, $p < .001$), E-testing ($F = 5.12$, $p < .001$), radiology clerkships ($F = 5.38$, $p < .001$) and radiology cases ($F = 7.04$, $p < .001$). The post hoc pairwise comparison results are reported in Table 4. Only significant pairwise differences are included in the table.

The effect sizes (Cohen's *d*) tell us about the magnitude of these differences. The results show an overall increase of mean attitude sores from year 2 to year 7 for all significant concepts of radiology education. No significant differences are observed in year 4 and year 5 students for concepts of radiology teaching, radiology syllabus, and E-testing. But the mean perception scores towards these concepts and additionally for the radiology clerkship peaks in year 6 students. This seems to be increasingly important for these students in view of their radiology education.

Fig. 2 illustrates the changes in student perceptions towards the radiology curriculum components. Perceptions about the *E-learning* component are already very positive in year 2 with mean 3.57) and rise consistently in nearly every training year, up to year 7 (mean 4.54). This curriculum component reflects the highest perception score (mean across training years = 4.19) and reflects a very strong and nearly consistent significant increase (mean to high effect size). The perception of the component *radiology teaching* is also very positive (mean 4.05), and also increases significantly and consistently in students of subsequent training years (medium or even large effect size). The perception of the *radiology syllabus* is rather neutral in year 2 (mean 3.13), but perceptions slightly evolve in a positive way up to year 7 (mean 3.64). Nevertheless, it remains the least – nevertheless positive – appreciated curriculum component. Perceptions about the *E-testing component* show a positive pattern across the training years, with only minor significant differences between training years (see overall small effect sizes). Studying the perceptions of fifth year students and older, additional curriculum components become central in the educational approach. Right from the start, *radiology research* is perceived as a very important curriculum component. This high appreciation does not change through the different training years ($m > 3.94$). The component *radiology clerkship* is perceived in a rather neutral way in the fifth year (mean 3.13), but perceptions become gradually more positive in year 6 (mean 3.34) and year 7 (large and medium effect sizes). The perceptions about the curriculum component *radiology cases* decreases; but this significant decrease is limited (small effect size).

4. Discussion

At Gent University, the innovative radiology curriculum was implemented step by step from 1999 on, in the context of a large scale curriculum reform. The overall efficacy of the curriculum reform has been underpinned in an earlier study [35]. But, in the post 1999 period, a next step was made in the particular innovation of the radiology curriculum by the adoption of a new E-learning system and the implementation of E-testing. The latter was in particular geared to radiology teaching due to the adoption of special software (touch screen). Additional innovations extended the curriculum with of case-based radiology learning. This approach builds

Table 4
Post hoc analysis (Thamhane post hoc test) of differences in student attitude towards components of the Radiology curriculum according to training year.

Curricula component[a]	Years of training	Mean difference*	Effect size	
Radiology teaching	7 > 2	0.71*	1.14	L
	7 > 3	0.37*	0.56	M
	6 > 2	0.84*	1.43	L
	6 > 3	0.50*	0.80	L
	5 > 2	0.67*	1.13	L
	5 > 3	0.33*	0.52	M
	4 > 2	0.64*	1.02	L
	4 > 3	0.30*	0.45	M
	3 > 2	0.34*	0.52	L
Radiology syllabus	7 > 2	0.51*	1.80	L
	6 > 2	0.74*	1.22	L
	5 > 2	0.54*	0.89	L
	4 > 2	0.57*	0.90	L
	3 > 2	0.55*	0.88	L
E-learning	7 > 2	0.96*	1.57	L
	7 > 3	0.28*	0.46	S
	7 > 4	0.36*	0.62	M
	6 > 2	0.95*	1.60	L
	6 > 3	0.26*	0.44	S
	6 > 4	0.35*	0.61	M
	5 > 2	0.84*	1.28	L
	5 > 4	0.24*	0.38	S
	4 > 2	0.60*	0.96	L
	3 > 2	0.69*	1.07	L
E-testing	3 > 2	0.14*	0.30	S
	3 > 4	0.19*	0.29	S
	3 > 5	0.21*	0.31	S
	6 > 2	0.19*	0.41	S
	6 > 4	0.24*	0.37	S
	6 > 5	0.25*	0.40	S
Radiology clerkship	7 > 5	0.44*	1.07	L
	7 > 6	0.23*	0.58	M
Radiology cases	5 > 6	0.25*	0.24	S
	5 > 7	0.20*	0.18	S
Radiology research	No significant differences			

Effect size based on Cohen's *d*: small effect (>.20); medium effect (>.50); and large effect (>.80).
[a] Items were scored from "totally disagree" (1) to "totally agree" (5).
* $p < .05$.

on small groups discussion of radiology cases to develop an appropriate case solution by using Internet based supervised electronic forums.

