Students' perceptions of vertical and horizontal integration in a discipline-based dental school

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Abstract

Introduction: Integration is a key concern in discipline-based undergraduate dental curricula. Therefore, this study compared feedback on integration from students who participated in different instructional designs in a Comprehensive Patient Care course.

Methods: The study was conducted at the University of Pretoria (2009-2011). Third year cohorts (Cohorts A, B and C) participated in preclinical case-based learning, while fourth year cohorts (Cohorts D and E) received didactic teaching in Comprehensive Patient Care. Cohorts A, D and E practiced clinical Comprehensive Patient Care in a discipline-based clinic. Cohort B conducted their Comprehensive Patient Care patient examinations in a dedicated facility supervised by dedicated faculty responsible to teach integration. Students had to indicate on visual analogue scales whether the way they were taught at the school helped them to integrate knowledge from the same [horizontal integration] and preceding [vertical integration] year of study. The end-points of the scales were defined as "definitely" and "not at all". Analysis of Variance (ANOVA) was employed to measure differences between cohorts according to year of study.

Results: Third year case-based learning cohorts rated the horizontal integration close to 80/100 and vertical integration ranging from 64 to 71/100. In year four Cohort B rated vertical and horizontal integration 9-15% higher (ANOVA, $P<0.05$) than Cohorts A and D. In year five Cohort A rated vertical and horizontal integration 11-18% higher (ANOVA, $P<0.05$) than Cohorts D and E.

Conclusion: Preclinical case-based learning and Comprehensive Patient Care supervised by dedicated faculty were associated with more favourable perceptions about integration in the discipline-based undergraduate dental curriculum.

Introduction

The integration of knowledge, skills and dispositions relates to how students learn from interacting inputs originating from various sources (1). The need for integration stems from complexity, originating from the “real world” context, encountered during patient care (2) and the rapid expansion and separation of different sciences during the past century (3).

The integration of knowledge, skills and dispositions in dental education is a quality assurance requirement (4), especially in discipline-based undergraduate dental curricula where subjects are often taught in disciplinary silos. The ability to integrate scientific knowledge obtained from various sources during clinical decision-making is fundamental to ensure competence in clinical decision-making (4). The requirement for integration is, however, not new. More than a hundred years ago Flexner suggested that clinical decisions should be based on scientific evidence (5). Flexner proposed that basic medical science knowledge, such as Anatomy, Physiology, Microbiology, Anatomical Pathology and Pharmacology, be integrated with clinical teaching and learning, preferably through active learning strategies (5). Experts in medical education still perceive Flexner’s proposals to be valid in the contemporary era (3). Unfortunately, the rapid expansion of science resulted in demarcated subject-specific content-based preclinical teaching and learning. This demarcation and isolation of different disciplines and the explosion of knowledge in each of the individual sciences complicate integration from a clinical perspective (3).

Integration is especially difficult for inexperienced students. The knowledge structures of novices are most often not intricate enough to make conceptual links between different sources of information (6). Research stemming from cognitive psychology suggests that the integration of knowledge is about the formation of mental models (6). Learning starts with the formation of conceptual models in the mind of the learner by answering the question “What is this? As soon as the student

starts to conceptually link different concepts together structural and causal mental models start to develop, enabling improved reasoning ability. Structural mental models are representations of how different concepts interrelate, while causal models provide an understanding of how concepts influence each other (6). These more advanced mental models may allow for, amongst others, the understanding of the aetiology and pathogenesis of disease, risk estimation, the determination of prognosis, as well as treatment planning (7). It is the teacher's responsibility to make relationships between prior knowledge and newly acquired knowledge known to students as part of the preclinical and clinical teaching, learning and assessment (8, 9, 10). Intentional integration of basic medical science knowledge during the teaching of clinical reasoning skills has indeed been linked to positive clinical reasoning outcomes (11).