In this study, we centered on student perceptions about the key curriculum components in the innovation: Radiology syllabus, E-learning, E-teaching, Radiology clerkships, Radiology cases and Radiology research are integrated in education approach of undergraduate radiology. As stated in Section 1, the importance of the affective learning domain cannot be underestimated in relation to the clinical competences and performance [28]. Affective attitudes

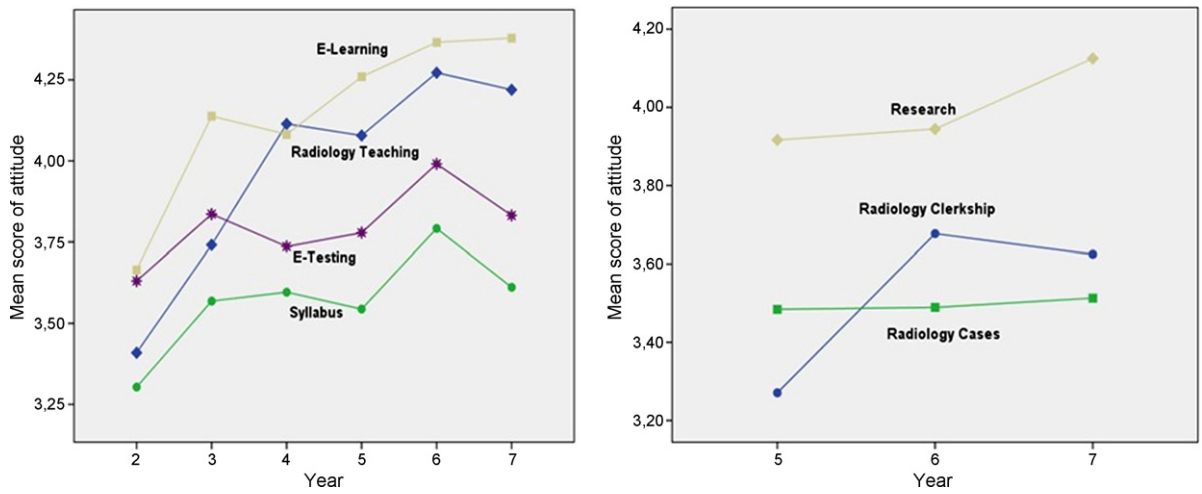

Fig. 2. Changes in student's perceptions about the different components of the radiology curriculum. Significant differences are observed in the components: radiology teaching, syllabus, E-learning, E-testing, and radiology cases and radiology clerkship ($p < .05$).

reflecting emotional responses and personal experiences are sensitive to personal feelings and the context [36]. The innovations in learning and teaching environment are only beneficial and result in higher learning performance when they are perceived as such by the students [29,30]. This brings us to the central research question about the curriculum innovation. In addition, we were interested in the way student perceptions evolved during consecutive training years.

The results shown an overall positive perception about the different radiology curriculum components. This is in line with the results of previous studies that pointed at the positive impact of a "blended learning" approach: combinations of E-learning and face-to-face methods such as traditional lectures and the adoption of printed materials [9,17]. Next to favorable attitudes towards learning, these studies also refer to the positive impact on knowledge acquisition. In the present study, student perceptions about all curriculum components are positive and receive a higher appreciation throughout the training years. This can partly be explained by the increased experience with the valid components of the curriculum. This helps students to understand sufficiently the place of radiology in the overall medical curriculum in the pre-clinical and clinical training years.

The positive perception of *the traditional printed radiology syllabus* is especially important in the third training year, with a slight jump between year 5 and 6. The latter change in perceptions can be linked to the introduction of the concurrent new curriculum component radiology clerkships. The syllabus might have become at that stage a relevant resource to carry out the specific tasks during the clinical clerkship. In addition, the need to repeat basic radiology knowledge is also pressed by the planning of an interdisciplinary exam at the end of year 6 that implies mastery of integrated radiology knowledge and skills. The latter interpretation points at the relevance of traditional knowledge resources to guarantee continuity in the curriculum [20].