To ensure integration during the learning process the teacher has to create a broad enough context for the student to understand how information from different sources and stages of learning link together (6-8). This could be done by allowing the student to practice in either a whole or a part whole-task context (6, 12). An integrated approach during teaching and learning should theoretically help to integrate disciplinary knowledge, skills and dispositions as part of comprehensive patient care (9, 12). In order to achieve these objectives universities have implemented educational innovations to simulate integrated learning through active learning approaches. Problem-based learning (PBL), for example, is used by some universities to develop integrated reasoning skills in medical (13, 14) and dental education (15, 16). PBL is effective as a teaching and learning strategy provided that the learning is properly supported by inputs from experts on the topics covered (17). Unfortunately, PBL strategies require more resources compared to traditional discipline-based approaches (18). Based on resource considerations traditional discipline-based dental schools continue to exist, requiring alternative strategies to facilitate integration (15). One such alternative is case-based learning (19, 20).

Case-based learning indeed allows for the integration of knowledge (9, 21). Despite the existence of integrative teaching and learning strategies such as case-based learning, the effectiveness of innovations to ensure "integration" within

undergraduate dental curricula remains relatively unexplored, especially in dental education literature.

“Integration” as a concept remains multidimensional (1) without any known measurement instruments that could be employed to quantify the construct objectively. Conceptually, the terms horizontal and vertical integration (4, 8-10) are most often used to provide some description of how integration could be facilitated in a multi-layered curriculum. Horizontal integration refers to the integration of skills, knowledge and dispositions acquired at, more or less, the same point in time (4, 8-10). Vertical integration refers to the integration of knowledge, skills and dispositions acquired at an earlier stage of learning (4, 8-10). With no objective measure of integration in existence the only viable option would be to ask the students about their perceptions integration in the curriculum. Despite obvious limitations, student perceptions have been recognised as a valuable source of information to gain some sense of the effectiveness of teaching and learning strategies (22).

Based on the deliberations above, this study sought to investigate the perceptions of students regarding the ability of different instructional designs to assist with knowledge integration in a discipline-based undergraduate dental curriculum.

Methods

Ethical approval

The University of Pretoria provided ethical approval to the researchers to use the student feedback for research purposes as part of a larger PhD project (Protocol 153/2009).

Institutional context

During the study period first and second year dental students at the University of Pretoria participated in a joint medical curriculum (23). During this time they were exposed to subjects such as Chemistry, Physics, Anatomy, Physiology, Microbiology and an introduction to Pathology. The first two study years also included a substantial amount of learning about the bio-psychosocial model of health care. The third year of study comprised Physiology, Pharmacology, Oral Biology and a head

and neck Anatomy block as well as disciplinary preclinical teaching and learning in all of the clinical dental disciplines. Over and above these subjects, the School of Dentistry has been using of a subject called Comprehensive Patient Care (24) to integrate knowledge across disciplines. For many years Comprehensive Patient Care comprised didactic teaching mainly in year four and clinical Comprehensive Patient Care in years four and five (7). The fourth year cohort of 2009, Cohort D (Figure 1), was the last cohort who participated in the original instructional design. In 2009 a novel integrated case-based instructional design was implemented for third year students to scaffold the transfer from preclinical to clinical teaching and learning (9, 25). Case-based learning was implemented through part-whole task simulation (6, 12) and the active integration of relevant basic medical science knowledge during teaching and learning as proposed by Snyman and Kroon (9). To achieve horizontal integration, the case-based instructional design of Comprehensive Patient Care placed an emphasis on integration between Odontology, Periodontology and Oral Biology, in particular. Cohort A was the first cohort to be exposed to case-based learning followed by Cohorts B and C (Figure 1).

Case-based learning continued in the fourth and fifth years by means of a case study portfolio of real life cases alongside clinical teaching and learning (7). It is pertinent to note that the same faculty members who previously presented the didactic teaching in Comprehensive Patient Care also presented the case-based learning during the study period. Over the years the integrated clinical teaching and learning took place as part of Restorative Dentistry (later called Odontology) and Fixed Prosthodontics in year four and five, respectively (7). Faculty members who presented the didactic teaching in Comprehensive Patient Care had only minimal inputs in the integrated clinical teaching and learning in year four until the end of 2010. The discipline-based faculty of Odontology still supervised Cohort A in Comprehensive Patient Care in 2010 (Figure 1) in year four. Comprehensive Patient Care faculty members took over the responsibility for comprehensive clinical patient examinations in the fourth year of study as from 2011 (for Cohort B) following the procurement of a dedicated treatment facility. With the comprehensive clinical examinations taking place under the supervision of faculty from Comprehensive Patient Care the students subsequently performed the required treatment in the various treatment facilities of the discipline-based school.

Target population

Third, fourth and fifth year students (2009 - 2011) served as the target population (Figure 1).

Year of study	2008	2009	2010	2011
3		**Cohort A** • Preclinical case-based learning supervised by faculty from CPC*	**Cohort B** • Preclinical case-based learning supervised by faculty from CPC*	**Cohort C** • Preclinical case-based learning supervised by faculty from CPC*
4	**Cohort E** • Integrated didactic teaching and portfolio of patient records supervised by faculty from CPC* • Integrated clinical teaching and learning supervised by faculty from Odontology	**Cohort D** • Integrated didactic teaching and portfolio of patient records supervised by faculty from CPC* • Integrated clinical teaching and learning supervised by faculty from Odontology	**Cohort A** • Portfolio of real life case studies supervised by faculty from CPC* • Integrated clinical teaching and learning supervised by faculty from Odontology	**Cohort B** • Portfolio of real life case studies supervised by faculty from CPC* • Integrated clinical teaching and learning supervised by faculty from CPC*
5		**Cohort E** • Portfolio of patient records supervised by faculty from CPC* • Integrated clinical teaching and learning supervised by faculty from Fixed Prosthodontics	**Cohort D** • Portfolio of patient records supervised by faculty from CPC* • Integrated clinical teaching and learning supervised by faculty from Fixed Prosthodontics	**Cohort A** • Portfolio of real life case studies supervised by faculty from CPC* • Integrated clinical teaching and learning supervised by faculty from Fixed Prosthodontics

Figure 1 Study design, indicating the students' exposure to integrated learning

*Comprehensive Patient Care

Case definitions of vertical and horizontal integration

For the purpose of the current study, horizontal integration was defined as the integration of knowledge, skills and dispositions learned in the same year. Vertical integration was defined as the integration of current learning with knowledge, skills and dispositions learned in previous years.

Data collection

Students were asked, as part of the routine course feedback at the end of the study year, to anonymously indicate on visual analogue scales whether the way they were taught at the school helped them to integrate knowledge from the previous (vertical integration) and same (horizontal integration) years of study (Figure 2.) The scales were 127mm in length with the endpoints being defined as "*not at all* = 0" and "*definitely* = 127". Students had to mark their perceptions about integration by making a cross on the line. The students' responses were measured with a standard ruler by an administrative member of staff. The values obtained were adjusted by dividing the value of each of the responses by 0.7874 to provide a continuous value on a hundred point scale.