The *E-learning* component becomes and is an indispensable tool in state-of-the-art radiology education [8,10–16]. This can be linked to the advantages related to instant accessibility, availability of exercises of different difficulty level, documented with high quality images. At Gent University, a dedicated E-learning and E-testing systems are in use since 2003. This means that students can build on seven years of experience in using these curriculum components. More than 7000 did already use this provision. In the context of this study, the positive and increase in positive perceptions of the E-learning component cannot be doubted. Up to the seventh training year, the perception remains positive and is the highest perception score when comparing different curriculum. We hypothesize that the positive curriculum perception can be linked to the collaborative learning environment, the flexibility in time and place, adaptation to the learning pace of the student, the E-learning provision. This implicates that the E-learning environment is perceived as a perfect medium for individualized, class-room independent, self-regulated learning that encourages the exploration of detailed knowledge and helps in the developing of the interpretation skills in radiology across al years of medical training.

In this context, the curriculum component *E-testing* is well perceived that support the previous research [13,37] on computer based method of evaluating students in radiology. Although, in the ICMC curriculum radiology is no longer considered a separate discipline, radiology is still assessed separately via the E-testing environment and this in almost every training year (except year 6). The focus on this separate exam is considered to be of importance. It consistently makes radiology visible in the curriculum and avoids students skipping radiology.

The radiology clerkships are reported in the literature as a vital part of a radiology curriculum [38–41]. In the present study, students reflect an increasingly positive perception of the radiology clerkships. We explain this by referring to the opportunities offered during these clerkships to attend radiological investigations, to learn working with radiological tools (PACS, web PACS and radiological CDs). The subscale items also stress good communication and supervision of staff, the opportunity to participate in multidisciplinary meetings and the possibility to experience the daily working of a department. The differences between perceptions of students in year 5 and 6 (7) can be related to the duration of the clerkship (half day for year 5 end 1 week or longer for years 6 and 7) and the nature of the tasks to perform during the clerkship (observational tasks for year 5 and active tasks for years 6 an 7).

A very high and positive perception was observed in relation to *radiology research* during the clinical training years. The lack of an increase in these perceptions can be due to a ceiling effect, or can be linked to the small percentage of selected students that continue to carry out scientific work in the radiology field. The findings that students nevertheless express a highly positive perception about scientific work in the radiology field are important because it might foster their future professional career choice for radiology.

Contemporary multidisciplinary medical education in which radiology plays an integral part, introduces *case-based learning* as a key curriculum component. Case-based radiology teaching is interlinked with the clinical radiological clerkships. During clinical radiological clerkships, students are asked to work with cases on PACS or web-PACS system (in year 5 and 6) or to develop cases making use of the PACS system (in year 7). Recently (since 2008–2009), "Radiology web-based cases" have been introduced in year 5 and 7 as part of interactive ex-cathedra lessons. The lecture setting can explain the less positive perception of *radiology cases* at this stage of the training. Previous research stresses that the case-based method is effective when linked to inter-professional learning and small-group collaborative learning. Only in those settings, increases in student satisfaction were observed [42]. Additionally, the fact that the "Radiology web-based cases" have only recently been introduced cal also explain the lower perception levels of students. Perhaps is too early to come to clear-cut conclusions about this component. Future research could focus on the specific position of the cases and this in relation to the other curriculum components, such as radiological clerkships and radiology research.

4.1. Limitations

A number of limitations have to be mentioned in relation to this study. First, though a response rate of 87.5% is acceptable, the small non-response can have introduced some bias. A second limitation is linked to the newly develop Evaluation Radiology Teaching Concept Scale (ERTeCS). Future research should underpin the completeness of the curriculum components covered by the instrument. In addition, further validation research is needed considering the nature of some of the goodness-of-fit indices. A third issue is related to the cross-sectional nature of the study. This allows to study the perceptions of students in different training years, but remains limited when it comes to the study of the longitudinal nature of the perceptions of the curriculum components. Lastly, our study centered on student perceptions about the radiology curriculum. Future research could center on a qualitative study approach, next to studying the link with actual student performance.

5. Conclusions

To conclude, the present research results point at a favorable perception of the innovative radiology curriculum components. The study points – both during pre-clinical and clinical years – at the appreciation for curriculum components that combine traditional curriculum components (ex-cathedra lessons with syllabus) with

distance learning components such as E-learning and E-testing. In clinical years – as expected – students switch to the application of knowledge and skills and therefore heavily appreciate practice linked curriculum components.

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