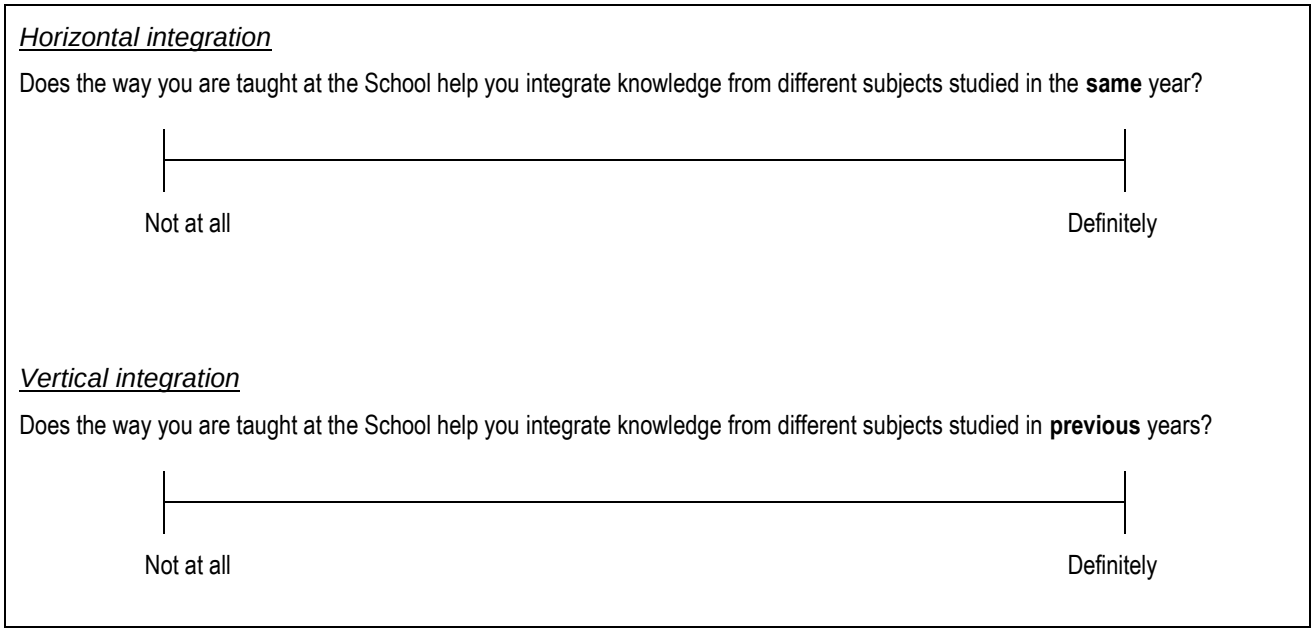

Figure 2 Visual analogue scales to measure student perceptions regarding horizontal and vertical integration

Statistical analysis

Differences in feedback between cohorts were analysed by means of Analysis of Variance (ANOVA) (26) for each of the years of study. These inquiries were complemented by Least Square Difference post hoc contrast analyses (27).

The analysis was conducted with Stata (StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP).

Results

The response rate to the course feedback was 100%.

Horizontal integration

Table 1 illustrates the students' perceptions about horizontal integration in the curriculum. The mean scores of third year Cohorts A, B and C ranged from 77.99 to 82.59. These differences were not statistically significant.

The mean score of fourth year Cohorts D, A and B were 63.81, 69.84 and 79.07, respectively (Table 1). The mean score of Cohort B (case-based learning group) was 15.26% higher (ANOVA, $P<0.001$) than the mean score of Cohort D. Cohort B on average rated the horizontal integration 9.23% higher (ANOVA, $P<0.05$) than Cohort A (Table 1).

In the fifth year Cohort A registered a mean score of 75.19 for horizontal integration (Table 1). The mean scores of Cohorts D and E and were 56.93 and 60.31, respectively. Both these scores were significantly lower (ANOVA, $P<0.001$) compared to the mean score of Cohort A (Table 1).

Table 1 Students' perceptions of horizontal integration

Year of study	**Year**	**Co-hort**	**CBL in year 3**	Dedica-ted faculty teaching for integra-tion	Does the way you are taught at the School help you integrate knowledge from different subjects studied in the **same** year?			ANOVA / LSD Post hoc contrast analysis (P)
					n	X	Sd	
3	2009	A	Yes=1	Yes	43	77.99	23.58	Not significant
3	2010	B	Yes=1	Yes	55	78.73	21.58	
3	2011	C	Yes=1	Yes	56	82.59	17.60	
4	2009	D	No=0	No	51	63.81	22.46	< 0.001 < 0.05
4	2010	A	Yes=1	No	46	69.84	19.34	
4	2011	B	Yes=1	Yes	53	79.07	18.59	
5	2009	E	No=0	Yes*	45	60.31	24.36	0.001 < 0.001
5	2010	D	No=0	Yes*	50	56.93	21.58	
5	2011	A	Yes=1	Yes*	43	75.19	20.68	

CBL= Case-based learning

*Faculty from Fixed Prosthodontics

Vertical integration

Table 2 illustrates the third year students' perceptions about vertical integration in the curriculum. The mean scores of Cohorts A, B and C ranged from 64.24 to 70.92. The differences between the scores were not statistically significant.

In the fourth year comparison (Table 2), Cohort B rated the vertical integration 72.22 out of 100. This score was 9.35% higher (ANOVA, $P<0.05$) than the mean score of Cohort D. The ratings of Cohorts A and B differed significantly (ANOVA, $P<0.01$). Cohort B rated the vertical integration 13.47% higher than Cohort A (Table 2).

Table 2 Students' perceptions of vertical integration

Year of study	**Year**	**Co-hort**	**CBL in year 3**	Dedica-ted faculty teaching for integra-tion	Does the way you are taught at the School help you integrate knowledge from different subjects studied in **previous** years?			ANOVA / LSD Post hoc contrast analysis (P)
					n	X	Sd	
3	2009	A	Yes	Yes	43	64.24	24.70	Not significant
3	2010	B	Yes	Yes	55	65.30	27.35	
3	2011	C	Yes	Yes	56	70.92	24.97	
4	2009	D	No	No	51	62.87	25.02	< 0.05 < 0.01
4	2010	A	Yes	No	46	58.75	23.45	
4	2011	B	Yes	Yes	53	72.22	20.42	
5	2009	E	No	Yes*	45	60.38	22.59	<0.05 0.001
5	2010	D	No	Yes*	50	55.10	21.95	
5	2011	A	Yes	Yes*	43	71.62	18.75	

CBL= Case-based learning

*Faculty from Fixed Prosthodontics

Cohort A registered a mean score of 71.62 for vertical integration in year five (Table 2), while Cohorts D and E rated vertical integration 55.10 and 60.38, respectively. These differences were also statistically significant (ANOVA, P<0.05).

Discussion

This study demonstrates student perceptions of vertical and horizontal integration in relation to curriculum interventions with the aim of improving integration in a discipline-based dental school. The implementation of preclinical case-based learning and the dedication of faculty to teach for integration are the two main interventions that are of interest in this study

Preclinical case-based learning

Preclinical case-based learning can be regarded as a part-whole scaffolding strategy (6, 12) employed to prepare students for clinical teaching and learning. Part-whole scaffolding can be defined as an attempt to create an authentic context for students to learn in, without making the learning overly complex. In other words, the task is designed in such a way that the student can recognize the "real world" connotation but does not contain all the elements of the "real world" task (6, 12). Literature contains examples whereby part-whole task approaches were employed to simulate diagnostic reasoning, treatment planning, patient administration (7, 12, 25) and dentist-patient communication skills using context rich case studies (7, 28, 29). By creating case studies that simulate "real world" contexts students have the opportunity to integrate knowledge that relate to different basic medical science (11) and clinical disciplines, which would not have normally occurred if the teaching and learning remained isolated in the disciplines.

Preclinical case-based learning has been associated with improved diagnostic and treatment planning decision-making during the clinical teaching and learning years (25), which by default suggests improved integration of information from different sources. Students who participated in preclinical case-based learning also expressed positive views regarding horizontal integration in a recent qualitative study (30). The early introduction of case-based learning in a discipline-based undergraduate dental curriculum allows for the integration of basic medical science knowledge (such as Anatomy, Physiology, Oral Biology and Pharmacology) with the clinical sciences on a just-in-time basis (6). It could be argued that by teaching different disciplines in closer proximity to each other it would be easier for inexperienced students to make conceptual links between different sources of information. Integration could further be enhanced when the teacher makes an active attempt to make conceptual links visible to the students (9, 11). For example, it can be argued that in order for students to learn the aetiology, pathogenesis, diagnosis and therapeutic reversal of dental caries, they need to understand the histological structure of the tooth, which is typically learned in Oral Biology. The facilitator of the case-based learning therefore has an obligation to relate the new information regarding dental caries to existing knowledge obtained in Oral Biology (9). Other typical examples, amongst others, include: the relationship between amelogenesis and dental fluorosis; the histological

structure of the periodontium and periodontitis; the histological structure of dentine and hypersensitivity; the histological structure of the pulp and pulpitis; the effects of certain medications on saliva flow and blood clotting; and the effect of vasoconstrictors on blood pressure and heart rhythm. The relatively high scores for horizontal integration (approximately 80 out of 100) in the third year of study measured in this study is an indication of what can be achieved through preclinical case-based learning when the above-mentioned principles are applied. The findings of the current study suggest that it may be practical and worthwhile to start with integrated simulation as early as the preclinical year of study.

The lower ratings given by the students in the current study for vertical integration as compared to horizontal integration maybe an indication of the difficulty to integrate knowledge from preceding years of study with newly learned knowledge. An alternative view maybe that perceptions of curriculum overload and lack of relevance (23) may have influenced students' opinions on vertical integration negatively as there may have been little information from previous years that could not be directly linked to the preclinical case studies. To completely understand integrated case studies that include dental caries, periodontitis, as well as pulpal and periapical conditions students require some understanding of microbiology, immunology, pathology and how these sciences relate to diagnosis, prevention, therapeutic, curative and rehabilitative treatment in a psychosocial context. Basic medical science disciplines such as immunology, microbiology and pathology are often taught in its entirety from a content perspective. By default most of this content will not have any bearing on typical case studies. Furthermore, from a teaching perspective it is not always known exactly what have been taught in previous years by different academic departments and faculty members. It would therefore be difficult for the teacher to know exactly what students have learned in order to assist them to make conceptual links. These observations suggest vertical integration needs to be strengthened in the discipline-based curriculum through inter-departmental collaboration throughout the continuum of the curriculum. The reduction of unnecessary content should also be explored (31).

Dedicated faculty teaching for integration

Lecturer aptitude and organisational ability has been linked to positive student perceptions about teaching and learning (32). On the one hand it is conceivable that faculty who are assigned to an integration process will organise the learning environment in such a way to focus on integrated learning. On the other hand faculty who are assigned to teach specific disciplines may support integrated learning but their focus is more likely to be on the discipline they have been assigned to. These assumptions appear to be evident in the results of the current study. From the results it was notable that Cohort A's relatively positive perceptions of integration achieved in year three, after participating in case-based learning, could not be sustained following their progression to the end of the fourth year of study. During their fourth year, Cohort A had to participate in clinical Comprehensive Patient Care in the discipline-based Odontology clinic under the guidance of discipline-based faculty members. The mean score of Cohort B in 2011 suggests that the appointment of dedicated faculty to facilitate integrated learning in a dedicated facility based on the principles taught in the preclinical case-based learning in year four enhanced perceptions of the levels of integration. An alternative interpretation could be that Cohort A was perhaps disappointed that their initial clinical teaching and learning were not exactly aligned with the preclinical case-based learning.

The same inferences about dedicated faculty could however not be drawn for the fifth year of study. It should be noted that all three the fifth year cohorts in the comparison were supervised by faculty from Fixed Prosthodontics, who generally follow an integrated approach due to the complexity of the clinical care rendered to patients. The substantial differences measured between Cohort A and D as well as between Cohort A and E (Tables 1 and 2) in the fifth year comparison indicate that students perceived the integration in the school to be on a substantially higher level than in the past when Comprehensive Patient Care was presented with a didactic approach in the fourth year of study. It therefore appears as if the preclinical case-based learning and portfolio cases studies supervised by the dedicated faculty form Comprehensive Patient Care may have indeed influenced their perceptions positively over an extended period of time.

Employing dedicated faculty to supervise initial integrated clinical teaching and learning and aligning preclinical and clinical teaching and learning therefore appear to be key considerations to enhance student perceptions of the quality of integration.

Limitations of the study

Inferences drawn in this study should only be interpreted by considering the limitations of the study. The quasi-experimental study design (33) of the comparisons is one of the biggest limitations of this study. Students from different cohorts are bound to experience teaching and learning differently due to a changing environment (33). The undergraduate curriculum of the School of Dentistry, UP (34), however, remained fairly stable during the study period (7) with the major changes being highlighted under the “Institutional context” in the Methods section.

Moreover, the results depend on students’ perceptions, which are not always the most ideal form of information (22). A causality link between integration strategies and integration can therefore not summarily be assumed. However, the way in which horizontal and vertical integration was measured in this study appeared to be a useful quantitative method to gain some understanding of the potential impact of integrated teaching and learning strategies implemented in a curriculum. Student evaluation is indeed an acceptable and useful method to measure the impact of innovation in education (22).

It is highly conceivable that other discipline-based dental schools may be faced with similar scenarios. The current study may therefore provide some strategic direction on how to facilitate and monitor integration in a discipline-based school.

Conclusion

The current study suggests that the educational strategies, including preclinical case-based learning as well as dedicated facilities and faculty with a focus on integration, could be associated with positive student perceptions regarding horizontal and vertical integration in a discipline-based undergraduate dental curriculum.

The quantitative methods used to measure horizontal and vertical integration from the students’ perspectives also appeared to be useful.

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References

1 Harden RM. The integration ladder: a tool for curriculum planning and evaluation. Med Educ 2000: 34: 551-557.

2 Mennin S. Self-organisation, integration and curriculum in the complex world of medical education. Med Educ 2010: 44: 20-30.

3 Finnerty EP, Chauvin S, Bonaminio G, Andrews M, Carroll RG, Pangaro LN. Flexner revisited: The role and value of the basic sciences in medical education. Acad Med 2010: 85: 349-355. doi: 10.1097/ACM.0b013e3181c88b09

4 Plasschaert AJ, Manogue M, Lindh C, McLoughlin J, Murtomaa H, Nattestad A, et al. Curriculum structure and the European Credit Transfer System for European dental schools: part I. Eur J Dent Educ 2006: 10: 123-130.

5 Flexner A. Medical education in the USA and Canada: a report to the Carnegie Foundation for the Advancement of Teaching. Boston, MA: Updyke, 1910.

6 Van Merriënboer JJ, Clark RE, De Croock MB. Blueprints for complex learning: the 4C/ID-model. Education Tech Research and Dev 2002: 50: 39-64.

7 Postma TC. Evaluating the impact of adjunctive integrated case-based dental teaching and learning on clinical reasoning in a discipline-based teaching and learning environment (Phd thesis). Pretoria: University of Pretoria. Pretoria, 2014: 1-346.

8 Oliver R, Kersten H, Vinkka-Puhakka H, Alpasan G, Bearn D, Cema I, et al. Curriculum structure: principles and strategy. Eur J Dent Educ 2008: 12 Suppl 1: S74-84.

9 Snyman WD, Kroon J. Vertical and horizontal integration of knowledge and skills − a working model. Eur J Dent Educ 2005: 9: 26-31.

10 Vidic B, Weitlauf HM. Horizontal and vertical integration of academic disciplines in the medical school curriculum. Clin Anat 2002: 15: 233-235.

11 Woods NN, Brooks LR, Norman GR. The value of basic science in clinical diagnosis: creating coherence among signs and symptoms.

Med Educ 2005: 39: 107-112.

12 Postma TC, White JG. Developing clinical reasoning in the classroom - analysis of the 4C/ID-model. Eur J Dent Educ 2015: 19: 74–80.

13 Neufeld VR, Barrows HS. The "McMaster Philosophy": an approach to medical education. J Med Educ 1974: 49: 1040-1050.

14 Prideaux D. Curriculum development in medical education: from acronyms to dynamism. Teaching Teacher Educ 2007: 23: 294-302.

15 Jacob PS. Problem based learning in dental education. J Educ Ethics Dent 2011: 1: 7-11.

16 Fincham AG, Shuler CF. The changing face of dental education: the impact of PBL. J Dent Educ 2001: 65: 406-421.

17 Schmidt, HG, Jerome IR, Elaine HY. The process of problem-based learning: what works and why. Med Educ 2011 45: 792-806.

18 Colliver JA. Effectiveness of problem-based learning curricula: research and theory. Acad Med 2000: 75: 259-266.

19 Kassirer JP. Teaching clinical reasoning: Case-based and coached. Acad Med 2010: 85: 1118-1124. doi: 10.1097/ACM.0b013e3181d5dd0d

20 Garvey MT, O'Sullivan M, Blake M. Multidisciplinary case-based learning for undergraduate students. Eur J Dent Educ 2000: 4: 165-168.

21 Savery JR. Overview of problem-based learning: definitions and distinctions. In: Ertmer PA, Helmo-Silver C, walker A, Leary H (Eds), Essential readings in problem-based learning: exploring and extending the legacy of Howard S. Barrows. West Lafayette, USA: Purdue University Press, 2015: 5.

22 Marsh HW. Students' evaluations of university teaching: Dimensionality, reliability, validity, potential biases and usefulness. In: Perry RP, Smart JC (Eds), The scholarship of teaching and learning in higher education: An evidence-based perspective. Houten, Netherlands: Springer, 2007: 319-383. DOI 10.1007/1-4020-5742-3_9

23 Postma TC, Bronkhorst L. Second-year dental students' perceptions about a joint basic science curriculum. Afr J Health Professions Educ 2015: 7: 199-201.

24 Seeliger JE, Snyman WD. A new approach to undergraduate dental education. JDASA 1996: 51: 746-749. Epub 1996/12/01.

25 Postma TC White JG. Developing integrated clinical reasoning competencies in dental students using scaffolded case-based learning – empirical evidence. Eur J Dent Educ 2015: doi: 10.1111/eje.12159

26 Armstrong RA, Slade SV, Eperjesi F. An introduction to analysis of variance (ANOVA) with special reference to data from clinical

experiments in optometry. Ophthalmic Physiol Opt 2000: 20: 235-241.

27 Williams LJ, Herv´e A. Fisher's Least Significant Difference (LSD) Test In: Salkind N (Ed), Encyclopedia of Research Design. Thousand Oaks, CA: Sage, 2010.

28 White JG, Kruger C, Snyman WD. Development and implementation of communication skills in dentistry: an example from South Africa. Eur J Dent Educ 2008: 12: 29-34.

29 White JG. Strategy for teaching communication skills in dentistry. SADJ 2010: 65: 260-265.

30 Postma TC Self-regulation – the key to progress in clinical reasoning? Afr J Health Professions Educ 2015: 7: 202-207.

31 Hanekom SD, Unger M, Cilliers F. Deriving criteria by which to determine core curriculum content: A high engagement process. Afr J Health Professions Educ 2014: 6: 180-184.

32 Elzubeir MA, Rizk DE. Identifying characteristics that students, interns and residents look for in their role models. Med Educ 2001: 35: 272-277.

33 Eccles M, Grimshaw J, Campbell M, Ramsay C. Research designs for studies evaluating the effectiveness of change and improvement strategies. Qual Saf Health Care 2003: 12: 47-52.

34 Snyman WD, Ligthelm AJ. The new Pretoria curriculum. SADJ 2000: 55: 642-648.